The Economics of Bioenergy

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Livelihoods, Sustainability and Value Chains

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Zusammenfassung

In den letzten Jahren befürworteten viele Industrieländer die Produktion und Nutzung von Bioenergien in ihren politischen Agenden (Butterbach-Bahl und Kiese 2013). Bioenergien beinhalten Energienutzung durch Holz und landwirtschaftliche Nutzpflanzen. Als Quelle für die Energienutzung von Holz werden Bäume und Sträucher aus Wäldern und landwirtschaftlich genutzten Flächen verwendet. Landwirtschaftliche Energiepflanzen beinhalten öl- und stärkehaltige Pflanzen wie Raps, Ölpalmen, Mais und Zuckerrohr (FAO 2004). Es gibt zwei Hauptgründe für die Nutzung von Bioenergien. Der eine Grund ist der Wunsch nach größerer Unabhängigkeit von fossilen Brennstoffen auch hervorgerufen durch die starke Fluktuation des Ölpreises. Ein weiterer Grund ist die gewünschte Reduktion von Treibhausgasen (Florin und Bunting 2009). Sub-Sahara Afrika ist ein geeigneter Kontinent für die Produktion und den Export notwendiger Biomasse nach Europa. Studien schätzten einen großen Anteil an verfügbaren Land, welches zurzeit nicht landwirtschaftlich genutzt wird (Smeets et al. 2007). Darüber hinaus wird das Produktionspotenzial in der Nähe des Äquators signifikant höher eingeschätzt im Vergleich zu Ländern mit gemäßigtem Klima wie z.B. in Europa (Landeweerd et al. 2012). Energie ist ein Grundpfeiler für ökonomische Entwicklung in Entwicklungsländern. Diese betrachten Bioenergien auch als Möglichkeit sich von der Abhängigkeit von fossilen Energien zu lösen, Wirtschaftswachstum anzukurbeln durch zusätzliche Beschäftigungsmöglichkeiten und damit auch das Einkommen der Haushalte zu erhöhen (Arndt et al. 2011). Neben diesen positiven Effekten wird die Produktion von Bioenergien auch als kritisch in Bezug auf die Ernährungssicherheit und Landraub gesehen, besonders in Entwicklungsländern in denen das Angebot an Lebensmitteln oft knapp ist (Maltsoglou et al. 2013).

Das Ziel der vorliegenden Arbeit ist die Analyse verschiedener Teile der Bioenergiewertschöpfungskette in Bezug auf Produktion, Konsum und Handel aus der Perspektive von Entwicklungsländern aus Sub-Sahara Afrika am Beispiel von Tansania. Die genauen Ziele der Arbeit sind folgende: (1) Ein Überblick über die derzeitigen Entwicklungen der Wertschöpfungskettenanalyse im Kontext von Umwelt und Handel, (2) die Untersuchung der Feuerholznutzung von Kleinbauern aus privater Agroforstwirtschaft und der Auswirkung auf deren Haushaltseinkommen in Tansania, (3) die Analyse des Beitrags von *Jatropha curcas* als Wirtspflanze für Schwarzen Pfeffer und Vanillepflanzen zum Lebensunterhalt ländlicher Haushalte, (4) die Untersuchung der Multiplikatoreffekte verschiedener Bioenergiepflanzen auf die Einkommen der Haushalte im Vergleich zu Agroforstwirtschaft, (5) die Abschätzung der Umsetzbarkeit zur Nutzung von *Jatropha curcas* als Energiepflanze

und damit Feuerholz zu ersetzen und (6) die Analyse der Determinanten des Handels von Rapsöl, welches als Vorleistung für die Produktion von Biodiesel in Europa genutzt wird.

Der Überblick bezüglich der derzeitigen Entwicklung von Wertschöpfungskettenanalysen wird in Kapitel 2 gegeben, welches damit auch die Basis der Arbeit bildet. Kapitel 3,4 und 5 gehören zu einem Bioenergieprojekt über die Evaluierung von Bioenergieproduktion und Konsum im ländlichen Tansania. Die Datenbasis besteht aus einem Querschnittdatensatz erhoben innerhalb einer Haushaltsbefragung in 2010. Die Erhebung fand in Tandai, einem Dorf im Distrikt Morogoro in Tansania statt. Dafür wurde eine zufällige Stichprobe aus verfügbaren Haushaltslisten gezogen, um eine repräsentative Stichprobe zu erzielen. Insgesamt wurden 314 von 1013 Haushalten befragt. Das Dorf grenzt an ein Waldschutzgebiet, welches sich durch einen hohen Grad an Biodiversität auszeichnet. Die Studienregion gehört zudem zu einem Wassereinzugsgebiet des nördlichen Uluguru Gebirges, welches die Region um Dar es Salaam mit Trinkwasser versorgt. In der Vergangenheit wurde der umgebende Wald von lokalen Haushalten stark degradiert durch Umwandlung von Wald in landwirtschaftlich nutzbare Flächen und Abholzung. Infolgedessen wurde das Waldgebiet in 1961 als Naturschutzgebiet deklariert, welches seit 2002 mit dem höchsten Protektionsgrad gesichert ist. Seit 2000 wird in diesem Gebiet private Agroforstwirtschaft gefördert um den lokalen Haushalten die Produktion von Feuerholz, Schnittholz und Nahrung zu bieten. *Jatropha curcas* wurde seit den 50er Jahren des 20. Jahrhunderts im Forschungsgebiet eingeführt. Heutzutage wird Jatropha als Wirtspflanze für Schwarzen Pfeffer und Vanillepflanzen genutzt, wobei letztere Gewürzpflanzen wichtige Produkte zur Einkommensgenerierung der Haushalte darstellen. Zuvor wurden hochwachsende Bäume wie Mahagoni-, Brotfrucht-, Mango- und Teakbäume als Wirtsbäume verwendet. Jatropha hat jedoch den Vorteil einer geringeren Wuchshöhe und dadurch weniger schwere Ernteunfälle durch Herunterfallen der Erntehelfer.

Im dritten Kapiel wird die Relevanz von Agroforstwirtschaft für Kleinbauern untersucht. Dafür wurde ein Indikator berechnet, welcher das natürliche Holzwachstum der eigenen Bäume mit der Abholzungsrate für Feuerholz vergleicht. Eine logistische Regression zeigt, dass Eigentumsrechte von landwirtschaftlichen Flächen und Umweltbewusstsein die Wahrscheinlichkeit erhöhen nachhaltige Forstwirtschaft zu betreiben. Die Empirie aus der Quantilen Regression zeigt, dass die ärmsten Haushalte des Dorfes höhere Einkommen generieren, wenn sie mehr Feuerholz extrahieren als die Wachstumsrate der Bäume im Jahr bietet. Haushalte mit höheren Einkommen dagegen generieren mehr Einkommen, wenn sie nachhaltig wirtschaften.

In Kapitel 4 wird die Rolle von *Jatropha curcas* zur Einkommensgenerierung von Kleinbauern analysiert. Dazu wurden die typischen Lebensgrundlagen betrachtet. Drei verschiedene Strategien wurden identifiziert: [1] „Subsistenz-wirtschaftende Haushalte, die teilweise als ungelernte Hilfsarbeiter Zusatzeinkommen außerhalb der eigenen Farm generieren", [2] „Auf eigene Landwirtschaft hochspezialisierte Haushalte" und [3] „Haushalte mit Landwirtschaft und hohem außer-landwirtschaftlichen Einkommen". Während Haushalte des 3. Clusters das höchste Pro-Kopf-Einkommen generieren, sind die Haushalte des Cluster [1] als arm charakterisiert. Das Einkommen durch den Gewürzanbau an Jatropha ist signifikant höher für das 3. Cluster. Einige der ärmsten Haushalte generieren jedoch einzeln bis zu 30% des Gesamteinkommens aus dem Gewürzanbau an Jatropha. Das Ergebnis der multinominalen logistischen Regression zeigt, dass Human- und Geldkapital, Transaktionskosten sowie institutionelle Faktoren die Unterschiede der Lebensgrundlagen erklären. Das Ergebnis dieser Regression hilft geeignete Interventionen zu entwickeln, um die Lebensgrundlagen des ländlichen Tansanias zu verbessern.

Die drei identifizierten Gruppen wurden weiterhin in der Erstellung einer „Social Accounting Matrix" (SAM) auf Dorfebene verwendet, beschrieben in Kapitel 5. Das Ziel der SAM ist die Bewertung von Einkommensmultiplikatoren potenzieller Bioenergiepflanzen wie *Jatropha curcas*, Maniok und Zuckerrohr für ländliche Haushalte. Umweltkonten für Feuerholzextraktion sind miteinbezogen als Referenz zur Beurteilung der Effekte. Diese Umweltkonten dienen der Beurteilung, inwieweit die einzelnen Haushaltsgruppen nachhaltig Feuerholz nutzen und ob eine zusätzliche Nachfrage von Biomassenpflanzen den Druck auf die vorhandenen Baumressourcen mindern könnte. Dafür wurden die Umweltkonten nach der Herkunft des Feuerholzes differenziert: Private Agroforstwirtschaft und Holz von öffentlichen Flächen wie z.B. staatliche Waldgebiete. Die Ergebnisse der Multiplikatoranalyse zeigen, dass der höchste Einkommenseffekt durch Agroforstwirtschaft erzielt wird, welche den Haushalten zur Generierung von Früchten und Feuerholz dient. *Jatropha curcas*, Zuckerrohr und Maniok erzielen in abnehmender Reihenfolge geringere Einkommenseffekte im Vergleich zu privater Agroforstwirtschaft. Bäume, die keine Früchte als Lebensmittel erzeugen, mindern auch den Druck auf natürliche Baumressourcen im Untersuchungsgebiet.

In Kapitel 6 wird ein Gleichgewichtsmodell auf Dorfebene angewendet, um die Auswirkungen alternativer Ressourcennutzung auf lokale Einkommensverteilungen zu analysieren. Die Untersuchung basiert auf einem Datensatz aus dem Kakamega Distrikt in Kenia erhoben durch das „Biodiversity Monitoring Transect Analysis" (BIOTA-Projekt) in 2006. Die Ergebnisse zeigen einen wichtigen Punkt in der Diskussion um Jatropha auf: Ohne politische Programme, die auf die Verteilung von Einkommen achten, können soziale Nachhaltigkeitsziele innerhalb einer dörflichen Volkswirtschaft nicht erreicht werden. Zusätzliche monetäre Gewinne durch Jatropha Produktion werden nur durch die schon begünstigten reicheren Haushalte erzielt.

Kapitel 7 analysiert die Determinanten des Rapsölimportes nach Europa zur Produktion von Biodiesel. Die sektorspezifische Analyse bezieht die Nachfrage nach Vorleistungen mit ein, um die Auswirkungen von verschiedenen Politik- und Handelsinstrumenten auf den Import zu beurteilen. Als Analysemethode wird das „Gravity Modell“ angewendet. Als ökonometrische Schätzmethode wird das Heckman Modell verwendet. Zusätzlich wurden räumliche Gewichte und multilaterale Handelsbewegungen miteinbezogen, um Cluster-Wirkungen zu berücksichtigen. Die Ergebnisse zeigen, dass verbindliche Beimischungsquoten von Biodiesel signifikant positive Auswirkungen auf den Import von Rapsöl haben. Im Gegensatz dazu haben Subventionen im Bereich der Investitionen in Bioenergieproduktion keinen Effekt. Der einheitliche Außenzoll hat keine negativen Auswirkungen auf den Import. Im Gegenteil, Länder außerhalb der Europäischen Union (EU) exportieren signifikant mehr Rapsöl in die EU im Vergleich dazu, wenn beide Handelspartner EU-Mitglied sind. Das Model verwendet Sekundärdaten erhoben von verschiedenen statistischen Datenbanken wie z.B. der Weltbank, FAO, EuhelpDesk und CIA Factbook.

Keywords: Bioenergie, Nachhaltigkeit, Wertschöpfungskettenanalyse, Lebensunterhaltstrategien, Umwelt, Agroforstwirtschaft, Tansania

Abstract

In recent years, many developed and developing countries emphasized the support for the production and utilization of biofuels in their political agenda (Butterbach-Bahl and Kiese 2013). Biofuels comprise of woodfuels and agrofuels. Woodfuels include bioenergy originating from trees and shrubs grown on forest and non-forest land. Agrofuels include fuel crops for liquid bioenergy production. Examples of fuel crops are oil and starchy crops such as canola, oil palm, maize, and sugarcane (FAO 2004). The two main drivers of biofuels are Governments aimed at becoming more independent from fossil fuels due to strong fluctuations of crude oil prices on the one hand, and reducing emissions of greenhouse gases on the other hand (Florin and Bunting 2009). Sub-Saharan Africa is argued to be a suitable continent for producing and exporting the necessary biomass to Europe. Studies estimated a large percentage of arable land, which is currently not used for agriculture (Smeets et al. 2007). Moreover, the production potential of developing countries near to the equator is significantly higher than that of countries in more temperate climates such as Europe (Landeweerd et al. 2012). Energy supply is considered a cornerstone for economic development particularly in developing countries. From the perspective of developing countries, governments view biofuels also as an opportunity to reduce the dependence on imported fuels, to stimulate economic growth through generating new job opportunities, and hence to increase households' income (Arndt et al. 2011). However, the production of biofuel crops is also viewed as a threat to food security and potentially leads to land grabbing especially in developing nations where food supply is often insufficient (Maltsoglou et al. 2013).

The overall objective of this thesis is to analyse bioenergy value chains focussing on energy production, consumption and trade patterns from the perspective of developing countries in Sub-Saharan Africa using the example of Tanzania. The specific objectives are: (1) to provide a review on the current methods on value chain analysis in the context of environment and trade, which can be applied to analyse the bioenergy value chain, (2) to explore the firewood extraction behaviour from agroforestry and its impact on household income of rural small-scale farmers in Tanzania, (3) to study the integration of *Jatropha curcas* utilized as a host plant for vanilla and black pepper in rural livelihoods of Tanzanian households, (4) to evaluate the multiplier effects of different bioenergy crops on household income referenced by the agroforestry sector, (5) to assess the feasibility of *Jatropha curcas* cultivation, used for bioenergy production, as a substitute for firewood collection from the global commons, and

(6) to analyse the determinants of canola oil trade when used as input for the biodiesel production within the European Union.

The review of existing literature on on-going developments of value chain analysis in the context of environment and trade is discussed in chapter 2 building the basis of the thesis.

Chapters 3, 4 and 5 belong to a Tanzanian project on the evaluation of rural bioenergy production and consumption patterns. The data basis of the analyses is a cross-sectional data-set collected from a household survey in Tandai village belonging to the Morogoro District in Tanzania in 2010. A random sampling technique was applied to select representative sample households. In total, 314 households out of 1013 were selected and interviewed. The village borders a forests reserve, which is characterized by a very high degree of biodiversity. The study region belongs to a sub-catchment of the northern Uluguru Mountains in Tanzania, which supplies the Dar es Salaam region with drinkable water. Historically, the surrounding forests have been heavily fragmented and depleted by local farmers converting forest into farmland, cutting firewood and harvesting timber. Consequently, the forest area was announced as a governmental forest reserve, which is protected by the highest level since 2002. From the early 2000s, private agroforestry has been promoted to supply the farmers with the required firewood, timber and food among others. Jatropha was already introduced into the study area in the 1950s. Nowadays, it is cultivated to serve as a supporting tree for vanilla and black pepper plants, which gained importance as profitable cash crops in the last years. In the past, other tree species such as jackfruit, African mahogany, breadfruit, mango, and teakwood trees were utilized as supporting trees; a few households still grow black pepper on these species. However, Jatropha – now used as a supporting tree - has a relatively low height compared to the aforementioned species. Villagers reported a significant decline of serious accidents during harvesting seasons due to the switch to Jatropha trees due to the natural small height of Jatropha trees.

In the third chapter, the relevance of agroforestry on small-scale farmers’ plots has been explored. We developed an indicator that compares the natural growth rate of own trees with its harvest rate. A logistic regression showed that land property rights and environmental awareness increase the likelihood of sustainable agroforestry practices. Empirical evidence from a quantile regression proved that the poorest households generate higher incomes with unsustainable extraction behaviour whereas wealthier households generate lower incomes.

Furthermore, the role of *Jatropha curcas* as part of small-holders’ income activities has been explored. Therefore, the typical livelihood strategies were of interest. Three different livelihood strategies were identified: [1] “subsistence farming households combined with unskilled wage employment”, [2] “farming households highly specialized in cash crop production”, and [3] “farming households specialized in cash crop production combined with skilled off-farm employment”. While households from Cluster [3] are better-off, those from Cluster [1] are the poorest. The income from cultivation of Jatropha/Spices is significantly higher for the third cluster. However, for poorer households of Cluster [1], the share of income from Jatropha/Spices is relatively high, up to 30% of household income. The result of the multinomial logit regression analysis identifies human and financial capital, transaction costs and institutional factors as helping to explain the differences in livelihood portfolios. The results of the regression help in shaping and targeting interventions to improve livelihoods of the rural poor in Tanzania.

These three derived clusters were used to develop the environmental extended Social Accounting Matrix (ESAM) on village level described in chapter 5. The objective of this SAM is to evaluate, how recently discussed bioenergy crops such as *Jatropha curcas*, cassava, and sugarcane affect households’ income. Environmental accounts for firewood extraction are included as a reference point on a village level. The environmental accounts are used to explore, whether the current firewood extraction is sustainable and whether an additional demand of other bioenergy crops would lessen the pressure on wood deposits in the case study region. Regarding the firewood sources, the model differentiates between private agroforestry and public areas are. Findings of the multiplier analysis indicate that the highest household income effect derives from trees, which the households use as a source of firewood and fruits for sale or home consumption, followed by *Jatropha curcas*, sugarcane and finally cassava. The non-food tree cultivation activities were also found to significantly ease the pressure on wood deposits (private and public) in the study area.

In chapter 6, a mathematical model is applied to analyse the impact of alternative resource management options on local income distribution. The study is based upon a data set from the Kakamega District in Kenya collected for the Biodiversity Monitoring Transect Analysis (BIOTA-Project) in 2006. The model outcome reveals a crucial aspect claimed by critics of the Jatropha system: Without distributional policy programs, social sustainability targets will not be realized within the village economy. Benefits will be realised by the already advantaged households.

Chapter 7 concentrates on the determinants of European imports of canola oil as an input for biodiesel production. The focus is on two aspects: (1) the role of different policy instruments

which are supposed to strengthen the European biodiesel industry and (2) whether there is a trade inhibiting effect for non-European countries due to tariff and non-tariff barriers. A gravity model is applied using the Heckman approach because of zero-inflated trade data, as well as spatial weights and Anderson and Van Wincoop's controls for multilateral resistance. The findings show that while the mandatory biodiesel blending quota has a significant positive impact on the import of canola oil, investment subsidies cannot be shown to have any effect. Furthermore, trade integration among EU member countries even has a trade inhibiting effect, since non-EU countries export significant more to the EU compared to EU countries. The latter result can be explained by a probably exhausted domestic European market for canola oil used for biodiesel production. The trade model uses a secondary data set collected from several data bases including from the World Bank, FAO, EUhelp-Desk, and CIA Factbook.

Keywords: Bioenergy, sustainability, value chain analysis, livelihood strategies, environment, agroforestry, Tanzania

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List of Abbreviations

BEAF	Advisory Service on Agricultural Research for Development
CF	Carbon Footprint
CGE	Computable General Equilibrium Model
cm^3	cubic centimetre
CO_2	Carbon Dioxide
e.g.	for example
Eds.	Editors
ESAM	Environmental extended Social Accounting Matrix
et al.	et alii
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistics
FQD	Fuel Quality Directive
GDP	Gross Domestic Product
GIZ	German Society for International Cooperation
GTZ	German Society for Technical Cooperation
ha	hectare
HH	Household
IMR	Inverse Mill's Ratio
IOA	Input-Output Analysis
kg	kilogram
m	meter
NGO	Non-Governmental Organization
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square Model
RED	Renewable Energy Directive
SAM	Social Accounting Matrix
TAC	Transaction Costs
TZS	Tanzanian Shilling
UN	United Nations
UN-REDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation
VCA	Value Chain Analysis

1 The Relevance of Bioenergy in the Economy

1.1 Background and Problem statement

In recent years, many developed countries emphasized the production and utilization of biofuels[1] in their political agenda (Butterbach-Bahl and Kiese 2013). This new interest in biofuels was mainly caused by the attempt to become more independent from fossil fuels due to strong fluctuations of crude oil prices and reducing emission of greenhouse gases (Florin and Bunting 2009). Hence, the EU set mandatory quotas introduced by the Biofuel Directive 2003/30/EC, to encourage the use of biofuel within the European transport sector: 2% by the end of 2005, 5.75% by 2010 and 10% by 2020 (Schnepf 2006, Lamers et al. 2011). The biofuel directive targets mainly the use of biofuels in the transport sector (Firrisa et al. 2013) since the transport sector consumes one third of the entire EU energy demand and is responsible for 25% of European greenhouse gas (GHG) emissions (Linares and Perez-Arriaga 2012).

With these market stimulating factors, Europe has quickly become the world's most important producer of biodiesel (Timilsina and Shrestha 2011). In the EU, the majority of biofuel feedstock is canola oil because of its chemical constitution for the transport sector; others are palm oil and soy (Lamers et al. 2011, Firrisa et al. 2013). However, Landeweerd et al. (2012) concluded that the EU will not be able to domestically produce the entire biomass needed for biodiesel. Therefore, additional canola oil needs to be imported. Indeed, the import volume of canola oil is smaller compared to other vegetable oils such as palm oil, though its relevance for the European biodiesel sector is significant (Lamers et al. 2011). Trade data from FAOStat (2013) showed an increase of canola oil imports in the past, which can be partly assigned to the EU, especially in the period between 2003 and 2006, where the biodiesel production in Europe soared.

Sub-Saharan Africa is argued to be a suitable continent for producing and exporting the necessary biomass to Europe. Studies estimated a large percentage of arable land, which is currently not in use for agriculture (Smeets et al. 2007). Moreover, the production potential of developing countries nearer to the equator is significantly higher than that of countries in more temperate climates such Europe (Landeweerd et al. 2012).

[1] Biofuels comprise woodfuels and agrofuels. Woodfuels include bioenergy originating from trees and shrubs grown on forest and non-forest land. Agrofuels include fuel crops for liquid bioenergy production. Fuel crops are e.g. oil and starchy crops such as canola oil, palm oil, maize, and sugar (FAO 2004).

With the growing international demand of biofuel, biomass production was required to meet a high standard of sustainability covering social, environmental and economic concerns if processed for biofuels. In the EU, environmental sustainability targets have been included in the Renewable Energy Directive (RED) and Fuel Quality Directive (FQD), respectively. The targets comprise minimum GHG savings and the condition that biofuels are not to be grown from land with a high degree of biodiversity or high carbon stocks (Linares and Perez-Arriaga 2012, Butterbach-Bahl and Kiese 2013).

From the perspective of developing countries, governments view biofuels also as an opportunity to reduce the dependence on imported fuels, to stimulate economic growth through generating new job opportunities, and hence to increase households' income (Arndt et al. 2011). However, the production of commodities for biofuels is also viewed as a threat to food security due to indirect competition for water, land and other production inputs; especially in developing countries where food supply is often inadequate (Maltsoglou et al., 2013, Bonin and Lal 2012, Wedin et al. 2013). Furthermore, biofuel production could lead to land grabbing (Duvenage et al. 2012).

Tanzania is considered as a major forerunner in attracting bioenergy initiatives since adequate domestic energy supply is scarce (Romijn and Caniëls 2011). Over the last years, Tanzanian domestic energy needs have grown rapidly due to both the increase in economic activities and population growth (Cleaver et al. 2010). Basic biomass-based fuels particularly charcoal, firewood and crop residues contribute 90 per cent of the energy supply (Mshandete 2011). The remaining energy sources are fossil fuels (6.6 per cent), gas (1.5 per cent), hydro (0.6 per cent), and coal and peat (0.2 per cent) (Cleaver et al. 2010). Tanzania imports transport fuels because it does not own any oil deposits (Amigun et al. 2008).

To develop a political framework, Tanzania established a Bioenergy Task Force in 2006, which drafted a set of biofuel guidelines by 2010 (Romijn and Caniëls 2011, Arndt et al. 2011). Tanzania's national energy policy aims at ensuring both a sustainable energy supply and security, as well as supporting environmental protection activities such as public forests (Mshandete 2011). At this point of time however, the economic and environmental implications of increased investment in biofuel is relatively unexplored such as the income effects on macro and micro level as well as its environmental impact (land use change, CO^2 neutrality) (Romijn and Caniëls 2011).

Deforestation is a predominant problem in Tanzania. Forest losses at the regional level amount to 1 per cent per year between 2005 and 2010 (World Bank 2011), which is very high compared to the African continent (Godoy 2011). To counteract this trend, the Tanzania Forest Act emphasizes priority on conserving and managing natural forests (United Republic of Tanzania, 2002). The protection of forests aims to limit deforestation and simultaneously improving carbon sequestration and storage promoted by international frameworks such as United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD) (Sedjo 2012). Currently, Tanzania is one of nine pilot countries for the UN-REDD Programme (Burgess 2010).

Furthermore, a World Bank Study emphasised the importance of forest income for the rural poor (Vedeld et al. 2004). In order to cushion smallholders’ income losses arising from forest protection, agroforestry is promoted to complement the national reforestation strategy of the Tanzanian government (Sonwa et al. 2011). The National Agroforestry Strategy initiated in 2004 promotes agroforestry technologies to improve the livelihoods of resource-poor households (NASCO 2006). In fact, agroforestry has increasingly become part of the production portfolio of many small-scale farmers in the last decade (Pretty 2008, Mercer 2004).

Agroforestry has various benefits for farmers such as firewood, timber but also supplementary income possibilities from tree crops (Nair 2007). In addition, agroforestry is a promising solution to alleviate soil erosion on agricultural plots and hence helps to stabilize or even improve yields (Nair 2007, Gebreegziabher et al. 2010). Overutilization of agroforestry systems, associated with the decline of tree stocks, may weaken the positive impact on soil fertility, food production, firewood and timber availability, and thus farmers’ income in rural areas. In Tanzania, however, Schwartz et al. (2002) raised serious concerns about the long-term viability of tree systems given current tree harvest rates.

In parallel to efforts in the agroforestry sector, renewable bioenergy crops have also become the focus of interest for the Tanzanian government, especially *Jatropha curcas*. From its chemical constitution, the Jatropha meets the quality standards of canola oil and can be easily converted into biodiesel (Duraes 2011), which therefore makes it relevant to the European biodiesel market. However, there is potential for a more limited role of cassava, sugarcane and sunflower oil in biofuels. The only thing, what is missed currently is the analysis taking an appropriate reference point which is in sub-Saharan Africa wood production for firewood and charcoal.

In order to target specific households for policy interventions, for example the poorest in a specific area, the framework of livelihood strategies is a suitable method. It is increasingly applied to explore how households adapt to long-term shocks due to variable climate conditions (Morton 2007). A recent study from FAO (2010a) reported that bioenergy production of *Jatropha curcas* improves Tanzanian households' welfare if small-scale farmer are engaged in the production schemes as outgrowers. Others found that Jatropha production is not economically viable if the plant is cultivated in monoculture (GTZ 2009). Furthermore, it has been established that high seed yields can only be reached with high levels of inputs including labour, fertilizer, water and pesticides on fertile soils (Wahl et al. 2009, Segerstedt and Bobert 2013). The most attractive option suggested is to grow Jatropha as a fence based on low input use (GTZ 2009, Wahl et al. 2009). The largest welfare gains are reported for low-income households since intercropping of food crops and Jatropha is assumed to increase the yield of food crops and the engagement of more small-scale farmers compared to monoculture (Arndt et al. 2010). In this context, the GTZ concluded from its meta-analysis of *Jatropha curcas* for Tanzania that it "[…] could be a complementary component of a diverse livelihood strategy that contributes to overall increased agricultural productivity" (GTZ 2009 p.9). For Malawi, Mponela et al. (2011) found that poor households are more likely to cultivate Jatropha trees compared to wealthier households, although the crucial factor was labour availability. Poorer households were less frequently engaged in off-farm employments than higher income households enabling them simultaneously cultivate Jatropha (Mponela et al. 2011). Van Eijck et al. (2012) found that low input systems with family labour as the major production input increases the economic viability of *Jatropha curcas* implying no labour costs within the cost-benefit analysis.

Agriculture-based economic growth has the largest impact on reducing poverty rates compared to non-agriculture growth (IFPRI 2012). In Tanzania, the agricultural sector accounting for 25 per cent of GDP employs 80 per cent of the workforce (Kaliba et al. 2008) and generates more than 50 per cent of the total export earnings (Arndt et al. 2011, Kaliba et al. 2008). Around 81 per cent of households living below the poverty line are rural households being mainly engaged in agriculture (Cleaver et al. 2010). Hence, biofuel-crops are expected to provide new income possibilities for rural farmers, particularly, adequate energy supply services are lacking (Eijck and Romijn 2008). Biofuel crops may also lessen the pressure on public forests due to new energy sources, which may substitute firewood (Arndt et al. 2011).

Recent studies addressed the question of income generation from the national perspective showing that large-scale production of feedstock generates larger gains in agricultural GDP than smallholder outgrower production schemes (Arndt et al. 2012; FAO 2010b). However, the findings indicate that lower-income households benefit more under smallholder than large-scale schemes in terms of household welfare (Arndt et al. 2012). Overall, decentralized bioenergy crop production has been evaluated as being pro poor since it offers increased market access and income diversification strategies for the rural population (Arndt et al. 2010). Associated with the additional marketing possibilities, the associated economic multipliers are expected to be high especially for energy net-importing countries, such as Tanzania (Domac et al. 2005, Malik et al. 2009). However, the magnitude of the economic multipliers especially for poor households is assumed to vary regionally depending on crops and production and consumption pattern (Domac et al. 2005). It is therefore crucial that governments in countries such as Tanzania understand which economic multipliers are caused by proposed biofuel policies (e.g. supporting specific feedstock) to achieve national development objectives (Arndt et al. 2012).

One particularly relevant method to further analyse the impacts of bioenergy is value chain analysis. In general, the common value chain analysis focuses primarily on the calculation of the value-added and its distribution among value chain actors (Faße et al. 2011). Along with the internationalization, the need of analysing linkages to up- and downstream value chain stages has been highlighted. Thus, the spatial range of value chains has expanded considering both the local and global scale. Natural resource management is strongly associated with economic production emphasising the importance of integrating both in the VCA approach. Hence, the consideration of value chain effects on the environment demands additional evaluation methods to include environmental costs and benefits or physical flows of natural resources (Faße et al. 2011). Thereby, former economic as well as socio-economic value chain tools were enhanced to integrate environmental dependencies - monetary or physical.

1.2 Research Objectives

The overall objective of this thesis is to analyse different parts of the bioenergy value chain focussing on production, consumption and trade patterns from the perspective of developing countries in Sub-Saharan Africa using the example of Tanzania. The specific objectives of this thesis are as follows:

1. To review the recent developments in applying value chain analysis in the context of environment and trade.
2. To explore the economic relevance of sustainable agroforestry practices in rural Tanzania.

3. To study the role of *Jatropha curcas* cultivation in livelihood strategies of small-scale farmers.
4. To analyse the influence of bioenergy crops on the rural development based on an environmentally extended Social Accounting Matrix on village level.
5. To assess the feasibility of *Jatropha curcas* cultivation for bioenergy production as a substitute for firewood collection in the forests.
6. To analyse the determinants of canola oil trade used as the most important input for the biodiesel production within the European Union.

1.3 Structure of the Dissertation

This dissertation is organized in seven chapters, where each chapter presents one article with the exception of chapter 1, which represents the introductory part of the whole thesis. Table 1 provides an overview of the included articles.

Chapter 2 presents an article reviewing the methodologies, which are currently applied in the framework of value chain analysis (VCA) in the context of environment and trade (Faße et al. 2011). These summarized methods show that VCA cannot be equated with a single approach; it is rather a comprehensive concept representing a field of different approaches. Many conceptual handbooks on VCA have been published; however, hardly any summary of quantitative measures in the field of VCA is available. This paper provides a systematic overview of different accounting methodologies related to VCA considering the environmental developments. It is based on a critical review of up-to-date literature from different disciplines. The methods included are (1) Value chain mapping; (2) financial VCA by calculating the value added, (3) national accounting tools and Social Accounting Matrices and its environmental extensions followed by Computable Equilibrium Models, and (4) environmentally oriented methods based on physical accounting (Faße et al. 2011).

Chapter 3 discusses the economic relevance of sustainable agroforestry practices in Tanzania (Faße and Grote, 2013a). The total sample size is 314 rural households. The article evaluates the share of households extracting firewood sustainably from the point of a developed indicator. A Logistic regression is applied to explore the determinants of sustainable agroforestry practices. Here, the findings suggest that property rights regarding the ownership of agricultural land and environmental awareness increase the likelihood of sustainable firewood extraction.

Chapter	Authors	Title	Published in / Submitted to / Presented at
2	Faße, A., Grote, U. and E. Winter (2011)	Recent Developments in Applying Environmental Value Chain Analysis	Published in: Environmental Economics, Vol. 2 (3), pp. 74-86.
			An earlier version is published as Discussion paper No. 429, 2009. Institute for Environmental Economics and World Trade, Leibniz University of Hannover. URL: http://www.wiwi.uni-hannover.de/2583.html.
3	Faße, A., Grote, U. (2013)	The Economic Relevance of Sustainable Agroforestry Practices – An Empirical Analysis from Tanzania	Published in: Ecological Economics, Vol. 94, pp. 86-96. DOI: 10.1016/j.ecolecon.2013.07.008
			Contributed paper at the 28th IAAE 2012 Conference 'The Global Bio-economy', Foz Do Iguacu, Brazil, August 18-24, 2012. URL: http://ageconsearch.umn.edu/bitstream/126666/2/Agroforestry.pdf
			Contributed paper at the International Farming Systems Association Symposium, 2012, Aarhus, July 1-4, 2012.
			Contributed paper at the Tropentag 2011, Bonn, Oct. 5-7. 2011. URL: http://www.tropentag.de/2011/abstracts/links/Faszlige_BZeYS4wx.php
4	Faße, A., Grote, U. (2013)	The role of cultivation in Livelihood Strategies of small-scale households in rural Tanzania	Published in: Regional Environmental Change, Special Issue, DOI: 10.1007/s10113-013-0494-7.
			Presented at Tropentag 2012, University of Göttingen, September 19 - 21, Göttingen - Kassel/Witzenhausen. URL: http://www.tropentag.de/2012/abstracts/links/Owolabi_br1UZRZg.php
5	Faße, A., Winter, E. and Grote, U.	Bioenergy and Rural Development: Applying an Environmentally Extended Village SAM to Tanzania	Under Review in the Journal: "Ecological Economics".
			Contributed paper at the PEGNet Conference 2013, University of Copenhagen, October 17-18, Denmark.
6	Winter, E., Faße, A. (2009)	Food security, Energy Equity, and the Global Commons: A Computable Village Model applied to sub-Saharan Africa	Contributed paper at the 27th IAAE 2009 Conference, Beijing, China, August 16-22, 2009. URL.: http://ageconsearch.umn.edu/handle/51683
			Winter, E., Faße, A. and K. Frohberg (2008): Management Options of Conserving the Kakamega Tropical Rainforest: a game-theoretic village modelling approach. Contributed paper at the International Society for Ecological Economics. 7-11 August 2008, Nairobi, Kenya.
			Winter, E., and K. Frohberg (2008). Management Options of Conserving the Kakamega Tropical Rainforest: a game-theoretic village modelling approach. Paper presented at the ecomod conference, 2-4 July, Berlin, Germany.
			Winter, E. (2009). Food Security, Energy Equity, and the Global Commons: a Computable Village Model applied to sub-Saharan Africa. Paper presented at the EAERE, June 24-27, Amsterdam, NL.
7	Röttgers, D., Faße, A. and U. Grote (2010)	The Canola Oil Industry and EU Trade Integration: A Gravity Model Approach	Proceedings of the German Development Economics Conference, Hannover, No. 32, Verein für Sozialpolitik. URL: http://www.econstor.eu/bitstream/10419/40018/1/306_roettgers.pdf
			Faße, A. and D. Röttgers (2009). An Analysis of EU Canola Oil Trade for Biodiesel: A Gravity Model Approach. Paper presented at the International Conference on Applied Business Research (ICABR), Sep 21 - 25, Ravello, Italy.
			Faße, A., Grote, U. and D. Röttgers (2009). Analysing the EU Canola Oil Trade with Developing Countries: A Gravity Model Approach. Paper presented at Tropentag, October 6 – 9, Hamburg, Germany. URL: http://www.tropentag.de/2009/abstracts/full/283.pdf
			Röttgers, D., Faße, A. and U. Grote (2012). The Canola Oil Industry and EU Trade Integration: A Gravity Model Approach". Proceedings of the International Annual Conference of the German OR Society, September 4 – 7, Hannover, Germany.

Note: On the project website www.better-is.com under the information system are condensed reports of chapter 3-5 among others available.

Table 1: List of papers included in the dissertation

Additionally, empirical evidence from the quantile regression shows that poorest households generate higher income if they extract firewood unsustainably. Thus, the poor smallholders are likely to increase environmental degradation to achieve more income in the short run resulting in income losses in the long run (Faße and Grote, 2013a).

Chapter 4 presents a paper exploring the role of *Jatropha curcas* in the livelihood strategies of rural small-scale farmers in Tanzania (Faße and Grote, 2013b). The results help in shaping and targeting interventions to improve livelihoods of the rural poor in Tanzania. The paper relies on the same data base as Chapter 3. In the case study village, *Jatropha curcas* is currently not utilized as a bioenergy plant, but as a supporting plant for spice production of vanilla and black pepper. The study uses cluster analysis to identify different livelihood strategies, and how the Jatropha tree is incorporated into these different strategies. The results show that Jatropha plays a niche role, however for certain households it serves as important host plant for increasing spice production (up to 30% of total income composition in the case study region). Finally, multinomial logit regression analysis identifies human and financial capital, transaction costs and institutional factors explaining differences in livelihood portfolios (Faße and Grote, 2013b).

Chapter 5 consists of an article developing an environmental extended Social Accounting Matrix (ESAM) on village level. The paper aims at analysing the economic multipliers for several bioenergy crops on household income. This village SAM includes two aspects, which have been not considered in a village SAM framework, yet: (1) Inclusion of *Jatropha curcas* as a host plant for spices upgraded with harvest activities for oil seeds. (2) Firewood production activities from public and private tree stock resources. Findings of the multiplier analysis indicate that the highest household income effect is derived from trees which the households use as a source of firewood and fruits for sale or home consumption, followed by *Jatropha curcas*, sugarcane and finally cassava. The non-food tree cultivation activities have been also found to significantly release the pressure on wood deposits (private and public) in the study area.

Chapter 6 presents the development of a computable village model to analyse the impact of alternative resource management options on the income distribution of rural households using the example of *Jatropha curcas* as a substitute for firewood (Winter and Faße 2009). The analysis has been applied to the Kakamega District of Western Kenya. The findings of the model indicate the importance of forest income for the rural poor. Sustainable utilisation of public forest resources will not be feasible unless alternative energy systems have been integrated into the village economy. The model outcome validates a crucial aspect of the *Jatropha* system: Without distributional policy programs, social sustainability targets will not be realized within the village economy. The additional profits due to Jatropha cultivation will be received by rather prosperous households, while forest conservation policies will significantly increase labour time of poor families (Winter and Faße 2009).

Chapter 7 concentrates on the determinants of European imports of canola oil as an input for biodiesel production (Röttgers et al. 2010). The focus is on two aspects: (1) the role of different policy instruments which are supposed to strengthen the European biodiesel industry and (2) whether there is a trade inhibiting effect for non-European countries due to tariff and non-tariff barriers. A gravity model is applied using the Heckman approach because of zero-inflated trade data, and spatial weights and Anderson and Van Wincoop's controls for multilateral resistance. The findings show that while the mandatory biodiesel blending quota has a significant positive impact on the import of canola oil, investment subsidies cannot be shown to have any effect. Furthermore, trade integration among EU member countries even has a trade inhibiting effect, since non-EU countries export significant more to the EU compared to EU countries. The latter result can be explained by a probably exhausted domestic European market for canola oil used for biodiesel production.

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Note:

The contribution of the authors to the submitted articles is as follows: The data collection, literature review, all calculations and drafting the text have been done by Faße unless noted otherwise. The contribution of Grote can be defined as: overall supervision, providing suggestions and guidance on methods, results and general contents; as well as thorough editing. The contribution of Winter in chapter 5 is restricted to the guidance of developing the social accounting matrix. In chapter 6, Winter provided the primary data set and was responsible of programming and simulating the village model; both authors were involved in collecting secondary data, discussing the results and writing the paper in equal shares. Regarding chapter 7, Röttgers and Faße collected the secondary data, estimated the model and wrote the paper in equal shares.

2 Recent Developments in Applying Environmental Value Chain Analysis

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4 The Role of *Jatropha curcas* Cultivation in Livelihood Strategies of Small-scale Households in Rural Tanzania

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5 Bioenergy and Rural Development: Applying an Environmentally Extended Village SAM to Tanzania

Abstract

For a rural village in Tanzania, an Environmentally Extended Social Accounting Matrix (ESAM) at the village level is developed. The objective of this ESAM is to evaluate, based on a multiplier analysis, how the recently discussed bioenergy crops *Jatropha curcas*, cassava, and sugarcane affect the income of households. As a reference point, environmental accounts for changes in tree stocks are included to explore whether the current firewood extraction is sustainable, and whether an additional demand of these bioenergy crops would lessen the pressure on wood deposits in the case study region. Regarding tree stocks, private agroforestry with food and non-food trees as well as public forestry areas are distinguished. Findings indicate that the highest household income effect comes from agroforestry in which the households use Trees as a source of firewood and fruits for sale or home consumption, followed by *Jatropha curcas*, sugarcane and finally cassava. The non-food tree cultivation activities have been also found to release the pressure on wood deposits (private and public). However, although agroforestry is part of the agriculture system, the local firewood extraction rate is found to be unsustainable compared to current natural growth rates of trees. The multiplier results support further promotion of agroforestry systems to achieve a sustainable system of generating income from selling wood and fruits, consuming energy and lessen the pressure on public forest resources.

Keywords: Social Accounting Matrix, multiplier analysis, agroforestry, forest, bioenergy, village economy

5.1 Introduction

Considerable debate exists about potential trade-offs from establishing bioenergy production activities in developing countries (Karp and Halford 2010). Governments in developing countries regard bioenergy as an opportunity to reduce the dependence on imported fuels, to stimulate economic growth through generating new job opportunities, and hence to increase households' incomes. However, the production of biomass for biofuel production is also viewed as a threat to social and environmental sustainability, as well as food security especially, where food supply is often inadequate (Maltsoglou et al. 2013).

In recent years, Tanzanian domestic energy needs have rapidly grown due to both the increase in economic development and population growth (Cleaver et al. 2010). Basic biomass-based fuels, particularly charcoal, firewood and crop residues, dominate the energy supply with 90 per cent of total use (Mshandete 2011). The remaining energy consumption is composed of fossil fuels (6.6 per cent), gas (1.5 per cent), hydropower (0.6 per cent), and coal and peat (0.2 per cent) (Cleaver et al. 2010, FAO 2010b). Tanzania imports fossil fuels because it does not own any oil deposits (Amigun 2008). An adequate energy supply is lacking (van Eijck and Romijn 2008). Its national energy policy aims at ensuring both a sustainable and secure energy supply, as well as supporting environmental protection activities (Mshandete 2011). To ensure this sustainable energy supply, two major strategies for the agricultural sector are promoted: (a) bioenergy initiatives such as *Jatropha curcas*, sugarcane, cassava, and sunflower oil and (b) agroforestry.

Agriculture-based economic growth has the largest impact on reducing poverty rates compared to non-agriculture growth (IFPRI 2012). In Tanzania, the agricultural sector accounts for 25 per cent of GDP, employs 80 per cent of the workforce, and generates more than 50 per cent of the total export earnings (Kaliba et al. 2008). Around 81 per cent of the households living below the poverty line are rural households where the main activity is agriculture (Cleaver et al. 2010). Hence, biofuel-crops are expected to provide new income possibilities for rural farmers (Arndt et al. 2011) and lessen the pressure on public forests due to new energy sources, which may substitute firewood. Tanzania is considered as a major forerunner in attracting national and international bioenergy investments since adequate energy supply is scarce (Romijn and Caniëls 2011).

Arndt et al. (2012) and FAO (2010b) addressed the question of income generation from the national perspective showing that large-scale production of bioenergy crops may generate larger increases of agricultural GDP than production through smallholder schemes. Differentiated by the income level of households, the results indicate that lower-income households benefit more under smallholder than large-scale schemes in terms of household welfare than high-income households (Arndt et al. 2012). Overall, decentralized bioenergy crop production has been evaluated as being pro poor since it offers increased market access and income diversification strategies for the rural population (Arndt et al. 2010). Associated with the additional marketing possibilities, the associated economic multipliers are expected to be high especially for energy net-importing countries, such as Tanzania (Domac et al. 2005, Malik et al. 2009, Amigun 2008). However, the magnitude of the economic multipliers especially for poor households is assumed to vary regionally depending on crops and production and consumption pattern (Domac et al. 2005). It is therefore crucial that governments in countries such as Tanzania understand which economic multipliers are influenced by proposed biofuel policies (e.g. supporting specific feedstock) to achieve national development objectives (Arndt et al. 2012).

No study is known to the authors, which quantify and compare the economic multipliers for several potential bioenergy crops including firewood at a household level (see also Allan, 2011). Therefore, we developed a Social Accounting Matrix (SAM) at the village level to apply a multiplier analysis. We extended the village SAM by natural resource accounts comprising firewood production as the major reference point for rural energy production and consumption. The case study area is characterized by two firewood sources: a) private agroforestry including food and non-food trees and b) public areas including community and governmental forest as well as trees on scattered communal land. We analyse the following two questions. First, which of the cultivated crops suitable for bioenergy is most pro poor in terms of income compared to agroforestry? Second, which of these crops release the pressure on wood deposits (private and public) in the study area? In terms of relevant food crops, income multipliers for cassava, maize and rice are included.

The remainder of the paper is structured as follows: the section 5.2 reviews the empirical literature on the economic impact of renewable energy. Section 5.3 briefly describes the underlying data and the SAM framework applied in this study. The empirical results are presented in section 5.4 including the discussion; section 5.5 finally concludes.

5.2 Economic Impact of Renewable Energy

In the years around 2005, Tanzania attired to attract international biofuel investors. Along with this bioenergy hype, Tanzania established a Bioenergy Task Force in 2006, which drafted a set of biofuel guidelines in 2010 (Romijn and Caniëls 2011). Without formal legislation, biofuel producers in Tanzania can only produce for export markets despite high transport costs and considerable demand for alternative fuels (Arndt et al. 2011). However, at this point of time, the economic and environmental implications of these investment activities were quite unexplored such as the income effects on macro and micro level as well as its environmental impact (land use change, CO_2 neutrality) (Romijn and Caniëls 2011).

Amidst this situation, the GTZ (2005) classified maize, cassava, sugarcane, Jatropha, and palm oil as the most promising for biofuel production in Tanzania. FAO (2010a) conducted scenario analysis to evaluate the most promising agricultural crops for potential bioenergy development in Tanzania, Peru, and Thailand/Cambodia. In terms of food security, the most relevant crops were maize, cassava and rice based on per capita calorie consumption in Tanzania (FAO 2010b and 2012). Tanzania has changed from being a slight net importer to a net exporter of maize, while cassava is hardly exported. Maize and cassava prices have steadily increased in the country since 2000 (FAO 2012).

Based on a dynamic economy wide model of Tanzania, cassava as a major food and staple crop has large production potential throughout Tanzania (FAO 2010b). The analysis shows that ethanol production schemes based on cassava would result in economic growth and support poverty reduction (FAO 2010b).

Jatropha curcas is affects economic growth positively through a smallholder-based system (FAO 2012). However, these results derive from Jatropha schemes where only the oil seeds were harvested. The joint-product production schemes where *Jatropha curcas* is utilized as a host plant for the production of black pepper and vanilla have not yet been considered in a multi-sectoral model. The GTZ (2009) recommends further analysis of such a scheme.

In terms of sugarcane, Tanzania is ranked as the sixth largest producer in the east African region producing 187 thousand of tons of sugar (Hassan 2008). The share of domestic consumption approximates 87 per cent of total produced sugar; the remaining is exported to the European Union (Hassan 2008). With a population of around 38 million inhabitants, the average consumption per capita is about 4.3 kg. The cultivation of sugarcane in Africa is mainly rainfed however higher productivity is reported from irrigated production schemes (Hassan 2008). FAO (2010b) suggests that sugarcane potential for bioenergy production under rainfed conditions is limited; irrigation could significantly change this. Although, sugarcane-ethanol is competitive in Tanzania, it requires a large-scale industrial production scheme. While this type of biofuel supply chain could lead to more economic growth, it is doubtful whether it has a poverty reduction effect (FAO 2010b). However, bioenergy investments in small-scale agriculture along with the target of increasing yields of food crops could be economically viable and help reduce poverty (FAO 2010b). Tanzania would only be competitive on the world market when the crude oil price at their borders is greater than US$ 66 per barrel (Arndt et al. 2011).

From the macroeconomic perspective, several studies were conducted based on partial and Computable General Equilibrium (CGE) models (Zhang et al. 2013, Arndt et al. 2011 and 2010). The findings of CGE models done by Arndt et al. (2012) within the framework of FAO (2010b) suggest that all biofuel production scenarios improve households' welfare, but "there are significant differences in the distributional impacts across household groups" (FAO 2010b p. 188, Arndt et al. 2012 p 1929). While all rural households would gain from a biofuel industry in Tanzania, higher-income rural households in larger-scale production scenarios, such as sugar may benefit more. Outgrower schemes based on small scale farmers are rather effective in raising poorer households' incomes than large scale plantations (Eijck et al. 2010, FAO 2010b). This suggests that the participation of smallholders in bioenergy value chains contribute to poverty reduction, especially when additional agricultural investments are included to improve the general productivity smallholder (FAO 2010b).

5.3 The Model Framework and Underlying Data

5.3.1 Underlying Data

This environmentally extended village SAM is based on primary data collected from an own household survey (see also Faße and Grote 2013a, Faße and Grote 2013b). Therefore the results can be directly linked to information from the household-level data set.

In order to identify an appropriate study site, a village scoping study was carried out. The selection of the village is based on certain requirements including the existence of Jatropha shrubs on plots of mainly small-scale farmers, and at least two other potential bioenergy crops. Furthermore, the level of transaction costs and the heterogeneity among households played a critical role. High transaction costs may lead to isolation from outside markets (evolvement of endogenous prices) often resulting in non-seperability of production and consumption. Low transaction costs rather result in exogenous prices channeled via distant markets outside the village (Taylor and Adelman 1996).

Within this context, Tandai, a village located in Kinole ward, Morogoro district has been identified as an appropriate study location. The village borders the governmental forest reserve considered as a biological hotspot (Finch et al. 2009) (Figure 1). The study region belongs to a sub-catchment of the northern Uluguru Mountains in Tanzania, which supplies the Dar es Salaam region with drinkable water (Jindal et al. 2013). Historically, the surrounding forests have been heavily fragmented and depleted by local farmers converting forest into farmland, cutting firewood and harvesting timber (Doggart et al. 2004). Since 2002, this area has been declared as a forest reserve characterized by the highest level of protection (United Republic of Tanzania 2002). From the early 2000s, private agroforestry has been promoted to supply the farmers with the required firewood, timber and food among others (Jindal et al. 2013).

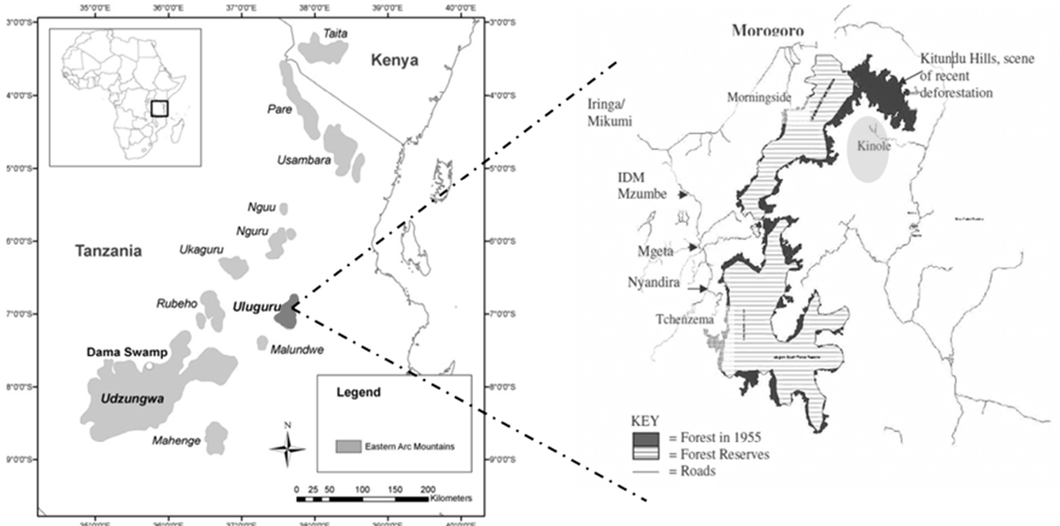

Figure 1: Case study region

Source: adapted from Finch et al. 2009 and www.easternarc.or.tz

The study village is divided into seven sub-villages where the households are widely scattered with a varying altitude between 314m and 1128m above sea level. The altitude differences result in varying characteristics of soil conditions, risk of soil erosion and soil quality. The uphill areas neighboring the forest reserve are characterized by more fertile arable soils compared to the agricultural plots in the valley. However, the uphill plots are much more vulnerable to soil erosion due to the slopes. In addition, remoteness to the central market in Tandai and proximity to the forest have an impact on the crop portfolio and energy consumption patterns due to poor market access.

Of the 1015 households living in Tandai, 314 (30 per cent) were interviewed in 2010 (see also Faße, 2012). The households were chosen randomly, based on household lists provided by the village head. The survey aimed at capturing all economic activities carried out in the study village. The respondent was the household head. Different aspects of households' participation (production, consumption, trading) in energy value chains (firewood, charcoal, residuals, kerosene) were interviewed as well as production activities regarding potential bioenergy crops such as *Jatropha curcas*, cassava, and sugarcane. The entire input-output relationships (monetary and non-monetary) were modelled both within one household as well as between the households covering the whole village economy. Concerning the input-output relationships within a household, emphasis was put on the utilization (consumption for subsistence, input use, or processing) of agricultural cash and food crops including all by-products and their uses (fertilizer, food, energy, seedlings). The same applied to energy production and consumption patterns in particular the utilization of firewood as the most important forest product in the village. The linkages between households were captured by quantifying market participation (e.g. weekly market, intermediaries, or wholesaler). Overall, the questionnaire helps to build a village SAM by assessing the questions: "Who does what, with whom, in exchange for what, by what means, for what purpose, with what change in stocks" (United Nations 2009 p. 16).

In order to derive environmental multiplier effects, information related to the classification of the cultivated species, number, and average age of trees managed on households' properties was taken into account. Trees were intercropped with food and cash crops (agrisilviculture) and commonly utilized different purposes: as a measure against soil erosion, own firewood supply, spices (cardamom, cinnamon, black pepper, vanilla) and fruit production. Some farmers reported collecting firewood from public sources. Thus, this questionnaire allows capturing forest utilizations from wood collection and the usage for cooking, ripening bananas, or making bricks with its direct and indirect multiplier effects on household activities. Charcoal production was forbidden in the study village and thus imported from other neighbouring villages.

In the case study region, *Jatropha curcas* is planted as a host for black pepper and vanilla cultivation. Since Jatropha oil seeds have not been harvested or sold in the village, we take secondary data from the literature. We assume minimum yields and a low harvest level of 0.5 kg per tree and year (Henning 2004). The use of minimum yield and harvest levels is justified because the major purpose of Jatropha cultivation is the production of black pepper and vanilla in the village where pruning is necessary. The price of Jatropha oil seeds is estimated at 150 TZS per kg; this is the price paid by one of the biggest producers of Jatropha oil in Tanzania (Wahl et al. 2009). Regarding the harvest, only Jatropha trees older than 3 years were included. The extraction of Jatropha oil is not included in this model. We assume that Jatropha oil seeds are directly sold out of the village after harvest.

Regarding other potential bioenergy crops, small-scale farmers cultivate cassava and sugarcane in the study village. Other bioenergy crops such as oil palm plants or sweet sorghum were not part of the agricultural portfolio. Food crops, primarily maize and rice, are the major import crops whereas cassava represents a major export crop in the case study village. These major food crops will be also considered within the multiplier analysis to capture some aspects of food security.

5.3.2 The Environmental Extended Village SAM

"Measuring the impact of biofuel production on household incomes and poverty is particularly complex" (Arndt et al. 2010, p. 15). The most robust method of assessing the impact of bioenergy production activities on the households of a regional economy is via economic multi-sectoral modelling (Allan 2011). In order to capture indirect effects of certain economic activities, different models are applicable to conduct economy-wide impact analysis (Alavalapati and Mercer 2005, Arndt et al. 2011, Roberts 2005, Allan 2001). The indirect effects are assumed substantial for biofuel investments (Arndt et al. 2011). Allan (2011) reported from his review of multisectoral modelling techniques that no SAM has been applied to evaluate the economic multiplier effects for biofuels at the micro level. The SAM approach, originally developed by Stone (1978), reconciles national income and product accounts with input-output (I-O) analysis (Table 1). It is used "to model diverse national economies for purposes of policy analysis and planning" (Taylor, Adelman 1996, p. 15). Leontief and Ford (1972) first considered pollution as a by-product of the regular economic activities in an I-O framework (Martinez de Anguita and Wagner, 2010).

Authors	Village or national Level	Economic or Environmental extended	Country	Main research question
Thurlow and Wobst (2003)	National	Economic	Tanzania	Poverty focus
Kaliba et al. (2008)	National	Economic	Tanzania	Agricultural crops
Martinez de Anguita and Wagner (2010)	National	Yes (different applications)	Compilation (book)	Various
Adelmann et al. (1988)	Village	Economic	Mexico	Migrant remittances
Taylor and Adelman (1996)	Village	Economic	Compilation (book)	Various
Subramanian and Qaim (2009)	Village	Economic	India	BT cotton
Shiferaw and Holden (2000)	Village	Yes: soil degradation	Ethiopia	Externalities of soil degradation
San Martin and Holden (2004)	Village	Yes: tree resources	Mozambique	Economic effects of charcoal demand

Table 1: Relevant studies related to SAMs

Source: own compilation

More recently, studies emphasize the need to incorporate also resources measured in physical or monetary units (such as energy, water or forests) (Alavalapati and Mercer, 2005).

The first application to village economies appears in Adelman, Taylor, and Vogel (1988). The analysis of labour, migrants, and remittances was the main research topic in of village SAMs (Taylor and Adelman 1996). Three recent studies developed a village SAM in India, Ethiopia and Mozambique (Subramanian and Qaim 2009, Shiferaw and Holden, 2000; San Martin and Holden 2004). The Indian study focused on the impact of BT cotton on the village economy (Subramanian and Qaim 2009). Shiferaw and Holden (2000) extended their village SAM by environmental accounts of income losses due to soil degradation for households. San Martin and Holden (2004) developed the only village SAM capturing tree resources in a SAM to assess the multiplier effects of charcoal production. Otherwise, SAMs incorporating agroforestry are scarce, especially on village level (Alavalapati and Mercer 2005).

Regarding Tanzania, only a national SAM exists, whereby the latest was developed for the year 2001 (Kaliba et al. 2008). However, none is available at the village level. The advantage of a SAM on village level is the high disaggregation of economic interactions between households and natural resources. The disaggregation enables researchers to give a more precise and comprehensive picture of the situation on the ground compared to highly aggregate national SAMs. Incorporating natural resource accounts provides quantitative evidence regarding sustainability targets. However, none of the available Tanzanian SAM studies includes environmental accounts. In general, village SAMs are sparsely applied because of huge data needs.

The environmentally extended village SAM applied in this study is depicted in Figure 2. It represents the whole economy including the linkages to natural resources. It captures all monetary transactions within a period of one year. Productive activities refer to all kinds of production methods of e.g. feedstock, livestock and off-farm employment carried out in the village. These activities purchase inputs from the factor markets such as labour, land, fertilizer, pesticides and water. These factors, particularly labour, are provided by households living in the village or in neighbouring villages who generate income through wage employment. The produced commodities and services are supplemented by imports, traded on the local market within the village, or exported to outside areas, often called rest of the country or rest of the world. Households consume either their own produce for subsistence or purchases at the local market; surpluses are sold on the market. The government receives taxes, water fees, and provides wages for governmental employees for village heads, teachers or supplies the village with health services.

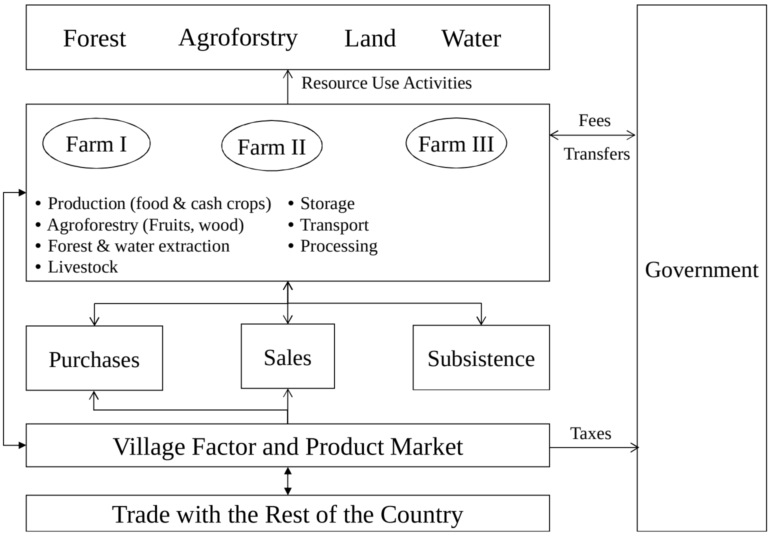

Figure 2: Schematic illustration of interdependencies between village institutions and natural resources in the model economy

Source: Adapted from Winter and Faße (2009)

The aggregated SAM framework in Table 2 represents these transaction flows in matrix form. The columns of the SAM contain payments received by respective rows depicting a system of double entry bookkeeping where the sum of each row corresponds to the sum of each column. The Aij matrix represents the endogenous accounts including the capital accounts similar to Shiferaw and Holden (2000). The objective in this study is to assess exogenous changes of bioenergy-crop-demand on households' income and changes in the resource stocks of public and private tree resources. Hence, the production activities, commodities, factors of production, capital accounts and households' institutions are considered as endogenous. The exogenous accounts include the account of the local government, transaction costs, the rest of the village and the rest of the country.

Activities

A SAM distinguishes between activities and commodities. Activities represent entities that carry out specified production sequences or technologies (Thurlow and Wobst, 2003). Different activities may produce the same product e.g. rainfed and irrigated rice cultivation yield rice as a commodity. Additionally, one activity may generate more than only one product such as trees, from which farmers can harvest wood for energy supply and fruits for selling or consumption. In the study village, the agriculture production techniques were the same among the households; since the area is very slopy und sometimes difficult to access even by foot, no technical equipment such as tractor or oxen is used. Everything is handcrafted regarding agriculture activities.

The sub-matrix $A_{1/2}$ represents the production of commodities, which are either sold to the market (export and local market) or used as an intermediate produce. The share of production, which is used for subsistence, is included in sub-matrix $A_{1/5}$. $F_{1/8}$ and $F_{1/9}$ represents the payments of the rest of the village and country for services provided by households of the study village (wage employment, manufacturing, or trading commodities).

		Endogenous Accounts					**Exogenous Accounts**				
		1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
Endogenous Accounts	1. Activities		$A_{1/2}$		$A_{1/4}$	$A_{1/5}$			$F_{1/8}$	$F_{1/9}$	
	2. Commodities	$A_{2/1}$				$A_{2/5}$			$F_{2/8}$	$F_{2/9}$	
	3. Factors	$A_{3/1}$									
	4. Capital	$A_{4/1}$				$A_{4/5}$				$F_{4/9}$	
	5. Institutions			$A_{5/3}$	$A_{5/4}$	$A_{5/5}$				$F_{5/9}$	
Exogenous Accounts	6. Government		$F_{7/2}$			$F_{7/5}$					
	7. Transaction costs	$F_{7/1}$									
	8. Rest of the village										
	9. Rest of Tanzania				$F_{9/4}$	$F_{9/5}$	$F_{9/7}$				
	10. Total										

Table 2: Frame of the basic village SAM

Source: adapted from United Nations (2000, 2009); Martinez de Anguita and Wagner (2010)

Commodities

Commodities, which are used as an intermediate for further production, are presented in sub-matrix $A_{2/1}$. Total intermediate demand includes inputs such as raw crops from village harvests being processed in a simple way on-farm such as drying of maize, rice, smoking of bananas etc. Besides the commodities for intermediate usage, the sub-matrix $A_{2/5}$ includes all commodities which households buy from the local market. $F_{2/8}$ and $F_{2/9}$ present the crops sold either on the village market or the export market, respectively.

Factors

The total value added at factor costs equals the sum of compensation payments of employees. The sub-matrix $A_{3/1}$ represents the payments to the factors of production, which are then distributed among the households as factor income $A_{5/3}$. The factors consist of family and hired labour, rented and own land for agricultural production differentiated by upland and lowland. In the case study area, the upland is more productive due to less degraded soils, which are close to the governmental forests. Other inputs are seeds and pesticides; fertilizers are not applied in the study area at all. Finally, firewood is included for smoking bananas.

Capital

In this study, capital comprises not only cash capital but also the utilization of private and public tree stock and seeds. $A_{1/4}$ includes seeds, which are stored as an input factor for the next cropping season. Additionally, the natural growth rate of wood provided through agroforestry grown on own land is assigned to $A_{1/4}$, which is separately depicted in Table 3 later. The sum of wood grown through agroforestry is handled as a joint product together with fruits and spices harvested from the respective trees. The amount of wood, which has been collected for firewood production activities, is included as a separate activity represented by $A_{4/1}$ distinguished by whether it is collected from private or public properties. The environmental debt, calculated as the amount household's extraction rates exceed natural growth rates, is assigned to the households in the sub-matrix $A_{4/5}$. Here, we can assess the degree of sustainability of the different household groups. Households, who behave unsustainably in firewood extraction from their own tree resources, gain a higher income in this year, whereby the others save the surplus from the natural growth rate on the capital stock of private trees.

The growth rate of the public wood resources could not be estimated due to the vast and partly inaccessible public forests. However, during the household survey, some farmers reported to collect firewood from the latter. According to the ESAM model of Martinez de Anguita and Wagner (2010), we assume that wood extracted from public resources is assigned to the rest of the country account denoted as an environmental debt similar to negative externalities. In this case study, the price for the exploitation of public wood resources is completely determined by the associated cost of extraction (opportunity costs of collecting and time needed to go to the public forest areas); the wood itself is treated as free (Lenzen and Schaeffer, 2004). Hence, the general extraction of wood from public areas as an input is entered in $A_{4/1}$ and the environmental debt of the village towards the rest of the country is represented by $F_{9/4}$.

Households

The incorporation of households to form of several groups is a major characteristic of a SAM providing the social component of the multiplier analysis. Households belonging to one group or cluster are assumed to have similar livelihoods, but are different between the groups regarding livelihood strategies and production activities as well as the market integration and hence welfare level.

In a prior study, a cluster analysis was conducted based on the household data set described above (Faße and Grote, 2013). From the sample of 314 households, 284 were clustered; the remaining households were identified as outliers. Three different livelihood strategies were identified: [1] “subsistence farm households combined with unskilled wage employment”, [2] “farm households highly specialized in cash crop production”, and [3] “farm households specialized in cash crop production combined with skilled off-farm employment”.

Cluster [1] households have on average 594 TZS (0.29 Euro) per day and per capita at their disposal, which is slightly below the poverty line of 617 TZS for the year 2009 for Tanzania. More than 90 per cent of the female-headed households belong to this cluster representing 40 per cent of all cluster members. Their main sources of income are unskilled off-farm employment, banana and pineapple for cash crop production as well as maize and rice as major staple crop production. However, with 4.88 acre, their land endowments are significantly smaller compared to Cluster [2] and [3]. 63 per cent of the households have at least one member who is engaged in seasonal unskilled off-farm employment, mainly as an agricultural labourer (weeding, carrying harvest to the market).

Households belonging to cluster [2] generate income mainly from banana and pineapple production. While some households are engaged in off-farm work, they are not working in the unskilled sector. In total, household members of Cluster [2] generate a significantly higher per capita income than Cluster of 1,045 TZS per day. Due to the labour intensive cash crop cultivation, 63 per cent of the farmers hire people supporting them during harvest or weeding activities. They are relatively land abundant with seven acre per household. Their labour demand is also characterized by significantly higher wage payments to employees.

Farmers from Cluster [3] are land abundant and specialize in cash crop production similar to Cluster [2]. Additionally, 25 per cent of the cluster members are mainly engaged in skilled off-farm activities. Hence, they face scarcity in family labour and therefore 94 per cent of the cluster members hire agricultural employees, and pay the highest daily wage rate. The income per capita per day is on average 1,627 TZS and hence significantly higher than those of Cluster [1] and [2].

The sub-matrix $A_{5/3}$ depicts the income from factor payments to the household groups. $A_{5/5}$ represents households’ transfers among the households within the case study village.

Remittances received from outside the village are included in $F_{5/9}$; remittances sent out to others not living in the village are represented by $F_{9/5}$.

Government

The households pay water and school fees to the government account $F_{7/5}$. Crops are taxed when imported into the village or sold in the village on the weekly market $F_{7/2}$. The village executive officers usually collect these taxes, which are then redirected to district revenue departments outside the village (here $F_{9/6}$) (Ellis and Ntengua, 2003).

Transaction costs

Transaction costs occur on different accounts. First $F_{7/1}$ accounts for opportunity costs for walking to the agricultural plots. $F_{7/2}$ includes transportation costs, importing crops from outside the village. The transaction costs are then assigned to the rest of the village and the rest of the country.

Rest of the village / rest of the country

Depending on the level of market development in the village, the rest of the country account includes exchanges with the rest of the village, the capital account of the village and the village government.

In this case study, the disaggregated village SAM is composed of 52 activity accounts, 51 commodity accounts, eleven factor accounts, six capital accounts, and three household groups included in the endogenous part of the matrix summing up to 133 accounts (Figure 3).

Activities: 52 Commodities: 51 Factors of production: 11 Capital: 6 Institutions: 3 household cluster,	Endogenous accounts
NGO, government Transaction costs (TAC) Rest of the village (ROV) Rest of the country (ROC)	Exogenous accounts

Figure 3: Accounts used in the village-SAM

Source: Own illustration

Balancing the SAM is achieved through the capital accounts $F_{4/9}$ and $F_{8/4}$. The exogenous part includes the government, NGO activities, the transaction cost account, and an account for the rest of the village and rest of the country respectively.

5.3.3 Multiplier Analysis

Conventional IO and SAM models capture the embeddedness of a sector in an economy and are used to derive multipliers. These multipliers quantify the economic effects of exogenous changes in income and demand pattern. For a SAM multiplier analysis, the first step comprises the partition of the accounts into endogenous and exogenous accounts (Kaliba et al. 2008). Subsequently, the village transaction matrix T is converted into a matrix of average expenditure propensities by dividing each element in the matrix by its respective column total. This normalization produces a matrix of average shares called S (Taylor and Adelman 1996). Deleting the exogenous rows and columns from S yields a new sub-matrix containing only the endogenous shares (Taylor and Adelman 1996). The village multiplier matrix is derived as:

$$M = (I - A)^{-1}$$

where M equals the inverse of the identity matrix (I) less the SAM coefficient matrix of endogenous variables (A) (Shiferaw and Holden 2000). Given some exogenous change in X, the effect on endogenous accounts in the village Y is determined by the village multiplier matrix (Taylor and Adelman 1996):

$$Y = M * X$$

The matrix M presents the village multiplier matrix because it contains the total direct and indirect effects of exogenous injections on endogenous accounts in the village SAM (Taylor and Adelman 1996). The village Leontief (input-output) multiplier is one component of the village SAM multiplier (Taylor and Adelman 1996). In addition to the Leontief production linkages, SAM multipliers also capture expenditure linkages induced by changes in production activities through their effects on incomes in the village. In village SAM models, the expenditure linkages typically are stronger than production linkages (Taylor and Adelman 1996). Although, a multiplier analysis provides a simple but comprehensive view on the economic effects of exogenous changes in demand pattern, such demand-driven applications however have some challenging characteristics; three of them should be mentioned:

1. "[…] prices are fixed and […] any changes in demand will lead to changes in physical output rather than prices" (Breisinger et al. 2010, p. 17).
2. "[…] factor resources are […] unconstrained, so that any increase in demand can be matched by an increase in supply" (Breisinger et al. 2010, p. 17).
3. "[…] input coefficients of producers and the consumption patterns of households remain unchanged […]" (Breisinger et al. 2010, p. 17).

	Activity	Commodity	Factors	Seeds	Cash	Private Tree Stock	Public Tree Stock	HH 1	HH 2	HH 3	NGO	Gov	TAC	ROV	ROC	Total
Activity		499906		23425		81678		75488	96615	66314				36500	11620	891545
Commodity	90354							148725	230814	137185	452			153360	237407	998297
Factors	618573															618573
Seeds			34582													34582
Cash								-39866	-67038	9899					178112	81107
Private Tree Stock	95186							-15654	-29056	31202						81678
Public Tree Stock	5330															5330
HH 1		75079	105647					4154				316			2061	187257
HH 2		41097	208681						5958						1694	257430
HH 3		19009	237551							6070		2572			2042	267245
NGO															452	452
GOV		11251						13010	18408	13294					2888	58850
TAC	74038	14886														88924
ROV		40804	23690	8446	81107							6517	29297			189860
ROC	8064	296265	8421	2712			5330	1401	1729	3283		49445	59627			436276
Total	891545	998297	618573	34582	81107	81678	5330	187257	257430	267245	452	58850	88924	189860	436276	4197406

Table 3: Aggregated village SAM of Tandai extended by resource accounts for wood in 1,000 TZS

Source: Own calculations (n=284), data 2010

5.4 Results

5.4.1 Descriptives

Table 3 depicts the aggregated village SAM of the case study. Only the capital and the institutional account including the household clusters are disaggregated.

The entire household sample generates a gross domestic product (GDP) of 812,442,000 TZS in 2009. The production value reached 891,545,000 TZS. The export share of goods and services reaches 28 per cent of the production value, the import share about 27 per cent.

The most important export crops are bananas and pineapples. While 61 per cent of bananas and pineapples are sold on the export market, together they make about 72 per cent of the overall export revenues, which shows the importance of cash crops as an income activity. In terms of the import value, the most important crops are rice (23 per cent), cassava (14 per cent), and maize (8 per cent), which shows, that the village is dependent on the import of major food crops to sustain their livelihoods.

Table 4 shows the average income in Tanzanian Shilling (TZS) differentiated regarding several income generating activities.

	Cluster [1] (n=102)	**Cluster [2]** (n=111)	**Cluster [3]** (n=71)	**Total** (n=284)
Total Household Income	1,127,579	2,116,836	3,068,726	1,999,512
Agroforestry	122,458	136,260	295,863	171,641
Potential bioenergy crops				
Jatropha: spices	9,190	11,676	29,813	15,368
Jatropha (oil seeds)	593	1,128	3,313	1,549
Sugarcane	2,470	5,477	3,138	3,810
Cassava	32,769	74,862	71,460	58,938
Food crops				
Rice	180,158	151,354	209,756	176,299
Maize	54,261	76,679	190,170	97,000
Cash crops (for comparison)				
Banana	384,797	117,374	138,1368	942,542
Pineapple	152,205	195,300	189,969	178,489.

Table 4: Contribution of different bioenergy and food crops to farm households' income (mean)

Source: Own calculations (n=284), data 2010

As indicated in section 3, Cluster [1] achieves the lowest total income, whereas Cluster [3] the highest. Agroforestry accounts for an average of 10 per cent of income. Obviously, trees already are an important determinant in terms of income generation compared to the potential bioenergy crops.

In addition to the potentially bioenergy crops, the major food and cash crops presented for comparison in table 4. Rice is, in economic terms, the most important food crop exceeding maize income. However, in absolute terms, the production of cash crops (banana and pineapple) generates the highest income.

Regarding the potential bioenergy crops, cassava plays the most important role followed by spices from Jatropha cultivation, sugar cane, and the theoretical income from selling the oil seeds of *Jatropha curcas*.

Being aware of the economic importance of households' agroforestry, the annual wood growth rate in 2009 has been estimated to 81,678 thousand TZS (table 3). Households, however, used in total 95,186 thousand TZS of wood for firewood production. This overutilization has been assigned to the households' expenditures in the private tree stock account implying the external effects directly at the household level. Household Cluster [1] and [2] assign negative values to their private tree stock, indicating overexploitation. Households belonging to Cluster [3] assign a positive value to their private capital stock indicating a sustainable consumption of own tree resources.

	Cluster [1] (n=102)	**Cluster [2]** (n=111)	**Cluster [3]** (n=71)	**Total** (n=284)
Firewood consumption per capita and day (kg)	1.07[a]	1.45[b]	0.61[c]	1.04
Firewood share from own agroforestry	0.73[a]	0.83[a]	0.58[b]	0.71
Firewood share from public sources	0.13[a]	0.11[a]	0.21[b]	0.15
Firewood share from the market	0.14[a]	0.06[b]	0.21[c]	0.14
Share of firewood in energy consumption	0.89[a]	0.87[a]	0.76[b]	0.85
Participation in forest protection (1=yes)	20.5[a]	31.5[b]	43.6[c]	30.4
Sustainable firewood extraction (1=yes)	22[a]	0.00[b]	92.9[c]	30.7
Energy consumption p.ca. and day (TZS)	217[a]	231[b]	269[c]	245
Per capita income (TSZ per day)	594[a]	1,045[b]	1,627[c]	1,034

Notes: Statistical tests: Continuous variables: Non-parametric two-sample test (Mann-Withney-U-Test); binary variables: chi-square test

Different letters a, b, c indicate significant difference of means ($\alpha = 0.10$)

Table 5: Characteristics of the household clusters in Tandai, Tanzania

Source: Own calculations (n=284), data 2010

Regarding the consumption of public wood, 5,330 thousand TZS are collected for firewood use. This amount is assigned to the rest of the world as a negative external effect also called "environmental debt" (Martinez de Anguita and Wagner 2010, p. 139). Here, household Cluster [3], with 52 per cent, extracts the highest share of firewood from the public tree resources, household Cluster [1] (23 per cent) and Cluster [2] (25 per cent). The consumption share of public firewood is 13 per cent, 11 per cent and 21 per cent for household Cluster [1], [2], and [3] respectively (see table 5).

These results show that Cluster [3] can claim to be sustainable in terms of its own wood resources but generates the highest share of negative externalities regarding the exploitation of public tree resources. An indication for this could be the distance to the forest, which is lowest for Cluster [3] with on average 119 minutes and highest for Cluster [1] (147 minutes).

In terms of the cash capital, again, household Clusters [1] and [2] are indebted, as indicated by the negative values whereas Cluster [3] is able to save some of their income.

5.4.2 Multiplier Analysis

Relevant results of the multiplier analysis are presented in Table 6. The extended version of this analysis is in the appendix (see Table A1). The interpretation of the multipliers is as follows: The third column (maize raw) indicates that an additional demand of one unit of maize generates 1.043 units in this sector and 0.738 units in other activities, which sums up to a total production multiplier of 1.781 units. The total induced income multiplier amounts to 1.219 units. However looking at the different clusters, Cluster [1] generates the largest share (multiplier 0.528; 43 per cent) of the income compared to Cluster [1] (multiplier 0.230; share 19 per cent) and Cluster [2] (multiplier 0,460; share 38 per cent).

Bringing the firewood production and the potential bioenergy crops into focus, the highest total income is generated by non-food producing trees (1.456), food trees (1.353), black pepper and vanilla on *Jatropha curcas* complemented by Jatropha oil seeds and wood (1.287), followed by sugarcane (1.257) and cassava (1.171). The food crops have tendentially a lower multiplier, which is due to the high subsistence level of usage. Interestingly, the highest multiplier in terms of bioenergy is generated by trees, which are already used as a multifunctional crop.

Subdivided into the three clusters, Cluster [1] generates the highest income multiplier from food trees followed by the non-food trees. The remaining crops follow the same declining order for the total induced income. The order of income multiplier of Cluster [2] corresponds to the order of the total induced income multipliers, whereas in the case of Cluster [3] the income multiplier of sugarcane exceeds the income multipliers of Jatropha and food trees.

Multiplier	Maize (raw)	Rice (raw)	Cassava	Sugar-cane	Black pepper / vanilla	Food trees	Non-Food producing trees	FW from own trees	FW from public
Seeds	0.086	0.166	0.076	0.035	0.036	0.043	0.063	0.051	-0.001
Cash	-0.149	-0.154	-0.127	-0.134	-0.144	-0.171	-0.165	-0.172	-0.017
private tree stock	0.124	0.109	0.127	0.137	0.137	0.135	0.154	1.139	-0.016
Puplic tree stock	0.009	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.999
HH 1 (n=102)	0.230	0.246	0.187	0.198	0.215	0.267	0.248	0.267	0.039
HH 2 (n=111)	0.460	0.452	0.414	0.442	0.463	0.517	0.529	0.526	0.019
HH 3 (n=71)	0.528	0.443	0.570	0.617	0.609	0.568	0.679	0.590	-0.106
total production	1.781	1.793	1.743	1.764	1.785	1.833	1.903	2.856	0.977
own sector	1.043	1.094	1.009	1.000	1.009	1.109	1.065	1.152	0.999
linkage production	0.738	0.698	0.734	0.764	0.776	0.725	0.839	1.704	-0.022
induced income	1.219	1.141	1.171	1.257	1.287	1.353	1.456	1.383	-0.048

Table 6: Multiplier effects of potential bioenergy crops and firewood

Source: Own calculations (n=284), data 2010

In terms of the food crops maize, rice, and cassava, the total induced income multiplier is highest for maize (1.219) followed by cassava (1.171) and then rice (1.141). The poorest Cluster [1] however generates the highest multiplier from rice (0.246), Cluster [2] from maize (0.460), and Cluster [3] from cassava (0.570).

From the tree perspective, the non-food tree cultivation activities generate the highest multiplier, both for private tree stock (0.154) as well as for public tree stock (0.011).

5.4.3 Discussion

In general, the processing multipliers relative to total production multipliers are highest for processing activities compared to the pure cultivation of crops and trees (Table A1). This coincides with the findings of Kaliba et al. (2008) who derived multipliers from the most recent national SAM from Tanzania developed for 2001. They also found that processing generates a higher multiplier in terms of total production compared to the pure cultivation of crops. Processing meat and food created the highest multiplier with 3.11 and 3.10 respectively. In terms of raw commodities, the most important crops were cassava (3.02) and fruits (3.01). They suggest from these results to participate not only in the production but also in further value chain activities to capture as much value added as possible within the village

(Kaliba et al,. 2008). Table A1 also shows higher multipliers in total production in the case of processing fruits or staple crops.

Kaliba et al. (2008) also included tree utilization but only in the form of general forestry utilization. Here, the multiplier, together with hunting, amounts to 2.93. In our case study, we found a lower multiplier with 1.833 for private food trees and 1.903 for private non-food trees. Firewood production from public resources generates a total production multiplier of 0.977 and 2.856 in terms of public and private tree stock respectively. Aggregating firewood production, the natural growth of wood, and harvest of fruits would probably increase the multiplier of cultivating agroforestry. Private agroforestry was not included in the national SAM of Kaliba et al. (2008).

In general, Kaliba et al. (2008) derived higher multipliers compared to our study results. This may be due to the lower economic integration of our study village within the Tanzanian market compared to the aggregated national multipliers.

Contrary to the findings of FAO (2010b), Arndt et al. (2010) and (2011), the results indicate that tree cultivation (food as well as non-food trees) generate the highest total income multiplier, whereby cassava results only in the lowest multiplier in terms of bioenergy crops. However, for the poorest Cluster [3] the highest income multiplier is reached among the major staple crops, which should be taken into account when food security issues are considered. Since the aforementioned studies did not include tree resources, neither from private or public sources, a relative comparison of income importance is difficult. However, supporting cassava would be most beneficial for the richest cluster but not for the poorest. Jatropha trees utilized as a host plant for black pepper and vanilla and additionally used to harvest wood during pruning and oil seeds achieve a higher multiplier than cassava does for all three clusters. The most pro poor bioenergy crops are food and non-food trees, from which the households can harvest wood and fruits either for selling or subsistence.

Interestingly, sugarcane yields only a very small share of income in absolute and relative term, but generates a higher income multiplier than cassava, food and non-food trees. This result indicates, how carefully multiplier should be interpreted since the scale of sugarcane production is very low and technical production coefficient might change in case of an increase of production activities.

5.5 Summary and Conclusion

Derived from the literature, biofuel crops are expected to provide new income possibilities for rural farmers (Arndt et al. 2011) and lessen the pressure on public forests partly due to substitution of firewood use. The magnitude of the economic multipliers is assumed high but diverse regarding regional characteristics (Domac et al. 2005). It is therefore crucial that governments in countries such as Tanzania understand which economic multipliers are influenced by proposed biofuel policies (e.g. supporting specific feedstock) to achieve national developing objectives (Arndt et al. 2012).

This paper targeted two major research questions: First, which of the cultivated bioenergy crops is most pro poor in terms of income? Second, which of these crops release the pressure on wood deposits (private and public) in the study area? Therefore, we developed an environmentally extended village SAM. Different from prior studies, we extended the village SAM by environmental accounts for firewood production activities from public and private tree sources to capture additionally a potentially positive effect on tree stock resources.

Findings of the multiplier analysis indicate that the highest household income effect derived from agroforestry, which the households use as a source of firewood and fruits for sale or home consumption, followed by *Jatropha curcas*, sugarcane and finally cassava. For the poorest household Cluster [3] food trees achieves the highest income multiplier. Besides trees for food use, the non-food tree cultivation activities have been also found to release the pressure on wood deposits (private and public) in the study area. However, although agroforestry is part of the agriculture system, the local firewood extraction has been found to be unsustainable compared to current natural growth rates of trees in the study area. The positive effects of agroforestry support further promoting of agroforestry systems to achieve a sustainable system of generating income from selling wood and fruits, energy provision and lessen the pressure on public forest resources.

Since the literature emphasized the variability of multipliers' magnitude, the findings drawn from this analysis can only illustrate a regional picture of economic impacts. Transferability has to be conducted carefully to adapt to other value chain and especially production characteristics. It would be important to include agroforestry and other bioenergy crops such as Jatropha in the national SAM for comparison.

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Multiplier	Fruits (raw)	Fruits processed	Maize (raw)	Rice (raw)	Maize flour	Rice dried	Cassava	Cassava flour	Sugarcane	Other crops	Other crops (processed)	Black pepper / vanilla	Black pepper / vanilla dried	Food trees	Food trees processed	Non-Food producing trees	Nursery	Livestock	unskilled agric. work	Trade / business	skilled work	Charcoal trade	FW own trees	Firewood public
Seeds	0.077	0.064	0.086	0.166	0.076	0.147	0.076	0.059	0.035	0.170	0.108	0.036	0.034	0.043	0.040	0.063	0.009	0.022	0.033	0.033	0.013	0.003	0.051	-0.001
Cash	-0.143	-0.140	-0.149	-0.154	-0.138	-0.148	-0.127	-0.147	-0.134	-0.137	-0.093	-0.144	-0.139	-0.171	-0.165	-0.165	-0.055	-0.106	-0.198	-0.198	-0.078	-0.015	-0.172	-0.017
private tree stock	0.121	0.114	0.124	0.109	0.113	0.105	0.127	0.127	0.137	0.120	0.080	0.137	0.130	0.135	0.129	0.154	0.039	0.107	0.140	0.140	0.055	0.012	1.139	-0.016
Puplic tree stock	0.009	0.009	0.009	0.009	0.009	0.008	0.009	0.010	0.010	0.009	0.006	0.010	0.010	0.010	0.010	0.011	0.003	0.008	0.011	0.011	0.004	0.001	0.011	0.999
HH 1 (n=102)	0.220	0.218	0.230	0.246	0.213	0.236	0.187	0.226	0.198	0.210	0.143	0.215	0.208	0.267	0.258	0.248	0.087	0.157	0.317	0.317	0.124	0.023	0.267	0.039
HH 2 (n=111)	0.442	0.427	0.460	0.452	0.424	0.434	0.414	0.458	0.442	0.430	0.290	0.463	0.444	0.517	0.498	0.529	0.161	0.348	0.583	0.583	0.229	0.045	0.526	0.019
HH 3 (n=71)	0.521	0.484	0.528	0.443	0.482	0.426	0.570	0.549	0.617	0.522	0.347	0.609	0.576	0.568	0.540	0.679	0.160	0.481	0.566	0.566	0.222	0.052	0.590	-0.106
total production	1.754	2.477	1.781	1.793	2.590	2.630	1.743	2.388	1.764	1.804	2.168	1.785	2.656	1.833	2.664	1.903	1.250	1.596	1.897	1.897	1.352	1.073	2.856	0.977
own sector	1.098	1.003	1.043	1.094	1.037	1.066	1.009	1.003	1.000	1.065	1.007	1.009	1.000	1.109	1.000	1.065	1.001	1.008	1.000	1.000	1.000	1.003	1.152	0.999
linkage production	0.655	1.475	0.738	0.698	1.553	1.564	0.734	1.385	0.764	0.739	1.160	0.776	1.656	0.725	1.664	0.839	0.248	0.588	0.897	0.897	0.352	0.069	1.704	-0.022
induced income	1.183	1.129	1.219	1.141	1.120	1.096	1.171	1.233	1.257	1.163	0.779	1.287	1.229	1.353	1.297	1.456	0.408	0.986	1.466	1.466	0.576	0.120	1.383	-0.048

Table A1: Multiplier analysis

Source: Own calculation, data 2010

This chapter is an extended version of:

Winter, E., Faße, A. (2009): „ Food security, Energy Equity, and the Global Commons: a Computable Village Model applied to sub-Saharan Africa“.

Contributed paper at the International Association of Agricultural Economists’ 2009 Conference, Beijing, China, August 16-22, 2009.

6 Food security, Energy Equity, and the Global Commons: a Computable Village Model applied to sub-Saharan Africa

Abstract

Depletion and fragmentation of eco-systems such as forests represent serious challenges for countries in sub-Saharan Africa. It is expected that current trends of deforestation will intensify, caused by the rapid extension of biofuel production. A computable village model has been developed to analyse the impact of alternative resource management options on local income distribution and long-term resource use. The analysis has been at first applied to the Kakamega District of Western Kenya. Model results validate the importance of forest income for the poor. Results further indicate that sustainable utilisation of forest resources will not be feasible unless alternative energy systems have been broadly integrated into the village economy.

Keywords: Deforestation, Resource Management, Bioenergy, Village Model, Value Chain Analysis, sub-Saharan Africa

6.1 Rationale and Objective

Depletion and fragmentation of eco-systems such as forests represent serious challenges for countries in sub- Saharan Africa (compare also Winter and Frohberg 2009). It is expected that current trends of deforestation will intensify, mainly caused by the rapid extension of biofuel production (Bird et al. 2013). Today we experience a growing area of conflict between global environmental concerns and the needs for direct utilisation of natural resources by the resident population. The World Bank Study “Counting on the environment” illustrates the importance of forest environmental income for the rural poor (Vedeld 2004). Besides food security, access to energy is considered to be central for poverty reduction (United Nations 2007). At present more than 500 million people in sub-Saharan Africa still rely on solid biomass to meet basic energy needs. In some least developed African countries traditional biomass still accounts for up to 90% of primary energy supply (IEA 2006). The unsustainable use of wood reinforced by steady population growth accelerates deforestation, resulting in soil erosion, desertification, and biodiversity loss (United Nations 2012). Furthermore, traditional energy use patterns are recognized to have negative repercussions on human health and to keep alive gender disparities (Molony 2011). In a number of regions women must walk at least six to ten km to collect fuel wood (IISD 2005). Degradation of woodlands will further increase time to collect wood resources in the future. Unfortunately, energy from modern renewable sources such as small hydro, solar and wind energy systems has high capital costs, and for this reason normally is inaccessible for remote poor communities. Liquid biofuels however are less-capital intensive, thus could provide a practicable alternative to modern technologies (United Nations 2007). In general, biofuel production from local feedstock is supported by traditional knowledge and provides communities with essential energy services and multiple valuable by-products. Even so, a reason for scepticism is bad agricultural practice, the consequences of which are loss of biodiversity, degradation of environmental services, increased water stress, and growing income disparity.

What options are available to restrain the encroachment of land used for energy production in sensible environmental areas? Is it possible to achieve the dual goal of biodiversity conservation and controlled forest extraction for supporting rural livelihoods? Biodiversity loss and conflicting uses of environmental services underline the need for a well thought-out management of natural resource use in sensitive areas, accounting for both, environmental and basic human needs (Zulu and Richardson 2013, Romero et al. 2013). This also includes research on sustainable biomass certification (UNEP-DTIE/ROA 2007, van Dam et al. 2006 and 2010, Scarlat and Dallemand 2011), and on innovative agroforestry systems that mimic natural ecosystems and facilitate biologically diverse production (Scherr and McNeely 2008, Branca et al. 2011, Tscharntke et al. 2011, Pinho et al. 2012, Kremen et al. 2012, Bacon et al. 2012). One focus of current research is on the introduction of new mixed cropping systems for combined production of food and energy crops. *Jatropha curcas* is one of these promising energy plants supposed not to replace food crops (van Eijck and Romijn, 2008, Del Greco and Rademakers 2006, Dufey et. al. 2007, FAO 2010). More recent publications however suggest also challenges, particularly concerning large-scale *Jatropha* cultivation (Romijn 2011, Favretto et al. 2013, Segerstedt and Bobert 2013).

Despite the on-going research on *Jatropha* production systems the collected data show shortcomings, especially with respect to information on seasonal labour requirements (Kumar et al. 2011). It is often assumed that labour is in surplus in developing countries. Conversely, empirical evidence suggests that for small-scale farmers in sub-Saharan Africa family labour is more often a scarce resource showing huge seasonal peaks and bottlenecks (Spaan et al. 2004, Abdulai et al. 2004) and labour constraints are most of all faced by women (Mwangi et al. 2011). These agronomic facts are significant for meaningful cost benefit analysis, but often neglected in assessments that are commonly based on highly aggregated data.

A village model is a useful tool for analysing differing, sometimes unreliable field data. In developing countries village markets represent the main link between the economy and nature whereby the natural resource base is a key input in peasant production systems; (Taylor and Adelman 2003, Sunderlin et al. 2008). Model simulations may illustrate repercussions of policy programs on natural resources; they can show distributional effects within the village and thus point to the feasibility of policies. Derived opportunity costs indicate costs and benefits of alternative strategies. A modelling approach applicable to quantify different management options and their resulting environmental and distributional effects can thus support a qualified decision process.

The paper describes the basic modelling concept for investigating determinants of land use management (compare also Winter and Frohberg 2009). At first, the analysis has been applied to the Kakamega District in Western Kenya (see also Winter 2009). Until today there are manifold competing interests of forest resource use (Pascal and Dosso 2004, Kisekka-Ntale 2008). For the model presented in the paper, we specify a value chain for local Jatropha production, and evaluate prospects for alternative employment and additional income that might reduce resource use conflicts and pressure on the forest.

6.2 The current forest management of Kagamega Forest

Today, significant movements from state-driven centralised forest management towards community-based management regimes can be observed in many developing countries (Kowero et al. 2003, FAO 2007, Agrawal and Angelsen 2009). Experiences with common-pool resources indicate their “tragedy” if not appropriately managed. Kakamega forest has been exposed to unsustainable practices and institutional dilemmas for decades resulting in continuous fragmentation of forest coverage and persistent degradation of environmental functions (Lung and Schaab 2006, Kisekka-Ntale 2008, Müller and Mburu 2008, 2009). The immense ecological value of the remaining forest fragments is broadly recognized today, while resource competition is persisting (Guthiga 2008, Börner et al. 2009). Today the management of Kakamega forest is supervised for the most part by two organisations (Guthiga 2007). The Kenya Wildlife Service (KWS), subordinated to the Ministry of Wildlife and Tourism governs about 4400 ha. KWS applies a protectionist-oriented management strategy. Direct extraction is absolutely prohibited and only guided tourist tours are operated. In contrast, the Forest Department (FD) employs an incentive-based management strategy showing some forms of cooperation with local communities and institutions. The local population is allowed to extract firewood, thatching grass, and to graze animals on glades within the closed forest. FD has been working under the legislation of the Ministry of Environment and Natural Resources. In 2007, the FD was reorganised, and today it constitutes the Kenya Forestry Service (KFS). KWS Management is supposed to bring about regeneration of indigenous forest resources and beside this positive development showing fewest illegal activities such as logging, debarking and charcoal burning (Bleher et al. 2006).

6.3 The village model

For considering competing resource uses and their dynamics, and for analysing interactions between different stakeholders, we developed a model consisting of a number of modules that represent the different users of the forest. We consider representatives that operate within a stretch of land surrounding the forest boundaries up to a distance of approximately 5 kilometres. The total population within this area is estimated at 582300 people. On average, a typical household accommodates 6 persons and cultivates one hectare of agricultural land. The total area covers about 1671 square kilometres including approximately 240 square kilometres forest land (Börner et al. 2006, Mueller and Mburu 2009). The entire village model consists of six components:

1. Modules representing diverse groups of farm households
2. A commercial sector module supplying different forest products and services
3. A component depicting the local market for food and forest products
4. The management system setting constraints and policy objectives
5. A forest bio-economic module
6. Trade with neighbouring regions

Figure 1 describes the basic structure of the modelling system. Farm households and commercial sectors are linked to the forest, to the local market and to a forest management system (controller).

The core component maps representative household groups that represent the heterogeneity of farming systems discovered in the study area. We analysed several surveys performed in the Kakamega district. Survey outcomes compare well with respect to agronomic data (Börner et al. 2006, Conelly and Chaiken 2000, Titonell et al. 2005). In contrast, survey results show significant discrepancies with respect to income data, and the magnitude of forest extraction activities discovered (Kamau 2007, Dose 2007, Gibbon and Mbithi 2002, Guthiga 2007). It is one advantage of quantitative models to display the likely range of impacts that result from biased data.

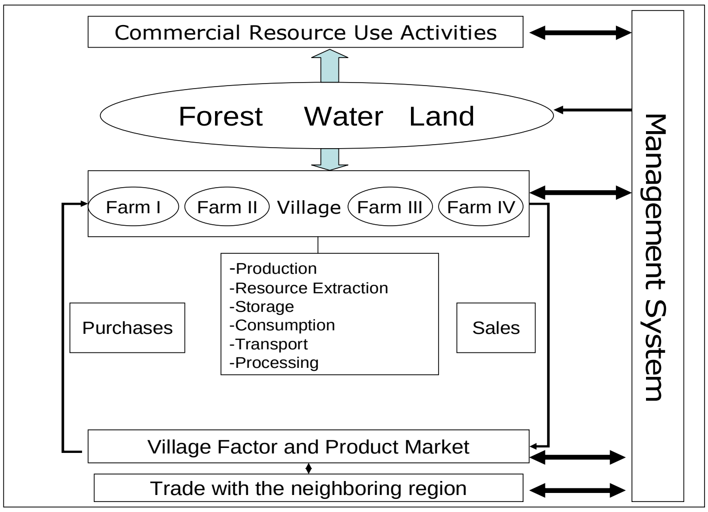
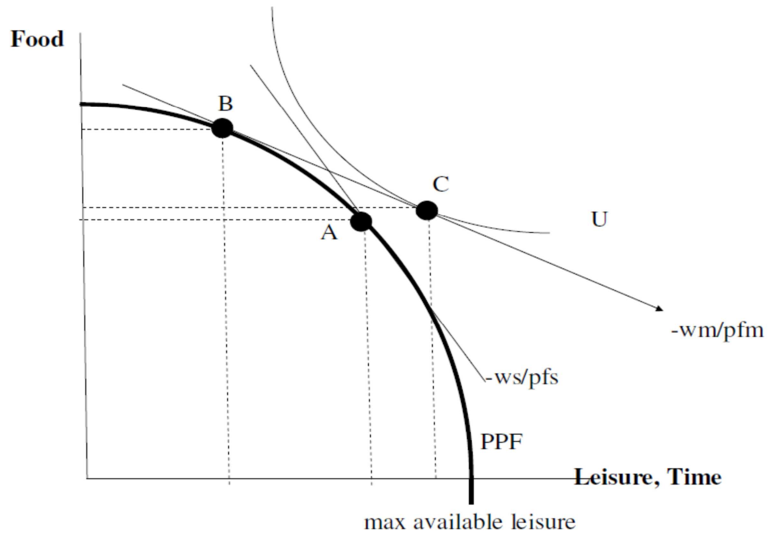


Figure 1 Schematic Structure of the Village Modelling System

Source: Own illustration

In case resource extraction is underestimated, cost benefit analysis will fail to appreciate the true impact which for example a ban of direct resource use may have on rural livelihoods. Accordingly, the derived opportunity costs of alternative energy supply strategies and land uses are biased. Modelling agricultural household behaviour in marginal areas is complex because farmers are most often not fully integrated in the market. Failure in factor and commodity markets implies that prices are distorted and cannot be used as the only guide for economic decisions. To account for market failure, various methods can be applied for calculating the true costs of factors and commodities. Labour costs for example might be approximated by considering the degree of local labour scarcity, and the grade of qualification. These kinds of adjustments are usually made in economic cost benefit analysis. Alternatively, opportunity costs can be endogenously determined by specifying a more complex non-separable household model (de Janvry et al. 1991, Angelsen 1999, Taylor and Adelman 2003, Holden et al. 2005). These models also abstract from the perfect market postulation and consider market disconnection due to huge transaction costs. The standard assumption of a non-separable household model is that households maximise their utility of consumption and leisure by balancing their disutility of work against their utility of consumption (Angelsen 1999 and 2007). In doing so, they reach their subjective household equilibrium (Nakajima 1986). The basic concept is described in Figure 2. In the extreme case, households have no access to markets for food and labour and the single household's production possibility frontier (PPF) also represents its budget constraint. The model determines the optimal plan of a subsistence household at point A. This point indicates the internal valuation (shadow prices) of food and leisure. In case perfect markets exist, households can produce at any point along the PPF and trade along the market price line (-wm/pfm). They realize production at point B and consumption at point C, which represents the maximum achievable utility U.



PPF = Production Possibility Frontier; -ws/pfs = shadow price line; -wm/pfm = market price line; U = Utility function

Figure 2: (Non)-market participation

Source: Adapted from Taylor and Adelman (2003)

Abstracting from general trade theory, households are better off with well-functioning markets; they can produce more food and at the same time consume more leisure. In real life households face missing markets for some specific goods and factors. High transaction costs constrain them to respond to price signals and this obliges them to shift the burden of adjustment on the non-traded goods and factors. The mathematical model presented here also abstracts from the concept of one representative consumer. Instead, different types of rural household are considered taking into account some appearance of specialization, and options for local trade within a village. The village model describes interactions between these different types of households. In addition, commercial activities of forest use as well as conservation policies may compete with those provided by farm households.

At farm level, agricultural supply is represented by a standard mathematical activity model. To be able to isolate the farm-firm component, the respective profit function π can be maximized subject to a farm type specific set of *n* economic and environmental constraints r_n.

$$\begin{gathered} \boldsymbol{Maximize\ \pi = f(x_n)} \\ \boldsymbol{s.t.\, g_n(x_n) \ \leq r_n;\ x_n \geq 0} \end{gathered} \tag{1}$$

Production activities cover production of food, cash crops, and the *Jatropha* value chain. All activities are distinguished with respect to the timing of land preparation, planting, weeding, pruning, and harvesting, and with respect to the technology applied. Seasonal prices, the distance to the market and to the forest, and seasonal labour scarcity, and nutrition requirements determine production, storage, transport and trade in regional markets. The specification of agricultural production is based on monthly data; this is meaningful since it considers essential constraints on the optimal farm program due to labour peaks, it also keeps in mind two or more cropping cycles per year. Important food crops are maize, beans, sweat potatoes, and cooking bananas. Major cash crops are tea, sugar cane, and sunflowers. Livestock is mainly kept for subsistence use. Indigenous dairy cattle breeds are the most important livestock. The average land holding per household in the district is a 1-2 ha, average household number is 6-7 persons, average yield of maize is about 1080 kg per ha. The distance to the market and the availability of seasonal labour pose important economic constraints on different farm household groups. Moreover, declining soil fertility, soil mining, and high fertilizer costs imply that the targeted area for planting reduces. This reveals the importance of establishing alternative local energy supply systems that can offer supplementary income opportunities for rural households and may diminish stress on primary forests. We specified a combination of activities to produce *Jatropha* oil. The processes have to be integrated into an existing farming system. Figure 3 portrays a typical farm in the Kakamega district.

Farmers minimize risk by operating a complex multi-species multi-cropping system that is adapted to micro-environmental variations such as soil conditions and varying slopes on small parcels. It is observed in the region that more labour and more complex crop mixtures are to be found where land is particularly scarce (Börner et al. 2006). However, a high level of diversity does not necessarily translate into food security once population pressure becomes severe (Conelly and Chaiken 2000).

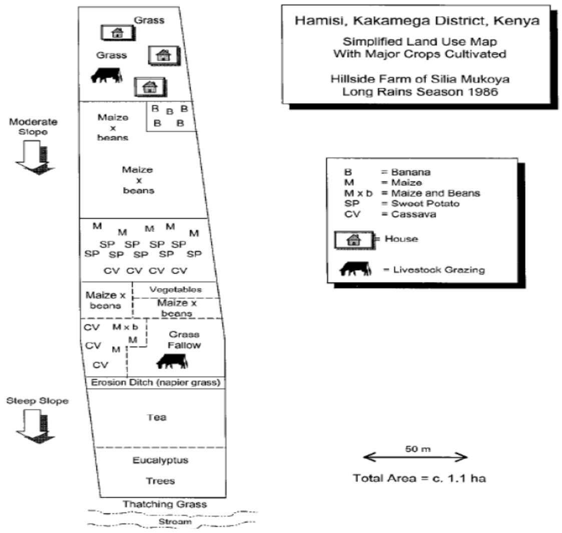


Figure 3: Simplified land use map of a typical farm in the Kakamega District

Source: Conelly and Chaiken (2000)

Principally, agricultural activities may also consider conversion of forest into agricultural land to respond to population pressure and food insecurity. In a pioneer paper, Angelsen (1999) developed a model to explain impacts of population growth, market forces and property rights on agricultural expansion and deforestation. The paper illustrates some fundamental differences of model results depending on the supposed behaviour of farm households. More precisely, it is assumed that market integration and property rights determine not only the degree but also the direction of agricultural expansion and deforestation. In the area our village model is applied to, agricultural expansion is de facto strictly prohibited. For this reason we focus on forest extraction impacts and do not depict the transformation into agricultural land. In our model, household demand is either represented by a Normalized Quadratic Expenditure System (Ryan and Wales 1999) or by a 2-stage additive Utility function (Angelsen 1999). Here, we use the additive Utility function. It includes a subsistence level of consumption $C_{subsistence}$, and an upper bound on monthly family labour availability T_{max}. The difference between maximum family labour and actual labour represents leisure; the difference between attained household income C and minimum required income $C_{subsistence}$ defines disposable surplus income of the farm household. Income is received from activities taking place on-farm, forest extraction, and off-farm labour offered by the commercial sector. The specification of the parameters α and β determines the supposed wealth state of households. A low value of parameter α means a relative low valuation of surplus consumption. Contrary, assigning a high value to α mimics a more materialistic oriented household. The expression *(1-α)* represents the marginal utility with respect to surplus consumption *(C-$C_{subsistence}$)*. Equation 2 shows the specified utility function of households.

$$Max\ U(C,T) = (C - C_{subsistence})^{\alpha} + v * (T_{max} - T)^{\beta} \quad \alpha, \beta \in (0,1), v > 0 \tag{2}$$

In accordance with economic theory, the utility function yields positive and declining marginal utility of total consumption *C* and increasing marginal disutility of labour time *T*. Total differentiation yields the shadow wage *Z*. The shadow wage *Z* represents the marginal rate of substitution between consumption and labour (see Equation 3). In case the household is completely disconnected from local food and labour markets, subsistence consumption determines a lower bound on food production. This implies also that the shadow wage *Z* becomes very low when the realized income level approaches the minimum subsistence level. We specify subsistence income for the farm types by using FAO minimum requirements for daily protein and energy intake per head. In addition, we consider basic energy requirements equivalent to 2 kg of firewood per person and day.

$$Z = -\frac{U_T}{U_C} = \frac{v*\beta*(C-C_{subsistence})^{1-\alpha}}{\alpha*(T_{max}-T)^{1-\beta}} \tag{3}$$

Using specific functional forms has important implications for model outcomes. In the two product case (here leisure and aggregate income), the utility function applied is flexible; the elasticity of *Z* with respect to an increase in productivity can take on values which are either above or below unity depending on the actually realized level of welfare. This means, different household groups may respond differently to a policy change. Including more than two independent variables, this means specifying a single-stage non-separable utility function, the *Angelsen utility functional form* will lose flexibility; a more sophisticated form such as the *Normalized Quadratic Expenditure System (NQES)* should be selected instead (Winter and Frohberg 2005). The commercial sector is assumed to behave as a price taker in a perfect neoclassical market. The commercial undertakings may encompass timber production, and tourism services. Commercial agents are assumed to maximize profits.

The forest is represented by a logistic growth model (Brander and Taylor 1997, Clark 1990, Conrad 2010). Equation 4 describes a common biological growth function considered in explaining net growth of natural resources such as forest and fish stocks.

$$G_t = F_t * r * \left(1 - \frac{F_t}{k}\right) \tag{4}$$

The variable *F* represents the state of the resource at time step *t*. The parameters *r* and *k* represent the intrinsic growth rate and the carrying capacity of the ecosystem respectively;

thus net growth G is explained by r, k and the actual state of the resource F. In the model with a conservation management regime, it is assumed that total harvest of the resource may not exceed annual net growth G of the resource F. The controller allocates the utilisation of the resource to different agents. This is specified by a weighted benefit function. The manager may set farm household specific priorities. In case of open access, the equilibrium is defined at the point at which the resource rent becomes zero. In this specific case, no environmental benefit of resource conservation is considered by the society.

To impede further deforestation and reduce human disturbance, the remaining forest fragments of the Kakamega tropical forest could be completely closed as practised by the KWS. Alternatively, the management regime may operate the incentive-based strategy by charging fees for the various permitted extraction activities. The FD provides controlled access for different forest products such as animal grazing, firewood collection, and harvesting of thatching grass (Börner et al. 2009). Outcomes of both strategies have been analysed by the model.

6.4 Potential of the Jatropha system for sustainable bioenergy production in remote rural communities

Apart from the promising characteristics attributed to the *Jatropha* oil-bearing bush, little systematic research has been done so far. Many uncertainties and knowledge gaps still exist referring to the question whether *Jatropha* can be cultivated and used for biofuel production in an environmental, social, and economic sustainable way (van der Zaan 2008). Actual published agronomic data show huge deviations, especially with respect to labour requirements during cultivation and harvesting. Figure 3 indicates the most appropriate climate conditions for *Jatropha* growing, ranging between 30°N and 35°S, including the Oil palm belt between 10°N and 10°S (Jongschaap et al. 2007).

There is hardly scepticism with respect to the ecological advantages of *Jatropha*. The plant is drought resistant, well adapted to tropical and semi-arid regions. It grows on marginal lands, capable to reclaim problematic lands, and combats desertification by restoring the vegetative cover in degraded areas thus preventing erosion due to its unique root architecture of one taproot and four laterals (Muys et al. 2007). For good yields, an average rainfall of 600-1200 mm is desirable. With annual rainfall of 1200-2000 mm, *Jatropha* production may be possible in the Kakamega district without irrigation. *Jatropha* has traditionally been used as a hedge to protect agricultural fields, and it has various medicinal and hygienic applications. The production chain additionally results in some valuable by-products such as seed cake, and fruit husks used as fertilizer or heating material. Published cost benefit calculations generally reveal acceptable gains for small-scale producers (Henning 2004). These results, however, are highly aggregated numbers, not accounting for seasonal constraints of peasant families. *Jatropha* cultivation, oil extraction, and eventual production of biodiesel occur at different scales. The UN Department of Economic and Social Affairs stresses the need to examine ways in which different scales of production and use can operate simultaneously and how they can complement and benefit from each other. Research is also needed to take into account best practices. More recently, life-cycle analysis is performed to the complete *Jatropha* chain (Prueksakorn et al. 2008). Net Energy Ratios (NER) in *Jatropha* biodiesel production yield an average NER of about 6.03; this number means energy output exceeds energy input about 6 times. The highest energy gain (NER of 11.99) could be attained if the valuable by-product, the seed cake is also used as a fuel stock. However, seed cake provides a favourable fertilizer for degraded soils substituting for expensive chemical fertilizers. In our model we will focus on the options for small-scale producers. Does the value chain fit within a remote African village, and could it replace firewood collection?

To include the chain in the farm program, we combined various sources of data, most of it stemming from field studies in sub-Saharan Africa. Family labour spent to collect firewood depends first of all on distance to the forest. We assume seven working hours per day and an average transported quantity of 15 kg per head lot (Guthiga 2007). On average, 2 kg per head and day are consumed. Hence, a 6 person household needs about 4380 kg firewood per year. At a rate of 2 km per hour, the household most adjacent to the forest may bring home 2.3 trips a day, needing about 7 hours per month to collect the firewood for the family. This time is low compared to the literature (IISD and UNEP 2005).

For cooking and lighting one person in sub-Saharan Africa requires about 55 litres of plant oil per year, equivalent to 730 kg firewood (Mühlbauer et al. 1998). It is supposed that 3 kg *Jatropha* seed can be collected per hour (Henning 2004). We further take a low oil extraction rate of 20%; 1.5 hours are needed to produce one litre of oil. Table 1 summarises the data to compare firewood collection and Jatropha processing with respect to labour time. Column 1 shows the average household size and land availability. Column 2 gives the distance to the forest in kilometres; trips per day are given in column 3. Column 4 and 5 display the calculated time per month allocated to firewood collection and plant oil production respectively.

Household type	Family size (n)	Land (ha)	Distance to forest (km)	Trips per day (n)	Wood collection (hours per month)	Jatropha collection (hours per month)
H1	4.15	0.52	1.0	2.3	7.2	8.6 (7.1)
H2	6.16	1.17	2.5	1.6	16.1	12.8 (10.5)
H3	4.47	1.38	2.5	1.6	11.7	9.3 (7.6)
H4	5.18	1.90	5.0	1.0	21.0	10.7 (8.9)

Table 1: Comparison of Firewood and *Jatropha* with respect to time (hours per month)

Source: Own calculation

The numbers indicate that household group 1 has a comparative advantage to collect wood due to a low distance to the forest. Increasing collection time implies that *Jatropha* becomes advantageous in any case due to rising opportunity costs of labour[1].

In a second step, we evaluate land use requirements for firewood and *Jatropha* plantings. Table 2 displays the estimated wooden biomass in cubic meters per ha forest land, and the yield of *Jatropha* seed per ha.

	Indigenous Forest	Woodland and Bushland	Agro-Forestry Farmland	Jatropha
Biomass m³/ha (kg/ha)*	176	18	20	3000*
Sustainable use (m/ha)	0.9	0.36	0.4	
Sustainable use (% of standing biomass)	0.5	2.0	2.0	
Sustainable use (kg/ha)	450	180	200	
Land need per person (ha)	1.62	4.06	3.65	0.1

Table 2 Comparison of Firewood and *Jatropha* with respect to land

Source: Own calculations based on Mbunga (2001)

An average standing biomass of 176 m³ per ha is estimated for Kenyan indigenous forests. The sustainable annual firewood extraction from these forests is supposed to be 0.9 m^3 per ha given the average density of wood is 500 kg per m³. Applying sustainability criteria, 450 kg may be extracted per ha of indigenous forest area. Kakamega Forest extends to approximately 24000 ha; accordingly, sustainable firewood use is about 21600 m³ in total. This quantity is equivalent to roughly 4% of total firewood required by the local population within the 5 km radius surrounding the forest. This means, 1.62 ha indigenous forest area would be needed per head in order to be sustainably harvested. In comparison, 0.1 ha Jatropha plantation land is needed to meet one person's energy needs.

[1] Compared to other regions, firewood collection time in Kakamega is pretty low. According to the IEA report (2006), distances in Tanzania to collect firewood are up to 11 km per day.

The data displayed in Table 3 show selected simulation results for group 1 representing the poorest household type. Simulation 1, 2, and 3 represent the benchmark situation, assuming differing objective functions without any *Jatropha* production in place. The first benchmark scenario minimises family labour by assuring the minimum subsistence income required to meet FAO minimum nutrition standards.

The family allocates 527 hours to labour, and about 65% of income stems from forest resources. In the second benchmark run, pure profit maximisation is supposed; now the complete disposable time is allocated to work. Wood extraction increases significantly by 43%, accordingly, forest income grows by 11%.

Household type 1	Minimizing Labour	Maximizing Gross Margin	Maximizing Utility	Minimizing Labour, No grazing	Max Gross Margin No grazing	Max Utility No grazing
Subsistence [€]	665	665	665			
Surplus [€]	0	151	127			
Labour [h]	527	700	673			
Leisure [h]	173	0	27			
Z (Shadow Wage)			0.86			
Wood [kg]	11,906	17,035	16,242	13,807	16,294	16,749
Labour [month]	1,2,3,4,7,12	All	All but 3			
Land [month]	6,7,8	6,8	6,8			
Forest Income (share)	0.65	0.76	0.70			
% Labour				+14	0	+2
% Income				0	-8	-18

Table 3: Simulation results of selected scenarios for group 1 households

Source: Own simulation results

The third benchmark run supposes maximisation of utility. We specified the *Angelsen utility function*. The endogenously determined shadow wage *Z* compares quite well to the observed daily wage paid for unskilled agricultural labour (about 0.7 € per working day in 2006). The solution resembles the profit maximization run. This outcome could be explained by the extreme poverty status of group 1 households. In the first policy scenario we restrict livestock grazing on forest glades. As a result, income sharply decreases by 18 % in the utility maximization scenario. More wood is extracted and sold on local markets to compensate for income losses caused by forbidding cattle grazing on forest glades. In the second policy scenario we prohibit any direct forest use. The model is not feasible under this policy program. This means in case strict conservation policy is expanded to the entire area of Kakamega Forest the poorest households represented by the group 1 could not secure minimum needs.

Table 4 displays simulation results for *Jatropha* scenarios. We presume that all households may hire and sell labour within the village community but cannot exchange labour with outside markets, thus the model determines endogenous farm group specific shadow values of labour (*Z*) displayed in the first row of Table 4. Furthermore, we offer community land for free, to practise *Jatropha* production. The constraints on minimum food production have to be maintained in this scenario, and any direct forest use is strictly forbidden. Results show that the least endowed farm households will cultivate *Jatropha* until seasonal labour allocated to subsistence production becomes binding[2].

Household	H1	H2	H3	H4
Z (Shadow Wage) [€]	0.52	0.69	0.68	0.72
Surplus [€]	0.6	412	401	6196
Labour [h]	699	1424	687	1220
Leisure [h]	1[3]	54	53	0.4
Utility	1	22	21	2500
Own Land [ha]	0.53	1.17	1.38	1.89
Community Land [ha]	0.44			8.12
Sold Labour [share of own labour]	Yes: 0.53	Yes: 0.84	Yes: 0.67	No: 1.8

Table 4: Simulation results for the village

Source: Own simulation results

The computed *Z-values* perfectly correspond to economic theory; *Z* is above market wage for group 4 farms, the only group hiring labour from other household groups. All other households sell labour; there subjective shadow value is below the market wage. Group 2 households sell 84% of allocated labour. The most disadvantaged group 1 households have to work hard to sustain minimum nutrition needs. *Jatropha* processing is organized by Group 4 households. Nearly the total surplus provided by the new energy system is gained by this

[2] An activity model allows farmers to respond to new technologies by changing existing agricultural practice. Farmers switch to alternative production plans of cattle husbandry to reallocate scarce resources. Time consuming cattle grazing on forest glades may move to more labour saving technologies, in case more efficient energy production systems are practised, and demand additional labour input. Income opportunities via *Jatropha* processing could take pressure away from forest land. Model results illustrate this kind of prospective leakage effects.

[3] The number 1 represents the lower bound specified in the mathematical model for computational reasons.

group. This result depends on the specified utility function; we postulated maximisation of joint utility without household-specific weights. However, the outcome reveals a crucial aspect actually claimed by critics of the *Jatropha* system. Without attendant distributional policy programs, social sustainability goals will not be achieved within the village community. Benefits will be relished by advantaged households, while forest conservation policy will significantly increase necessary labour time of poor families. The new supply chain might acquire a significant share of allocated labour, thus, the balance between food production and bioenergy production has to be directed by the government. There might not necessarily exist competition with respect to land use, however the allocation of seasonal labour is more likely to displace food production in the region.

6.5 Summary and Conclusions

Our model results validate the importance of forest income for the poorest farm household group surrounding the forest. As a consequence of banning any forest extraction, losses of these incomes in kind would be substantial. Poor households could not survive without alternative income sources. Moreover, sustainable extraction practices will not be feasible unless alternative energy sources have been broadly integrated into the current farming system. The *Jatropha* value chains may create additional income opportunities which might also lessen pressure on the forest. However more in depth agronomic research is recommended to assess the costs and benefits of different *Jatropha* value chains schemes.

The shadow value *Z* computed for the wealthiest household group lies above the rural market wage. This reveals the principal profitability of the *Jatropha* chain compared to jobs provided by the commercial sector at the market wage. Alternative utilization of oil and by-products, and the specification of additional bioenergy value chains still have to be integrated into the village model.

The findings suggest that forest management should account for the divergence the various farm household groups place on the values of different forest products. Payment for environmental-services schemes should respect household-specific opportunity costs. A part of the rent earned by common property resources should be taken for compensating disadvantaged groups and transferring capital to sustainable production alternatives. However, model outcome reveals a crucial aspect actually claimed by critics of the *Jatropha* system: Without attendant distributional policy programs, social sustainability goals will not be achieved within the village community. Benefits will be relished by the already advantaged households, while forest conservation policy will significantly increase necessary labour time of poor families.

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7 The Canola Oil Industry and EU Trade Integration: A Gravity Model Approach

Abstract

In the last years, biodiesel used for blending of fossil fuels has become prominent in European Union (EU) countries. The rapidly increasing domestic production and consumption of biodiesel is accompanied by increasing trade flows of inputs such as crude canola oil into the EU. It is questionable which factors significantly determine the trade of canola oil used for biodiesel production in the EU. Two factors are emphasised: (1) Bioenergy policies and (2) Potential trade barriers for non-EU countries. A sector-specific analysis taking industry patterns into consideration is necessary to evaluate the impact different policy instruments on trade flows. A common way to analyse trade flows is the so-called gravity model, which is applied here. Because of zero-inflated trade data, the model is expanded using the Heckman approach and augmented by spatial weights and Anderson and Van Wincoop's controls for multilateral resistance. The obtained results suggest that while the mandatory biofuel blending quota has a significant positive impact, investment subsidies cannot be shown to have any effect. Trade integration even has a trade inhibiting effect among EU members. The latter result can be explained by an exhausted domestic European market for raw and intermediate materials for biodiesel and proves stable even when controlling for sector specific variables.

7.1 The Production and Trade Situation in the Biodiesel Sector

In recent years, many developed countries emphasized the support for the production of biofuels in their political agenda (Butterbach-Bahl and Kiese, 2013). This interest in biofuels accrued mainly from the efforts for increasing national independence regarding energy supply. Specifically, governments aimed at becoming more independent from fossil fuels - due to strong fluctuations of crude oil prices - and reducing emission of greenhouse gases (Florin and Bunting, 2009). Hence, the European Union (EU) set mandatory quotas introduced by the Biofuel Directive 2003/30/EC to encourage the use of biofuel within the

European transport sector: 2% by the end of 2005, 5.75 by 2010 and 10% by 2020 (Schnepf, 2006; Lamers et al. 2011).

Further national and supranational measures followed, such as raising excise taxes or providing capital subsidies for green investments (Kutas et al., 2007). These political requirements set by the Commission at the supranational level are passed down to and enforced by the individual states at the national level. In the case of the mandatory biofuel quota, this resulted in different pathways of EU member states for the fulfilment of these requirements. For other measures the picture is even more diverse: capital subsidies and excise tax raises, for example, are fully implemented in some countries while non-existent in others (Wiesenthal et al., 2009). Transfers associated with these EU policies in support of biofuels amounted to around 3.7 billion Euros in 2006 alone (Kutas et al., 2007). However, many European member states have not succeeded in reaching their targeted blending quota yet (Charles et al. 2013).

With these market stimulating policies, Europe has quickly become the world's most important producer of biodiesel (Timilsina and Shrestha, 2011) (Figure 1).

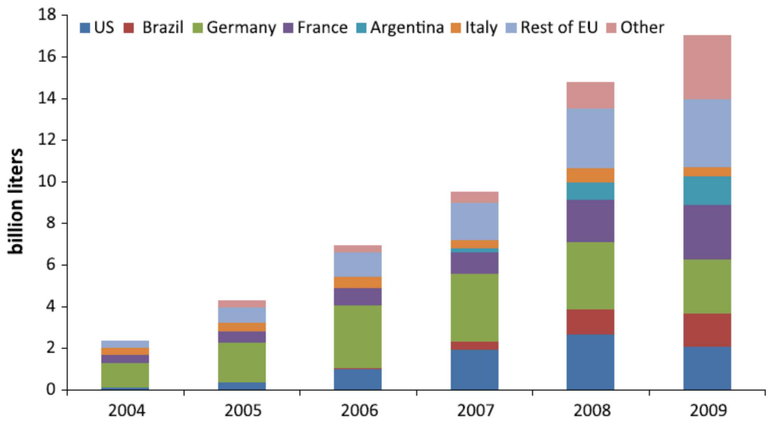

Figure 1: World Biodiesel Production 2004-2009

Source: Timilsina and Shrestha (2011)

The main biodiesel feedstock in the European Union is canola oil (Lamers et al. 2011; Firrisa et al. 2013). However, Landeweerd et al. (2012) stated that it is not very likely that the EU is not able to produce the biomass needed for biodiesel domestically at its own. Therefore, additional canola oil is imported into the EU. Indeed, the import volume of canola oil is smaller compared to other vegetable oils such as palm and soybean oil, though its relevance for the European biodiesel sector is significant (Lamers et al. 2011). Figure 2 shows the increase of canola oil imports in the past. As can be seen, the import increase can be partly attributed to the European Union, especially in the period from 2003 to 2006 when the biodiesel production in Europe soared. The political setting lead to a biodiesel market in the European Union which is mainly demand driven through the mandatory biodiesel quotas set in the transport sector. Banse et al (2008) confirmed based on a CGE model that, without policy intervention stimulating the use of biofuel crops, the mandatory blending quota will not be met.

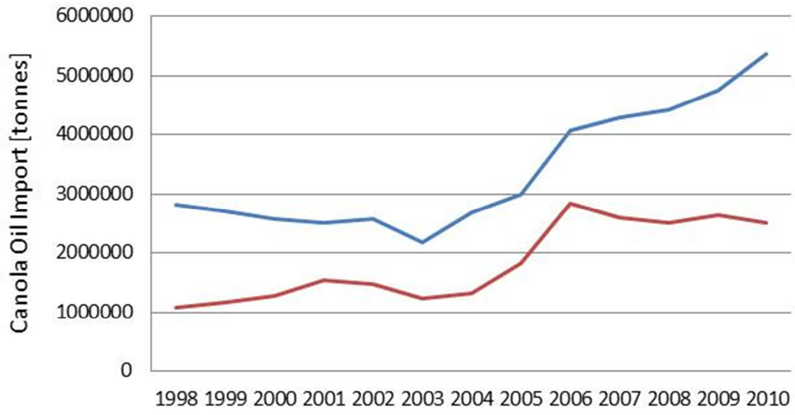

Figure 2: Canola oil import of the European Union (lower curve) in tonnes, (upper curve: World Import)

Source: FAOStat (2013)

Due to available land, labour, and favourable climate developing countries are regarded as a suitable producer and exporter of biomass (Landeweerd et al., 2012). These countries' governments, especially net importers of crude oil, value biofuels as a means for stimulating their economy and reducing the dependency on fossil fuels (Arndt et al. 2011). Although most developing countries are still lagging behind in biofuel implementation on a larger scale, they aim at participating in the production of biomass utilized for the biofuel production.

Lamers et al. (2011) hypothesised that the promotion of domestic biofuel in the EU affects the pattern of international biofuel trade. The authors assumed that import duties significantly influence trade volumes often resulting in trade barriers for less developing countries. It is obvious that being a member of the EU makes a difference for trade patterns of a country. Thus it creates a difference among members and, more importantly, between members and non-members.

The aim of this paper is to analyse the determinants of canola oil trade based on a gravity model. We assess the impact of the two important factors derived from the literature from the perspective of the European Union: trade regulations and bioenergy policies. To correctly analyse this question, biodiesel production and consumption patterns have to be taken into consideration as well. Therefore the employed gravity model is expanded with sector specific variables.

The paper is organized as follows: Section 7.2 provides an overview of the gravity model and its specification and the data set used here. Section 7.3 shows the results of the model estimations and interpretation. Based on these results, section 7.4 concludes.

7.2 Methodological Framework and Data Collection

To analyse trade relationships for canola oil, we apply the gravity model based on the Newtonian formulation of the gravitational concept. The gravity model describes the amount of trade between two countries as directly related to the size of the two countries involved and inversely related to the geographical distance between them (Bergstrand, 1985). The basic theoretical model of the gravity model on trade between two countries takes the following form:

$$X_{ij} = A\frac{M_i M_j}{D_{ij}} \qquad (1)$$

Here X_{ij} represents the trade flows in values from origin i to destination j. A is a constant of proportionality. M_i and M_j are indicators for the economic sizes of origin i and destination j, respectively, reflecting the ability to produce and consume. D_{ij} represents the distance between the trading countries. It functions as a proxy for transaction costs including transport costs which generally decrease trade.

Since the first application of the gravity model by Tinbergen (1962) and Pöyhönen (1963), its use has been justified on theoretical grounds by Anderson (1979), Deardorff (1998) and Bergstrand (1985, 1989). The model has been used for the analysis of bilateral flows as diverse as tourism (Lerch and Schulze, 2007) and migration (Afifi and Warner, 2008), but mainly for trade flows (e.g. Anders and Caswell, 2007; Martínez-Zarzoso et al., 2008; Rose, 1999). A gravity model applied to estimate the determinants of bioenergy trade has not been found in the literature yet.

The model can be expanded by other possible influential factors. However, when including other variables in equation (1), a choice has to be made between including it in a multiplicative or other form. After taking logs on both sides of the equation, a variable added multiplicatively (Siliverstovs and Schuhmacher, 2009). A variable added to equation (1), which is the power of the Euler's number, would however enter the regression as just one more summand. Compared to economic sizes of countries, it has to be determined if the new variable would automatically lead to zero trade if itself is zero. If that is the case, it would enter the gravity equation in multiplicative form. Otherwise it can be made the power of Euler's number for convenience, so it is just one more straightforward summand in the regression equation.

The flow analysed here is the import of canola oil for non-food use (TARIC: 15141110) into EU countries (EU Export Helpdesk, 2009). The data set is based on the trade data from 2006. It spans trade of 39 different countries, 23 EU members and 16 non-EU countries, leading to 1300 potential pairs of trade partners. However, by far not all of those 1300 actually trade; only 107 do. This leads to what is known as a zero-inflated dependent variable. Unfortunately, simply eliminating the irrelevant cases of non-trading pairs is not possible because there is no easy way to distinguish between relevant and irrelevant cases.

However, since this zero-inflation can be treated as a selection bias problem, it can be resolved using the method of Heckman (1979) as advised by Linders and de Groot (2006). Among the possible specifications, Martin and Pham (2008) prompt to use the 2-step-Heckman approach for this specific case. With this specification, the Heckman method calculates a selection equation in its first step. This equation tries to determine the impact of certain factors on the probability to trade canola oil at all rather than their impact on the amount traded. Consequentially, the dependent variable for this equation is a dummy which is equal to 1 if trade actually occurs between the pair and 0 otherwise. The selection equation contains the common variables 'economic sizes' and 'distance', augmented by canola seed production and regional block fixed effects, which are explained further below.

The results of the selection equation allow the calculation of the so-called inverse Mill's ratio (IMR). To counter the bias caused by the zero-inflation, the IMR can be introduced into the outcome equation, which includes the variables of interest. If it is significant, it is interpreted as an account for an assumed selection bias.

Even with this correction the outcome equation might still suffer from two more flaws. These two other possible problems are omitted multilateral resistance and spatial autocorrelation. Omitted multilateral resistance is caused by the lack of inclusion or observability of countries' alternatives to trade with a particular partner. While the amount of actual trade between two partners can be measured, the amount of potential trade occurring if certain factors of trade were different is impossible to know. This is not a new concept to the gravity model: the distance term already tries to control for the resistance to trade. However, as Anderson and Van Wincoop (2003) argue, this is not enough. There are other factors about possible trade partners which are not included in a standard gravity analysis. Therefore, they advise to use a term controlling for prices in potential other trade partner countries and transaction costs.

This would require vast amounts of data on prices, not only of goods, but also of transport and information services. Since these data are not available for the canola oil case, the proposed model here reverts to a method described in Behrens et al. (2007). Instead of calculating the omitted multilateral resistance term from a plethora of data for all countries, a fixed effects dummy is introduced for every country. This dummy is assumed to hold constant for all immeasurable factors concerning trade this country faces, thereby controlling for omitted factors causing resistance to trade.

By the assumption, these dummies rather serve as indicators for having trade at all than having more or less trade. Therefore, they are introduced in the selection equation rather than the main regression. Instead of using these country fixed effects as proposed by Behrens et al. (2007), the selection equation contains effects for country blocks. This is done to save degrees of freedom and essentially does not yield results very different from the use of country fixed effects due to the composition of countries in our data set.

Unlike multilateral resistance, which deals with the availability of trade alternatives, a further possible problem, spatial autocorrelation, deals with trade similarities. This kind of autocorrelation stems from being part of a cluster of traders or, conversely, being remote from clusters. As suggested by Porojan (2001), to correct for the part of trade that is explained by being part of a cluster, spatial weights are included in the gravity model. These weights summarize the relationship of the importer to all its trade partners relative to all other trade partners. They are used to weigh the dependent variable, which is then introduced as another right hand-side variable. Thus the part of trade caused by the importer being part of a cluster is controlled for. The most relevant kind of cluster is a geographical one. Therefore, the model here includes distance weights. Distance weights are $w_{ij} = (1/d_{ij})/(\sum 1/d_{ij})$. Here d_{ij} is the distance between the importer i and the exporter j and therefore the sum is the sum of distances between the importer i and the exporters j.

Additionally to distance, measured in kilometres according to a geographical approach developed in Mayer and Zignago (2006), the previously described IMR, country fixed effects and weighted trade values, the two regressions contain the following variables.

The total GDPs in current dollars taken from the IMF (2009) are used to account for the economic sizes of the trade partners in the selection equation. In the outcome equation total GDP of the exporter is replaced by the total GDP produced by agriculture, taken from

Earthtrends (2007). The size of the agricultural industry reflects the ability to produce and therefore export canola better than the less related total GDP. If both countries of the pair are members of the EU in 2006, the 'EU Both Dummy' is equal to 1 and 0 otherwise. There are two variables indicating political intervention. The first, biofuel quota, is compiled using mainly the REN21 (2009) database and Kutas et al. (2007), complemented by individual country data, for a mandatory quota for the amount of biodiesel that has to be blended with conventional diesel. The second is a dummy indicating if a capital subsidy for green energy projects exists taken again from the REN21 database. Furthermore, the model includes three variables describing the biofuel industry. Production cost ratio is an indicator for the disparity between the costs of production in the respective countries in a given pair. The data stem from Johnston and Holloway (2007). Canola seed production and biofuel consumption in the transport sector are indicators for the size of the respective parts of the value chain. Numbers for canola seed production were taken from FAOSTAT (2009) and biofuel consumption data stem from IEA (2009). Adding the error term leaves the outcome regression as follows, with the index i denoting importer and j denoting exporter of the observed pair:

$$
\begin{aligned}
\text{Canola Import}_{ij} = \quad & a \\
& + \beta_1 \text{ log GDP}_i \\
& + \beta_2 \text{ log Agricultural GDP}_j \\
& + \beta_3 \text{ log Distance}_{ij} \\
& + \beta_4 \text{ EU Both Dummy}_{ij} \\
& + \beta_5 \text{ Biofuel Quota}_i \\
& + \beta_6 \text{ Subsidy Dummy}_i \\
& + \beta_7 \text{ log Production Costs Ratio}_{ij} \\
& + \beta_8 \text{ Canola Seed Production}_i \\
& + \beta_9 \text{ Canola Seed Production}_j \\
& + \beta_{10} \text{ Biofuel Consumption Transport}_i \\
& + \beta_{11} \text{ Biofuel Consumption Transport}_j \\
& + \beta_{12}\, w_{ij} * \text{log Canola Import}_{ij} \\
& + \beta_{13} \text{ Inverse Mill's Ratio}_{ij} \\
& + e_{ij}
\end{aligned}
\qquad (2)
$$

To prevent skewing of results through outlying observations, the most likely candidates identified by both a QQ-plot and Cook's distance are removed. Moreover, the models are tested for heteroscedasticity with a Breusch-Pagan test and for multicollinearity using the variance inflation factor. The goodness of fit is verified by the Akaike’s information criterion.

7.3 Results

The results of the selection equation are shown in table 1 in order to identify the variables explaining the (non)-participation in canola oil trade. The coefficient for the exporter's as well as the importer's GDP are positive and significant. From the point of view of the importer, this suggests that the size of the economy has a pull effect on the probability of canola oil import. Similarly the GDP of the exporter countries is according to the expectation acting as a proxy of national economic output expressed in monetary units. As expected, distance has a significant negative effect on the probability of canola oil trade. This is consistent with the usual interpretation of the distance variable as a proxy for transaction costs: A longer route between two places will cause larger travel costs and is often also associated with other transaction costs such as costs of communication and information to bridge geographical, cultural and linguistic divides.

Dependent Variables	Independent Variable: Existence of Intern. Canola Trade (1=yes)	
	Coefficient	**t-value**
Intercept	3.09 ***	3.72
Log GDP_i	0.40 ***	8.13
Log GDP_j	0.31 ***	6.03
Log $Distance_{ij}$	-1.18 ***	-10.18
Block North $America_j$	1.35 ***	3.83
Block South $America_j$	1.44 **	2.52
Block Non-EU-$Europeans_j$	0.27	1.33
Block $Asia_j$	1.43 ***	2.99
Block $Africa_j$	1.76 ***	4.85
Log Canola Seed $Production_i$	-0.04 *	-1.72
Log Canola Seed $Production_j$	0.02	0.79
Adjusted R^2	0.34	
AIC	492.60	
N	1295	

Denotation: i = importer, j = exporter
*Significant at 10%, **Significant at 5%, ***Significant at 1%

Table 1: Selection Equation of the Heckman Model

Source: Own calculation

All regional 'block'-variables controlling for fixed-effects have a positive significant effect on the probability of canola oil trade except for an insignificant non-EU-European Block representing European countries not being a member of the European Union. This might be surprising since being closer to the EU should lead to a higher probability for trade relationships between non-EU Europeans and EU countries. However, large parts of this effect are taken up by the distance variable already. Exporters’ production of canola seeds for canola oil has no significant effect on the probability to export canola oil, whereas the importers' production of seeds decreases the probability of importing canola oil.

The results of the second step - the outcome equation - of the gravity model are shown in table 2. The outcome equation is used to estimate the determinants affecting the amount of the actual trade volume. The sample size for the sample of trading pairs is 107. Nine outliers needed to be dropped due to an unduly high influence on the outcome of the estimation process according to QQ-Plots and Cook's Distance. The dependent variable is the log-transformed import volume in Euro.

The Global Moran's I statistic as a measure for spatial autocorrelation in the data set suggests negative spatial correlation. To correct for the spatial autocorrelation, the variable 'value weighted distance' has been included in all four models. It uses a distance related weight on the trade value. The results show that 'value weighted distance' is robust and significant. Therefore we can conclude that cluster effects exist and are controlled for.

Variables	**Basic Gravity Model**		**+ Trade Integration Effect**		**+ Biofuel Policy Effect**		**+ Value Chain Effect**	
Dependent Variable	Log (Import Value Canola Oil)							
	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
Intercept	4.89^{***}	2.51	9.40^{***}	3.92	9.14^{***}	4.02	11.15^{***}	4.99
Log GDP_i	0.23	1.20	0.39^{**}	2.04	0.23	1.20	0.19	0.75
Log Agricultural GDP_j	-0.01	-0.09	0.06	0.34	0.01	0.06	-0.22	-1.19
Log $Distance_{ij}$	1.04^{***}	3.61	0.40	1.15	0.26	0.83	-0.04	-0.12
EU $Both_{ij}$ Dummy			-1.83^{***}	-3.00	-1.98^{***}	-3.51	-1.67^{***}	-3.05
Biofuel $Quota_i$					0.90^{***}	2.87	0.85^{***}	2.79
Subsidy $Dummy_i$					0.98	1.22	1.18	1.45
Log Product. Costs $Ratio_{ij}$							0.89	0.86
Canola Seed $Production_i$							$-4.59\cdot10^{-07*}$	-1.88
Canola Seed $Production_j$							$1.72\cdot10^{-07**}$	2.04
Biofuel Cons. $Transport_i$							$8.65\cdot10^{-04***}$	2.64
Biofuel Cons. $Transport_j$							$1.30\cdot10^{-04**}$	2.10
Value Weighted $Distance_{ij}$	$4.16\cdot10^{-06***}$	6.39	$4.09\cdot10^{-06***}$	6.54	$3.79\cdot10^{-06***}$	6.72	$3.21\cdot10^{-06***}$	5.68
Inverse Mill's $Ratio_{ij}$	-0.64^{**}	-2.37	-0.59^{**}	-2.27	-0.58^{**}	-2.46	-0.50^{**}	-2.20
Adjusted R²	0.13		0.15		0.20		0.24	
AIC	429.59		429.22		408.94		402.12	
Breusch-Pagan Test	insignificant		insignificant		insignificant		insignificant	
Global Moran's I Test	-0.28							
N	N=98		N=98		N=98		N=98	

Denotation: i = importer, j = exporter
*Significant at 10%, **Significant at 5%, ***Significant at 1%.

Table 2: Outcome equation: Determinants of Canola Oil Import to the European Union

Source: Own calculation

As indicated in all four estimations by a significant coefficient for the IMR, zero-inflation caused omitted variable bias and was countered by introducing the IMR. It also carries the country fixed effects from the first stage into the second stage of the regression.

The first estimation shown in table 2 represents the basic gravity model including only total GDP of the importer and the agricultural GDP of the exporter and the distance between them. Here, only the distance as a measure for transaction costs has a significant impact on trade and interestingly exhibits a positive coefficient. As opposed to the selection model result, distance does not seem to act as a barrier in terms of additional costs due to transportation and other distance-related transaction cost. An economic explanation could be economics of scale in terms of production and transportation costs.

The GDP of the importer and the agricultural GDP of the exporter country are insignificant. In the case of the importer's GDP this is not surprising since GDP is a very broad indicator for the economic size included in an analysis for a very specific sector. However, the GDP generated only from the agricultural sector in the exporter country has no significant effect on the trade volume either. In conclusion, the basic gravity model, even with further specifications, does not seem to explain trade well. That is also reflected in the relatively low adjusted R^2 of 13 per cent.

In the second model, the dummy variable for EU trade integration, 'EU Both Dummy' is added. A negatively significant coefficient indicates that the trade volume is higher if one of the partners is a non-EU country. This is a sign that the border effect of the European Union seem not to be a trade inhibitor for trade partnership of two EU countries but rather for a non-EU/EU-partnership. That is consistent with the interpretation of the distance coefficient of the first outcome equation: it indicates that higher transaction costs due to distances and tariffs play a minor role in the trade volume. After all, if both countries are in the EU it also means that they are close neighbours, which was captured by distance before the introduction of the new dummy. Therefore, once this effect is taken up by the newly introduced ‘EU Both’ Dummy, distance becomes insignificant. This is the opposite compared to the findings of Salamon et al. (2006) who found for the European ethanol market trade diverting effects. In particularly, regional agreements reduce the linkage to international markets and increase the intra-European trade. In the case of biodiesel, the production input canola oil seems to be scarce, wherefore a trade protection would threaten the European biodiesel industry.

In the third model, biofuel quotas and a dummy for the existence of subsidizing the green industry are introduced to gauge the effect of political measures. Biofuel quotas have a positive and significant coefficient whereas the dummy for a subsidization of the green industry in the importer country is not significant. The result concerning the quota is expected since the quotas are clearly defined and their ultimate goal demands an increase in production and consumption of biodiesel. Naturally that would lead to increased imports of intermediate products, too. The insignificance of the subsidy dummy could be due to the summary of very diverse subsidization schemes that are not even necessarily targeted at bioenergy in just one dummy variable. A variable that is more differentiated might have yielded a clearer result.

Lastly, the fourth and best specified model controls for up- and down-streamed value chain stages of the biodiesel chain. To avoid multicollinearity between the possible value chain variables and endogeneity with the dependent variable, we introduced only the two extreme ends of the biodiesel chain instead of variables for the whole chain: the production of raw material, for which canola seed production is a proxy, on the one hand and the consumption of the product, for which liquid biofuel consumption for transport is a proxy, on the other hand. Both parts of the value chain are assumed to affect the trade of canola oil: raw material because of its role for sector specific supply and liquid biofuel consumption for its role for sector specific demand. For the value chain stages, all coefficients for the importer and exporter countries are significant and have the expected sign, except for the biodiesel consumption of exporter countries exhibiting a positive coefficient. This indicates that the demand in biodiesel for transport of exporter countries might have an effect on a high level of canola oil production which is not only being consumed but also exported. However, the coefficient of the importer's biodiesel transportation sector is much higher, indicating that the pull is stronger on the importer side due to a higher biodiesel consumption level.

7.4 Summary and Conclusions

The main objective of this analysis is to identify the effect of different EU policies on the canola oil import of the European Union and the trade integration of non-EU member countries. The estimation results show a negative coefficient for the EU trade integration dummy. This indicates that even though EU trade integration has been set up to foster trade among members, in the case of canola oil, EU members do rather import from outside. This negative relationship could possibly be explained by the import pull caused by exhausted input production of canola oil in the biodiesel value chain. The magnitude of a mandatory biofuel quota showed a significantly positive influence on the import of canola oil. Though not surprising, it reinforces the interpretation that demand of biodiesel is policy driven and the demand for raw or intermediate inputs for biodiesel production cannot be satisfied within the EU. Therefore these intermediates have to be imported from non-EU countries. Accordingly the answer to our research question is that 1) political measures seem to have a positive influence on trade whereas 2) the EU trade integration cannot be found to have an inhibiting effect on canola oil trade.

Apart from these results, we have to withhold judgement on the effect of further political measures since the coefficient for a green investments subsidy dummy was insignificant. This warrants a closer look at the specific kinds of different political measures and their effectiveness.

In contrast to the interpretation of distance based on the outcome equation, the decision whether to import canola oil at all is significantly negatively affected by distance, as can be seen in the selection equation. Here, a closer look at economies of scale and resource scarcity in the importer country needs to be taken. The value chain structure, which also affects the trade volume of canola oil, has to be taken into account as well.

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Appendices

Appendix A: Disaggregated Social Accounting Matrix

	Village SAM, Tandai, Tanzania 2009		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1		Banana (raw)																														
2		Pineapple (raw)																														
3		Banana (processed)																														
4		Pineapple (processed)																														
5		Maize (raw)																														
6		Rice (raw)																														
7		Maize (processed)																														
8		Rice processed)																														
9		Cassava																														
10		Cassava flour																														
11		Sugarcane																														
12		Vegetables																														
13		Beans																														
14		Beans (processed)																														
15		Cocoyam																														
16		Magimbi																														
17		Sweet potatoe																														
18		Groundnuts																														
19		Groundnuts (processed)																														
20		Kaupis																														
21		Kaupis (processed)																														
22		Ginger																														
23		Black pepper / vanilla on JATROPHA																														
24		Black pepper / vanilla dried																														
25		Mango trees																														
26	Activities	Avocado trees																														
27		Coconut trees																														
28		Citrus/Orange trees																														
29		Breadfruit trees																														
30		Coffee trees																														
31		Jackfruit trees																														
32		Clove trees																														
33		Cinnemon trees																														
34		Mango (processed)																														
35		Coconut (processed) ropes																														
36		Citrus/Orange (processed)																														
37		Coffee (processed)																														
38		Non-Food producing trees																														
39		Nursery																														
40		Livestock (Meat)																														
41		Household Chorus																														
42		unskilled agric. Work (employed)																														
43		Agric TAC																														
44		Work unskilled																														
45		Work Trade / business																														
46		Business TAC																														
47		Work manufacturing																														
48		Charcoal Trade																														
49		Making Bricks																														
50		Firewood from Agroforestry																														
51		Firewood from other public forests																														
52		Leisure																														
53		Banana (raw)			17423																											
54		Pineapple (raw)				51																										
55		Banana (processed)																														
56		Pineapple (processed)																														
57		Maize (raw)							20867																							
58		Rice (raw)								40457																						
59		Maize (processed)																														
60		Rice (processed)																														
61		Cassava										1010																				
62		Cassava flour																														
63		Sugarcane																														
64		Sugar																														
65		Vegetables																														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
67	66	Commodities	Beans														6165
68	67		Beans (processed)														
69	68		Cocoyam														
70	69		Magimbi														
71	70		Sweet potatoe														
72	71		Groundnuts														
73	72		Groundnuts (processed)														
74	73		Kaupis														
75	74		Kaupies (processed)														
76	75		Ginger														
77	76		Black pepper / vanilla														
78	77		Black pepper / vanilla dried														
79	78		Mango														
80	79		Avocado														
81	80		Coconut														
82	81		Citrus/Oranges														
83	82		Breadfruit														
84	83		Coffee														
85	84		Jackfruit trees														
86	85		Clove														
87	86		Cinnemon														
88	87		Mango (processed)														
89	88		ropes from coconut husks														
90	89		Citrus (processed)														
91	90		Coffee (processed)														
92	91		Meat														
93	92		Honey														
94	93		young trees jatropha														
95	94		young trees other than jatropha														
96	95		Bricks														
97	96		Firewood														
98	97		Charcoal														
99	98		Jatropha seeds														
100	99		Kerosene / Petrol / Diesel /														
101	100		HH Chore														
102	101		HH Leisure														
103	102		Clothes footware														
104	103		Care products														
105	104	Factors	Family labor	109137	7430	3175	17	9442	35808	848	2855	265	538	2	786	5069	183
106	105		Hired labor	10174	2348	310	0	391	548	900	382	783	0	0	31	125	12
107	106		agric. Profit	102665	31777	0	0	10859	506	0	0	12702	0	921	1077	9979	0
108	107		Other Inputs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109	108		Seeds	7582	8365	0	0	1567	7364	0	0	817	0	7	65	5316	0
110	109		Firewood	0	0	546	0	0	0	0	0	0	0	0	0	0	0
111	110		Pesticides	5	3	0	0	1	2	0	0	3	0	0	1	1	0
112	111		Rent upland	0	0	0	0	116	164	0	0	3	0	0	5	107	0
113	112		Upland	2074	49	0	0	1122	718	0	0	35	0	0	38	747	0
114	113		Rent Lowland	91	11	139	0	43	289	0	0	10	0	0	5	141	0
115	114		Lowland	3684	358	0	0	986	1702	0	0	54	0	0	76	949	0
116	115	Capital Account	Seeds														
117	116		Cash														
118	117		Upland														
119	118		Lowland														
120	119		private Tree Stock														
121	120		Public forest														
122	121	Households	low income hh (n=102)														
123	122		middle income hh (n=111)														
124	123		high income hh (n=71)														
125	124	NGO															
126	125	Government (Tax)															
127	126	School															
128	127	Health_sector															
129	128	Church															
130	129	Transaction costs (TAC)		36546	8729	0	0	3740	8381	0	0	2379	0	160	371	3538	0
131	130	Rest of the village (ROV)															
132	131	Rest of the world (ROC)															
133	132	Total		**271958**	**59070**	**21592**	**68**	**28268**	**55481**	**22615**	**43693**	**17051**	**1548**	**1091**	**2454**	**25973**	**6360**
134	133	Water		0	0	0	0	200	0	0	0	30000	0	0	0	0	0
135				**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

	A	B	C	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
67	66	Commodities	Beans																
68	67		Beans (processed)																
69	68		Cocoyam																
70	69		Magimbi																
71	70		Sweet potatoe																
72	71		Groundnuts					468											
73	72		Groundnuts (processed)																
74	73		Kaupis							403									
75	74		Kaupies (processed)																
76	75		Ginger																
77	76		Black pepper / vanilla										1344						
78	77		Black pepper / vanilla dried																
79	78		Mango																
80	79		Avocado																
81	80		Coconut																
82	81		Citrus/Oranges																
83	82		Breadfruit																
84	83		Coffee																
85	84		Jackfruit trees																
86	85		Clove																
87	86		Cinnemon																
88	87		Mango (processed)																
89	88		ropes from coconut husks																
90	89		Citrus (processed)																
91	90		Coffee (processed)																
92	91		Meat																
93	92		Honey																
94	93		young trees jatropha																
95	94		young trees other than jatropha																
96	95		Bricks																
97	96		Firewood																
98	97		Charcoal																
99	98		Jatropha seeds																
100	99		Kerosene / Petrol / Diesel /																
101	100		HH Chore																
102	101		HH Leisure																
103	102		Clothes footware																
104	103		Care products																
105	104	Factors	Family labor	2415	247	495	339	16	335	21	82	1165	59	7973	400	4769	2177	1172	570
106	105		Hired labor	125	78	110	78	0	78	0	0	626	0	0	0	157	0	0	0
107	106		agric. Profit	8019	1017	1473	318	0	512	0	120	6504	0	3902	690	40614	-269	2379	5234
108	107		Other Inputs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109	108		Seeds	359	0	430	347	0	139	0	33	62	0	35	1	183	36	8	9
110	109		Firewood	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111	110		Pesticides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
112	111		Rent upland	0	0	5	18	0	4	0	0	1	0	0	0	0	0	0	0
113	112		Upland	19	61	48	43	0	54	0	9	33	0	188	5	238	25	35	32
114	113		Rent Lowland	2	0	10	18	0	6	0	0	2	0	8	3	16	5	1	1
115	114		Lowland	23	61	59	43	0	58	0	114	97	0	97	27	689	154	153	20
116	115	Capital Account	Seeds																
117	116		Cash																
118	117		Upland																
119	118		Lowland																
120	119		private Tree Stock																
121	120		Public forest																
122	121	Households	low income hh (n=102)																
123	122		middle income hh (n=111)																
124	123		high income hh (n=71)																
125	124	NGO																	
126	125	Government (Tax)																	
127	126	School																	
128	127	Health_sector																	
129	128	Church																	
130	129	Transaction costs (TAC)		1738	163	394	187	0	189	0	52	497	0	1439	56	3488	260	325	293
131	130	Rest of the village (ROV)																	
132	131	Rest of the world (ROC)																	
133	132	Total		**12700**	**1628**	**3025**	**1392**	**484**	**1376**	**424**	**410**	**8988**	**1403**	**13642**	**1182**	**50155**	**2388**	**4073**	**6159**
134	133	Water		0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0
135				**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**

	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP
1	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
2																							230301												
3																								47585											
4																									20117										
5																										0									
6																											24247								
7																												42877							
8																													2354						
9																														2308					
10																															12592				
11																																857			
12																																	892	0	
13																																			3627
14																																			
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	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP
67																																			
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81					240																														
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84							1840																												
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104																																			
105	1949	7093	17857	14	60	26	104	3920	1154	166	987	2970	1373	2956	31157	2220	7145	300	0	14175	2836	0													
106	0	0	0	0	0	0	0	0	2124	0	0	0	0	0	0	0	0	0	9120	0	0	0													
107	1618	-8017	-17499	0	0	0	0	26652	85	3765	0	0	0	0	0	0	0	240	0	-14648	-2984	0													
108	0	0	0	0	0	0	0	0	1126	0	0	0	0	0	0	0	0	0	0	0	0	0													
109	6	136	701	0	0	0	0	1014	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1920	0	0	0													
111	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
113	54	325	1068	0	0	0	0	1206	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
114	39	0	148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
115	1006	1184	2469	0	0	0	0	1696	15	0	0	0	0	0	0	0	0	0	0	0	0	0													
116																																			
117																																			
118																																			
119																																			
120																				95186															
121																					5330														
122																																			
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125																																			
126																							5576	1152	487	0	587	1038	57	56	305	21	22	0	39
127																																			
128																																			
129																																			
130	293	47	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	473	148		7378	1524	644	0	777	1374	75	74	403	27	29	0	52
131																							0	0	0	0	0	0	0	0	0	0	0	0	1607
132										1960								6104					0	0	0	0	0	0	22607	68914	0	42884	0	20850	14027
133	**4967**	**768**	**4896**	**66**	**300**	**61**	**1943**	**34488**	**4505**	**5891**	**987**	**2970**	**1373**	**2956**	**31157**	**2220**	**7145**	**6644**	**11040**	**95186**	**5330**	**0**	**243255**	**50262**	**21248**	**0**	**25611**	**45288**	**25094**	**71352**	**13300**	**43789**	**942**	**20850**	**17353**
134	0	0	0	0	0	0	0	0	52000	0	0	0	0	0	0	0	0	0	0	0	0	0													
135	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**

	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY
1	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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14	17545																																		
15		3402																																	
16			9368																																
17				1485																															
18					1695																														
19						1134																													
20							474																												
21								646																											
22									176																										
23										392																									
24											3643																						276		
25												1392																							
26													7546																						
27														343																					
28															17581																				
29																1667																			
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31																		2274																	
32																			517																
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34																					1026														
35																						26													
36																							300												
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49																																6344			
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	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY
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125																																			
126	425	82	227	36	41	27	11	16	4	9	88	34	183	8	426	40	37	55	13	8	25	1	7	1	47	58	2	0	0	0	0	0	0	0	0
127																																			
128																																			
129																																			
130	562	109	300	48	54	36	15	21	6	13	117	45	242	11	563	53	49	73	17	10	33	1	10	2	62	77	2	0	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132	0	17465	0	73	384	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19138	0	0	0	0	43758	15594	0	22037	0
133	**18531**	**21058**	**9895**	**1641**	**2175**	**1198**	**500**	**682**	**186**	**414**	**3848**	**1470**	**7970**	**362**	**18569**	**1760**	**1599**	**2402**	**546**	**329**	**1084**	**27**	**317**	**52**	**2042**	**21690**	**82**	**783**	**3722**	**11040**	**56810**	**21938**	**276**	**22037**	**0**
134																																			
135	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**

	CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE	EF	EG
1	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	
2															6517				0		8819	15769	10552							0	0	271958		1
3															6818				0		1729	1933	1005							0	0	59070		2
4															0				0		140	1026	309							0	0	21592		3
5															0				0		0	58	10							0	0	68		4
6															756				0		1795	485	985							0	0	28268		5
7															4470				0		2830	4095	1210							0	0	55482		6
8															0				0		3359	7555	9347							0	0	22615		7
9															0				0		15664	14084	11637							0	0	43693		8
10															558				0		738	2383	780							0	0	17051		9
11															0				0		360	243	87							0	0	1548		10
12															5				0		58	90	46							0	0	1091		11
13															28				0		245	370	183							0	0	2454		12
14															2968				0		966	2130	2364							0	0	25973		13
15															0				0		1104	1278	576							0	0	6360		14
16															318				0		633	1805	576							0	0	12700		15
17															0				0		11	0	132							0	0	1628		16
18															235				0		115	490	490							0	0	3025		17
19															120				0		0	42	96							0	0	1392		18
20															0				0		6	0	4							0	0	484		19
21															67				0		177	133	353							0	0	1376		20
22															0				0		62	168	18							0	0	424		21
23															0				0		2	0	16							0	0	410		22
24															7				5043		14	2	3							0	0	8988		23
25															0				0		4	2	5							0	0	1403		24
26															14				2938		1260	1108	776							0	0	13642		25
27															1				773		12	36	18							0	0	1182		26
28															139				25305		1873	2538	2720							0	0	50155		27
29															12				363		80	117	150							0	0	2388		28
30															6				1568		301	360	325							0	0	4073		29
31															0				3885		0	0	0							0	0	6159		30
32															4				3518		342	283	303							0	0	4967		31
33															44				385		6	1	20							0	0	768		32
34															337				3493		1	0	40							0	0	4897		33
35															0				0		0	41	0							0	0	66		34
36															0				0		0	0	0							0	0	300		35
37															0				0		0	12	0							0	0	61		36
38															0				0		0	10	0							0	0	1943		37
39															0				34410		0	0	0							0	0	34488		38
40															0				0		0	0	0							0	0	4505		39
41															0				0		974	1360	1141							0	0	5891		40
42															0				0		349	363	275							0	0	987		41
43															0				0		0	0	0							2950	20	2970		42
44																			0		0	0	0							1148	225	1373		43
45															0				0		0	0	0							2936	20	2956		44
46															0				0		0	0	0							24227	6930	31157		45
47																			0		0	0	0							500	1720	2220		46
48															0				0		0	0	0							4440	2705	7145		47
49															0				0		0	0	0							300	0	6644		48
50															0				0		0	0	0							0	0	11040		49
51															0				0		30264	34892	16978							0	0	95186		50
52															0				0		1196	1352	2782							0	0	5330		51
53															0				0		0	0	0							0	0	0		52
54																					0	0	0	0						78075	147757	243255		53
55																					0	0	536	0						17918	31756	50262		54
56																					0	0	0	0						7187	14061	21248		55
57																					0	0	0	0						0	0	0		56
58																					0	871	0	0						3873	0	25611		57
59																					0	0	0	0						2831	2001	45288		58
60																					12726	0	12368	0						0	0	25094		59
61																					7434	46345	17573	0						0	0	71352		60
62																					0	0	0	0						6940	5350	13300		61
63																					0	37033	6756	0						0	0	43789		62
64																					0	0	0	0						283	659	942		63
65																					7432	871	12546	0						0	0	20850		64
66																					4179	9163	3921	0						0	89	17353		65

	CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE	EF	EG
67																					0	0	0	0						9196	3170	18531		66
68																					5063	9903	4820	0						0	1272	21058		67
69																					0	0	0	0						5525	4370	9895		68
70																					0	0	878	0						0	763	1641		69
71																					0	1141	0	0						0	1033	2175		70
72																					0	0	0	0						477	253	1198		71
73																					0	0	0	0						213	287	500		72
74																					0	0	0	0						199	80	682		73
75																					0	0	0	0						0	186	186		74
76																					0	0	0	0						414	0	414		75
77																					0	0	0	0						570	1933	3848		76
78																					0	0	0	0						0	1470	1470		77
79																					0	0	0	0						2884	5035	7970		78
80																					0	0	0	0						253	109	362		79
81																					432	7182	0	0						1176	9540	18569		80
82																					0	0	5	0						697	1023	1760		81
83																					0	0	0	0						1540	59	1599		82
84																					0	0	0	0						0	562	2402		83
85																					0	0	0	0						486	59	546		84
86																					0	0	0	0						0	329	329		85
87																					0	0	0	0						0	1084	1084		86
88																					0	0	0	0						27	0	27		87
89																					0	0	0	0						317	0	317		88
90																					0	0	0	0						0	52	52		89
91																					0	0	0	0						0	2042	2042		90
92																					2928	6314	12447	0						0	0	21690		91
93																					0	0	0	0						82	0	82		92
94																					200	524	59	0						0	0	783		93
95																					174	331	864	452						1156	744	3722		94
96																					0	0	0	0						11040	0	11040		95
97																					5096	39364	12350	0						0	0	56810		96
98																					8037	5391	8509	0						0		21938		97
99																					0	0	0	0						0	276	276		98
100																					6215	7366	8455	0						0	0	22037		99
101																					0	0	0	0						0	0	0		100
102																					75079	41097	19009	0						0	0	135185		101
103																					7665	9625	9905	0						0	0	27195		102
104																					6065	8291	6181	0						0	0	20537		103
105																																296255		104
106																																28500		105
107																																230211		106
108																																1126		107
109																																34582		108
110																																2466		109
111																																20		110
112																																423		111
113																																8226		112
114																																990		113
115																																15774		114
116								34582																								34582		115
117																					-39866	-67038	9899								178112	81107		116
118																																0		117
119																																0		118
120																					-15654	-29056	31202									81678		119
121																																5330		120
122	75079			66736		32334					190	1559	398	4430		0			0		4154				316						2061	187257		121
123	41097			119909		77896					128	4013	345	6390		0			0			5958			0						1694	257430		122
124	19009			109610		119982					105	2654	247	4954		0			0				6070		2572						2042	267245		123
125																														0	452	452		124
126	0	0	0																		612	678	450								2888	15879		125
127																					5328	7636	5494									18458		126
128																					5054	7319	5624									17996		127
129																					2016	2775	1726									6517		128
130	0	0	0																													88924		129
131	0	20110	19087	0	21224	0	0	0	2466	0	0	0	0	0	8446	81107	0	0	0	0	0	0	0	0	0	0	0	6517	29297	0	0	189860		130
132	0	7085	1450	0	7275	0	1126	0	0	20	0	0	0	0	2712	0	0	0	0	5330	1401	1729	3283	0	12991	18458	17996	0	59627	0	0	436276		131
133	**135185**	**27195**	**20537**	**296255**	**28500**	**230211**	**1126**	**34582**	**2466**	**20**	**423**	**8226**	**990**	**15774**	**34582**	**81107**	**0**	**0**	**81678**	**5330**	**187257**	**257430**	**267245**	**452**	**15879**	**18458**	**17996**	**6517**	**88924**	**189860**	**436276**	**4197406**		**132**
134																					2902	3387	2648											**133**
135	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**	**133**	

Appendix B: Questionnaire of the Household Survey, Tandai Village, Tanzania.

Section 1 Master-Fragebogen english

Tabelle t_hh

The Reference period for all questions is always the last Masika and Vuli rain season from March 2009 to Febuary 2010 (12 months!!!)

Filled in by enumerators

1	Interviewer	1001
3	Name of the key respondent	1003
5	Name of the household	1005
2	Subvillage	1002

12 Notes 1012

filled out in Germany

11	Questionnaire number	1011
10	Person Data entered	1010
4	Respondent ID	1004
6	Household ID	1006

GPS Coordinates South 1007a; East 1007b

Altitude 1008

Questionnaire Language 1013

Interview Date 1009

1

Section 2: HH Member Tabelle: t_mem

0	1	2	3	4	5	6	7	8	9	10
ID	*Please give me a list of all individuals you consider members of this households.*	Who is the household head?	Gender	Age in years	How many months does ... stay in this household in the last Masika and Vuli rain season?	Number of years of schooling	Who is currently enrolled in school?	What was the amount of school expenses ... in the last Masika and Vuli rain season?	When did the household head first work on his nown farm?	In which of the agricultural and household activities ... is involved?
			Codes:				**Codes:**	**Codes:** *for each hh member enrolled in school*	**Codes:** *ask only for the household head*	**Codes:** *1= related to homestead* *2= related to own field work* *3= related to livestock keeping* *4= related to shopkeeping / selling* *5= school*
2000	*First Name, Surname*	*Mark the household head with X*	*1 = male* *2 = female*	*years*	*months*	*years in school*	*0=no* *1=yes*	*TZS per year*	*year*	
HHM1	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
HHM2										
HHM3										
HHM4										
HHM5										
HHM6										
HHM7										
HHM8										
HHM9										
HHM10										

Hinzugefügt: Number of member
Anyone Off-farm employed } Tabelle t-hh

[Better-IS] Householdsurvey Tanzania 2

Tabelle: t_mem *OFF-FARM EMPLOYMENT* *Every work NOT related to the own farm!*

0 ID	1 *Please continue asking for the household members from page 2!* *First Name, Surname*	2 How many days per week does ... work on the farm?	3 Did ... work in an off-farm wage employment in the last Masika and Vuli rain season? **Codes:** *0=no* *1=yes*	4 How many different jobs did ... have in the last Masika and Vuli rain season? *number of jobs outside the own farm*	5 Where does ... work mainly in off-farm-employment? **Codes:** *1= in the village* *2= outside the village*	6 Type of off-farm activity *Off-farm employment activity* *9,9898E-289*	7 IF 1= IN THE VILLAGE: Where is the hh member employed? **Codes:** *1= Own* *2=Employed (please name the employer)*	8 **Codes:** *1= Tandai, 2=Doga* *3= Lusegwa, 4=Lukenge* *5=Nyange, 6=Kisaga* *7=Tonya* *subvillage*	9 IF 2= OUTSIDE THE VILLAGE: Name the village or town. *name of the village or town*	10 Why ... work outside the village? **Codes:** *1= no work available in the village* *2=own wish*
HHM1		2011	2012	2013	2014	2015	2016	2017	2018	2019
HHM2										
HHM3										
HHM4										
HHM5										
HHM6										
HHM7										
HHM8										
HHM9										
HHM10										

Type of off-farm activity: *1=village community, district, government* *2= teacher* *3= trader* *4= fisher* *5= shopkeepe*
6= tailor *7= cook* *8= traditional healer* *9= agricultural labourer on other farms* *10=church, mosque* *11= driver (tra* *12= guide (tou*

Tabelle: t_mem *RECEIVING FROM off-farm-employed* *SENDING TO off-farm employed*

0 ID	1 *Please continue asking for the household members from page 2!* *First Name, Surname*	11 Distance in travelling time (hours)? *hours*	12 Way of travelling? **Codes:** *1= on foot* *2= bike* *3= motorcycle* *4= dalla dalla* *90 = other, please specify*	13 What did ... earn during off-farm employment in the last Masika and Vuli rain season? *TZS per year*	14 Did you RECEIVE or SENT any mony or in kind from or to the OFF-FARM employed household member? **Codes:** *0=no* *1= recieve* *2= sent* *3=both* ***If 0=no ===> proceed with next page***	15 Money RECEIVED from the off-farm working hh member between in the last Masika and Vuli rain season. OFF-FARM ==> HH *TZS per year*	16 In kind RECEIVED from the off-farm working hh member between in the last Masika and Vuli rain season. OFF-FARM ==> HH *crop / item*	*amount*	*unit*	17 Money SENT to the off-farm working hh member between in the last Masika and Vuli rain season. HH ==> OFF-FARM *TZS per year*	18 In kind SENT to the off-farm working hh member between in the last Masika and Vuli rain season. HH ==> OFF-FARM *crop / item*	*amount*	*unit*
HHM1		2020	2021	2022	2023	2024	2025	2026	2027	2029	2030	2031	2032
HHM2													
HHM3													
HHM4													
HHM5													
HHM6													
HHM7													
HHM8													
HHM9													
HHM10													

r
urism)

Value in Tsh: 2028 Value in Tsh: 2033

Tabelle: t_mem

Section: Migration besides Off-farm employment

0	1	2	3	RECEIVING remittances FROM migrated: 4	5	6	7	SENDING remittances from migrated member: 8	9	10	11
ID	*Please continue asking for the household members from page 2!*	Did you RECEIVE or SENT from/to a migrated household member apart from the off-farm workers any kind of cash or in kinds? **Codes:** *0=no* *1= recieve* *2= sent* *3=both*	Where do they live?	Money RECEIVED from the hh member in the last Masika and Vuli rain season? MIGR ==> HH	In kind RECEIVED from the absent hh member in the last Masika and Vuli rain season MIGR ==> HH			Money SENT to the absent hh member in the last Masika and Vuli rain season HH ==> MIGR	In kind SENT to the absent hh member in the last Masika and Vuli rain season HH ==> MIGR		
	First Name, Surname	***If 0=no ===> proceed with next page***	village / town	*TZS per year*	*crop / item*	*amount*	*unit*	*TZS per year*	*crop / item*	*amount*	*unit*
HHM1		2034	2035	2036	2037	2038	2039	2041	2042	2043	2044
HHM2											
HHM3											
HHM4											
HHM5											
HHM6											
HHM7											
HHM8											
HHM9											
HHM10											

Value in Tsh: 2040 Value in Tsh: 2045

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Table T_Labour

Section: Hired employees (NO Household members!!!)

1 In which months do the household face scarcity in familiy labour? 3001 a-l } + Variable in General Yes/no Table T_hh

2 In which months do you hire labour? 3002 a_l } + Variable in General Yes/no Table T_hh

Please, list all hired labourers on your farm for the last Masika and Vuli rain season:

0	1	2	3	4	5	6	7	8	9	10	11
ID	Name of the employed worker	Gender **Codes:** *1 = male* *2 = female*	Age in years	Relationship to the employed worker? **Codes:** *1= direct neighbour* *2= relative* *3= friend* *4= did not know before*	Living where? **Codes:** *1= in the village* *2= outside the village*	Number of working days in the period	Main activities **Codes:** *1= land preparation / slashing* *2= harvesting* *3= weeding* *4= helping in shopkeeper activities* *5= helping in homestead*	wage in cash per unit?	Wage in kind per unit?		
3003	*Name of the employed worker*		*years*			*estimated working days*	*90 = other, please specify*	TZS per unit	*crop / item*	*amount*	*unit*
W1	3004	3005	3006	3007	3008	3009	3010	3011	3012	3014	3015
W2											
W3											
W4											
W5											
W6											
W7											
W8											
W9											
W10											
W11											
W12											

12 In which months do you look for other employment possibilities? 3000 a-l } + Variable in General Yes/no Table T_hh

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Table T_Plots

Section: Land tenure

Do you own or rent agricultural plots, woodlots, traditional, individual forests or borrowed? 4000 Table T_hh

							renting in land				
0	1	2	3	4	5		6	7	8	9	10
ID	Distance to homestead in hours to walk	Subvillage location of the plot?	Plot size?	Ownership?	Tenure status	Since which year are you using this plot?	If RENTED IN, please name the owner of the land.		How much money did you pay for the unit of land in the last Masika and Vuli rain season??		User of the plot
	Codes:	**Codes:** 1= Tandai, 2=Doga 3= Lusegwa, 4=Lukenge 5=Nyange, 6=Kisambwa 7=Tonya	**Codes:**	**Codes:** 1=individual 2=family 3= community 90 = other, please specify	**Codes:** 1=rented in 2=rented out 3= inherited 4= community land 5= purchased 90 = other, please specify		**Codes:**	**Codes:**	**Codes:**	**Codes:** 1=per year 2=per 2 years 3=per 5 years 4= per 10 years 5= lifetime	**Codes:** 1=household itself 2=other household in the village 3= relatives in the village 90 = other, please specify
4001	hours	subvillage	acre			year	name (surname) of the household	Subvillage	TZS	unit	
plot 1	4002	4003	4004	4005	4006	4007	4008	4009	4010	4011	4015
plot 2											
plot 3											
plot 4											
plot 5											
plot 6											
plot 7											
Traditional forest											
Woodlot											

4012, 4013, 4014 Payments in in Kind

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Table T_Plots

Section: La

	renting out land				Tenure security							
0	11	12	13	14	15	16	17	18	19	20	21	22
ID	If the HOUSEHOLD ITSELF IS NOT the user, please name the user of the land.		How much did you get for renting out this piece of land in the last Masika and Vuli rain season??		Perception of land tenure security	Right to grow any crop you want?	Right to grow perannuals such as agroforestry?	Right to cut trees?	Right to sell?	Right to rent out?	Would you like to expand your land size?	If 1= yes: for which purpose?
	Codes:	**Codes:**	**Codes:**	**Codes:** 1=per year 2=per 2 years 3=per 5 years 4= per 10 years 5= lifetime	**Codes:** 1= secure 2= insecure	**Codes:** 1= yes without consultation 2= yes with consultation 0=no		**Codes:**	**Codes:**	**Codes:**	**Codes:** 0=no 1=yes	**Codes:**
	name (surname) of the household	Subvillage	TZS	unit								Keywords
plot 1	4016	4017	4018	4019	4023	4024	4025	4026	4027	4028	4030	4031
plot 2												
plot 3												
plot 4												
plot 5												
plot 6												
plot 7												
Traditional forest												
Woodlot												

4020,4021,4022 Payments in in Kind

4029 Comments Land tenure

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Section: Soil fertility

Table T_Plots

1	2	3	4	5	6	6	7	8
	Land type at time of acquisition	Land use type now	Slope type of the plot?	Soil type of the plot?	Colour of the soil?	Fertility of the plot now?	How would you assess the fertility now compared to the fertility at aquisition?	If 1 or 3: Why do you think it has been reduced or improved?
Codes:	Codes: *1= cropland in use (food and cash)* *2= abandoned cropland* *3= grassland* *4= forest or other wooded land* *5= wetland* *90 = other, please specify*	Codes: *1= cropland in use* *2= abandoned cropland* *3= grassland* *4= forest or other* *5= wetland* *90 = other, please specify*	Codes: *1=flat* *2=sloping* *3=steep* *90 = other, please specify*	Codes: *1= sandy* *2= loamy* *3=clayey* *90 = other, please specify*	Codes: *1=blackish* *2=brownish* *3=redish*	Codes: *1=unfertile* *2=somewhat fertile* *3=fertile* *4=very fertile*	Codes: *1=reduced* *2= stayed the same* *3= has improved*	Codes: *0= do not know* *Keywords*
plot 1	4032	4033	4034	4035	4036	4037	4038	4039 improved
plot 2								4040 reduced
plot 3								
plot 4								
plot 5								
plot 6								
plot 7								
traditional forest								
woodlot								

Section: Sc Table T_Plots

soil conservation measurements

1	9	10	11	12	13	14	15	16
	What is the predominat type of environmental conservation on each plot?	Do you face yield losses due to soil degradation for specific crops in the last 10 years?	For which crops?	Yields in the past	Yields now	Do you plan to invest to reduce more soil degradation to improve yields?	If 1=yes: Which kind of measurements you want to invest in?	If 0=no: Why not?
Codes:	Codes: *1=contouring* *2=tree planting* *3=terracing* *4=intercropping* *5=grass strips* *90 = other, please specify*	Codes: *0=no* *1=yes*	Codes: *name*	Codes: *quantity*	Codes: *quantity*	Codes: *0=no* *1=yes* *quantity*	Codes: *1=contouring* *2=tree planting* *3=terracing* *4=intercropping* *5=grass strips* *90 = other, please specify*	Codes: *keywords*
plot 1	4041	4042	4043	4044	4045	4046	4047	4048
plot 2								
plot 3								
plot 4								
plot 5								
plot 6								
plot 7								
traditional forest								
woodlot								

Section 9: Specification of cash and food crops, contract farming

Please think of the last Masika and Vuli rain season in the last year (march

Table T_crops

0	1	2	3	4	5	6	7	8	9
ID	Please name all agricultural FOOD and CASH crops you produced in the last Masika and Vuli season?	On which plot do you produce the crops?	Did you face any difficulties to start cultivation of this crop?	Did you change agricultural practices in the last 5 years?	Do you have a contract with a buyer for ...? (name the crops from question 1)		Where is the buyer located?	What is the content of the contract / buyer-seller relationship?	Do you have to meet specific criteria to fullfill?
	crop	**Codes:** *plot 1* *plot 2* *plot 3* *plot 4* *etc.* *plot number*	**Codes:** *1= no access to credit* *2= no access to output markets* *3= low output prices* *4= high input prices* *5= agricultural knowledge* *6= no access to land*	**Codes:** *0=no* *1=yes*	**Codes:** *1= written contract* *2= oral contract* *3= no contract but specific buyer* *4= no contract, no specific buyer* *if 4 ==> go to next page* *90 = other, please specify*	**Codes:** *if 1,2, or 3: Since when?* *starting year*	**Codes:** *1= in the village* *2= outside the village*	**Codes:** *1= minimum prices* *2= buying guarantee* *3= free access to seeds* *4= free access to fertilizer* *5= free access to pesticides* *90 = other, please specify*	*Keywords*
c1	5002	5003	5004	5001 hh-table	5005	5006	5007	5008	5009
c2				***Keywords***					
c3									
c4									
c5									
c6									
c7									
c8									
c9									
c10									
c11									
c12									
c13									

Cassava	Sorghum	Cocoyam	Beans	Sweet potatoe	Rice	Maize
Banana	Pinapple	Citrus	Vegetables	Groundnuts	Coconut	Mango
Coffee	Kaupis	Sugarcane	Vanilla	Black pepper	Cardamon	

5010 Comments Crops

Table T_crops

Section: agricultural output quantities

Please think of the last Masika and Vuli rain season in the last year (march 2009 to febuary 2010).

0	1	2	3	4	5	6	7	8	9	10	11	12	13
ID		How many plants of ... do you have? (ASK ONLY for the PERENNIAL crops)	Yields obtained in the last Masika and Vuli rain season?		Did the yields correspond to a normal harvest?	Own CONSUMPTION quantity FROM OWN PRODUCTION at household?		In WHICH MONTHS do you CONSUME the OWN produced food crops?	Quantity sold?		In WHICH MONTHS did the household SELL ...?	Where did you sell the output?	Way of transportation to the market?
	crop	*estimated number*	*quantity*	*unit*	**Codes:** *1= lower* *2= higher* *3= stayed the*	*quantity*	*unit*	*corresponding month*	*quantity*	*unit*	*corresponding month*	**Codes:** *1= in the village* *2= outside the village* *90 = other, please specify*	**Codes:** *1= on foot* *2= bike* *3= motorcycle* *4= dalla dalla* *5= from farm* *90 = other, please specify*
c1		5011	5012	5013	5014	5015	5016	5017-5028	5029	5030	5031-5042	5043	5044
c2													
c3													
c4													
c5													
c6													
c7													
c8													
c9													
c10													
c11													
c12													
c13													

Land Size 5011b-5011c

Table T_crops

Section: agricultur

Please think of the last Masik

Storing | Byproducts

0	1	14	15	16	17	18	19
ID		In WHICH MONTHS did the household need to BUY ...?	Do you store certain food and cash crops	Which crops does the household store?	Which month do you store...?	Which main by-products do you obtain when you harvest ....?	Purpose?
			Codes: *0=no* *1=yes*	**Codes:** *0=no* *1=yes*	**Codes:**	**Codes:** *1= straw* *2= hay* *3= husks* *4= other crop residuals* *5=leaves*	**Codes:** *1= fertilizer for other crops* *2= fodder* *3= energy for cooking* *4= packing material for transport transport*
	crop	*corresponding month*			*corresponding month*	*90 = other, please specify*	*purpose*
c1		5045-5057		5058	5059-5070	5071	5072
c2							
c3							
c4							
c5							
c6							
c7							
c8							
c9							
c10							
c11							
c12							
c13							

Section: Processing

Do you use any of your agricultural produce for processing activities? (excl. planting activities)

Table T_crops

0	1	2	3	4	5	6	7	8	9	10	11
ID		Which crops do you process and how do you process them?	Quantity of the processed ouput?		Which by-products are produced during those processing activities?	For which purpose do you use these by-products?	Are the pocessing activities done by family or hired labour?	How much do you pay for processing your harvest?	Do you sell or use the processed goods for own consumption?	Quantity of selling?	
		1= milled *2= dehulled* *3= dried* *4= brewed* *5= pressing* *6= sqeezing*	**Codes:**	**Codes:**	**Codes:** *1= presscake* *2= briquettes* *3= other residuals* *4= husks*	**Codes:** *1= fertilizer* *2= fodder* *3= energy for cooking*	**Codes:** *1= familiy labour* *2= hired labour* *3= both*	**Codes:**	**Codes:** *1= own consumption* *2= selling* *3= both*		
	crop	*7= ripening*	*quantity*	*unit*	*90 = other, please specify*	*90 = other, please specify*	*90 = other, please specify*	*TZS / Unit*	*90 = other, please specify*	*quantity*	*unit*
c1		5073	5074	5075	5076	5077	5078	5079	5080	5081	5082
c2											
c3											
c4											
c5											
c6											
c7											
c8											
c9											
c10											
c11											
c12											
c13											

Section: Processin

Table T_crops

0 ID	1 crop	12 If 2= selling or 3=both: Where did you sell the output? Codes: 1= in the village 2= outside the village 90 = other, please specify	13 Way of transportation to the market? Codes: 1= on foot 2= bike 3= motorcycle 4= dalla dalla 90 = other, please specify
c1		5083	5084
c2			
c3			
c4			
c5			
c6			
c7			
c8			
c9			
c10			
c11			
c12			
c13			

Processing Comment 5085

Section: Seeds, seedlings

Table T_crops

0 ID	1 crop	2 How many seedlings / seeds / cuttlings / succers did you plant from the last Masika to Vuli rain season for ...? quantity	3 unit	4 What portion or amount came from your own seedstock? quantity	5 unit	6 From where? Codes: 1= in the village 2= outside the village	7 If 1=within the village: Please name the seller. name (surname) of the seller
c1		5086	5087	5088a	5088b	5090	5091
c2							
c3							
c4							
c5							
c6							
c7							
c8							
c9							
c10							
c11							
c12							
c13							

5089a 5085b Seedstock Swaheli

Fertilizer and pests

Table T_crops

		Fertilizer		Pests				Water			
0	1	2	3	4	5	6		7	8	9	
ID	Please name all agricultural FOOD and CASH crops you produced in the last Masika and Vuli season?	Did you use any kind of fertilizer in the last Masika and Vuli rain season? F	If ORGANIC OR DUNG please specify from which source?	For which crops do you have problems with pests or wild animals reducing the yield?	Wich pest?	What did you do against that pest?	Costs of chemical pesticides in total for this crop?	In which months does the household face water shortages for rain fed production?	What is the most severe problem in terms of water supply for agriculture?	Do you use irrigation for certain crops?	How much water did you use for irrigating this crop?
		Codes: 0=no 1= chemical 2= organic	**Codes:** 1= cow 3= chicken 4= goat 5= crop residuals	**Codes:** 0=no 1=yes		**Codes:** 0=nothing 1= chemical			**Codes:** 1= drought 2= temporary water shortages 3= volatile rain in rainy seasons 4= water conflicts / competitiveness 5= water logging	**Codes:** 0=no 1=yes	
	crop	*90 = other, please specify*	*90 = other, please specify*				*TZS*	*month*	*90 = other, please specify*		*liter or other unit*
c1		5092	5093	5094	5095	5096	5097	5102 hh t	able 5103	5098	5099
c2											
c3											
c4											
c5											
c6											
c7											
c8											
c9											
c10											
c11											
c12											
c13											

5100 Water costs
5101 Water Distance

Section: ENERGY SOURCES USED BY THE HOUSEHOLD!

Table T_energy

0		1	2	3	4	5	6	7	8	9	10	11	12	13
ID	Energy sources USED by the household	Which type of energy source does your houshold use?	For which purposes do you use the source?	How much do you need for home consumption per week?		How much do you produce per week on your own farm? Ask only for firewood, charcoal and solar!		How much of ... do you buy per week?		How much of ... do you sell per week?		Where do you sell or buy...?	Where do you charge your mobile phones?	Is the own firewood production sufficient for the households needs?
	Codes:	**Codes:** *mark the respective energy source* 0=no 1=yes	**Codes:** 1= cooking 2= lighting 3= transport 4= generator / electricity 90 = other, please specify	*quantity*	*unit*	*quantity*	*unit*	*quantity*	*unit*	*quantity*	*unit*	**Codes:** 1= in the village 2= outside the village	**Codes:** 0= no mobile phone 1= household owned generator 2= household owned solar panel 3 = service provide	**Codes:** 0=no 1=yes
E1	Firewood	6000	6001	6002	6003	6004	6005	6006	6007	6008	6009	6010	6011 hh Ta	ble 6012
E2	Charcoal													
E3	Solar power													
E4	Diesel													
E5	Petrol													
E6	Kerosene													
E7	Crop residuals													
E8	Dung													
E9	*other?*													
E10	*other?*													
E11	*other?*													

6013 Energy Comments

Section: Agroforestry

hh table trees yes no + number of Species

Table T_agrof

0	1	2	3	4	5	6	7	8	9	10	11	12
ID	Which species of trees or shrubs do you have on your plots?				IF 1= WITH CROPS: Production system?	If 1=HEDGE: Does the hedge reduce social conflicts with your neighbours?	Major purposes of plantation?	How many trees did you plant this year?	Where did you get the seedlings / seeds from?	Do you plan to extend or decrease planting trees and shrubs?	Do you plan to cultivate other species?	Did the tree species for firewood change in the last 10 years? If yes: which species did you use 10 years ago?
	Codes: *Species*	**Codes:** *Number of trees or shrubs*	**Codes:** *average age*	**Codes:** *1= together with food or cash crops* 7003 *2=woodlot* 7004 *3=traditional forest* 7005	**Codes:** *1=hedge* *2=intercropping with agriculture* *90 = other, please specify*	*0= no conflicts* *1= reduced neighbour's livestock of your property* *2= fixing of farm boundaries* *3= does not reduce conflicts* *90 = other, please specify*	*1= firewood* 7008 *2 = timber* 7009 *3 = medicine* 7010 *4=seedlings* 7011 *5= supporting tree* 7012 *6= against soil erosion* 7013 *7=food* 7014 *90 = other, please specify* 7015	**Codes:** *Number of trees or shrubs*	**Codes:** *1= in the village* *2= outside the village*	**Codes:** *1= extending* *2= decreasing* *3= no changes* *0= no plan*	**Codes:** *0=no* *1=yes*	**Codes:** *0=no* *1=yes*
1	7000	7001	7002		7006	7007		7016	7017	7018- 7021	7022	7023
2											*Species*	*Species*
3												
4											hh table	hh table
5												
6												
7												
8												
9												
10												
	Jatropha	*Mango*	*Mifenesi*	*Mishelisheli*	*Mitiki*	*Karafuu*	*Miparachichi Mkongazi*	*Migrevilea*	*Msederela*	*Minazi*	*Mikababo*	*Mdalasi*

Table T_forest

The next part of the questionnaire will deal with forest extraction. Again, all information will be treated absolutly confidentially!
The following questions concern benefits that you obtained from the forest.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ID	Which products have you used from the last Masika to Vuli rain	Where do you get the following forest products from?				Which forest product you need from the forest most?	Did you sell any kind of these forest products?	Quantity sold?		Where did you sell the output?	How many headlots of Firewood do you store?	For which months / period does the household store the firewood?		How often you go to the forest?	
	Codes: *0=no* *1=yes*	On farm **Codes:** *0=no* *1=yes*	market **Codes:** *0=no* *1=yes*	Forest reserve **Codes:** *0=no* *1=yes*	other individual farm **Codes:** *0=no* *1=yes*	*rank the most important 3*	**Codes:** *Ask for all but not for firewood!* *0=no* *1=yes*	*quantity*	*unit*	**Codes:** *1= in the village* *2= outside the village* *3=both*	**Codes:** *number*	*starting month*	*ending month*	*number of trips*	*period*
1 Firewood	8000	8001	8002	8003	8004	1.8005					8012/13	8014-	8025	8026	8027
2 timber						2.8006	8008	8009	8010	8011					
3 Medicine plants						3.8007									
4 Edible fruits															
5 Thatching grass															
6 Fodder															
7 Grazing															
8 Mushrooms															
9 Honey															
10 roots, tubers															
11 wild vegetables															
12 bush meat															

hh table

8028 Forest Comment

Table T_hh

0	1	2	3	4	5	6	7	8	9
ID	Do you participate in the forest protection?	In which activities do you participate?	Do you think it is meaningful to protect the forest completly so no extraction is allowed at all?	Do you think deforestation has changed in the last 5 years?	Did the population of Colabus monkeys...?	Did the population of Kulumbizi bird...?	Did you ever collected Jatropha seeds?	How many kg seeds did you harvest in total at this point to sell?	To which price you would collect and sell Jatropha seeds on a regulary base?
	Codes: *0=no* *1=yes*		**Codes:** *0=no* *1=yes*	**Codes:** *1= decreased* *2= no change* *3= increased* *90 = other, please specify*	**Codes:** *1= decreased much* *2= decreased* *3=no change* *4= increased* *5= increased much* *90 = other, please specify*	**Codes:** *1= decreased much* *2= decreased* *3=no change* *4= increased* *5= increased much* *90 = other, please specify*	**Codes:** *0=no* *1=yes*	*kg*	*TZS*
1	9001	9002	9003	9004	9005	9006	9007	9008	9009

Table T_anim

Section: Livestock keeping

I will now ask questions about your livestock keeping. Do you possess any kind of livestock such as chicken or goat? owning livestock: 10002 Table t_hh

0	1	2	3	4	5	6	7	8	9	10
ID	Which type of livestock do you have?	Number of animals of this type belonging to this household today?	Number of animals of this type BOUGHT in the last Masika and Vuli rain season?	From where?	Way of transportation to the market?	Number of animals SOLD in the last Masika and Vuli rain season??	Where sold?	Way of transportation to the market?	Number of livestock of this type slaughtered for home use in the last Masika and Vuli rain season??	Estimated value of this herd of this livestock type if you would sell all animals today?
	10002 *90 = other, please specify*	*number*	*number*	**Codes:** *1= in the village* *2= outside the village*	**Codes:** *1= on foot* *2= bike* *3= motorcycle* *4= dalla dalla*	*number*	**Codes:** *1= in the village* *2= outside the village* *3= farm gate*	**Codes:** *1= on foot* *2= bike* *3= motorcycle* *4= dalla dalla*	*number*	*TZS*
1	Chicken	10003	10004	10005	10006	10007	10008	10009	10010	10011
2	Ducks/goose									
3	Guinea fowls									
4	Pigeons									
5	Goat									
6	Bees									
7	Pigs									
8	Cattle									
9	other, please specify									

Section: Animal products and byproducts

Table T_animby

0	1	2		3		4		5	6
ID	Which animal output does the the household produce? 11001	Production of the household in th elast Masika and Vuli rain season?. Refer to suistable time periode (days/weeks/months)		Own CONSUMPTION quantity FROM OWN PRODUCTION at household?		Quantity sold?		Where did you sell the output? Codes: 1= in the village; 2= outside the village; 90 = other, please specify	Way of transportation to the market? Codes: 1= on foot; 2= bike; 3= motorcycle; 4= dalla dalla; 90 = other, please specify
		quantity	unit	quantity	unit	quantity	unit		
1	Milk from goat	11002	11003	11005	11006/7	11008	11009/10	11011	11012
2	Milk from cattle								
3	Eggs								
4	Meat from chicken								
7	Meat from goat								
8	Feather								
9	Meat from cattle								
10	Leather								

Hatching eggs 11013

11004 time period

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Table T_extent

Section 8: Extension Service HH extension access 12000 hh-table 12001 RowID

12002	1	2	3	4	5
	Do you have access to the extension service?	How often do they visit your farm per year? number of visits	Content of extension service? Codes: 1=training on fertilizers; 2=energy production; 3= water management; 4= soil ersosion; 5= agroforestry; 90 = other, please specify	What could be improved Codes: 1= more visits; 2= better information for energy production; 3= better information for livestock; 4= better information for agricultural production; 90 = other, please specify	Do you get information on possibilities of improved firewood / energy production and consumption? Codes: 0=no; 1= planting new tree species; 2=planting more trees; 3=substituting by other sources; 4= improved stoves for wood and charcoal; 90 = other, please specify
UMADEP	12003	12004	12005	12006	12007
Government					
Others					

Section: Indicators of wealth number of houses hh-table 13000 13001 RowID

13001	1	2	3	4	5	6
	Type of roof Codes: 1= tin roof; 2= iron sheet; 3= grass	Age of the roof in years?	Wall used in the house Codes: 1= mud; 2= bricks (unburned); 3= bricks (burned); 4=bricks (concrete)	How many rooms the house have? Codes: number	Age of the house? age	How did your housing condition change in the last 5 years? Codes: 0=not at all; 1=positve change; 2=negative change
Homestead 1	13003	13004	13005	13006	13007	13008
Homestead 2 if present						

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Table T_asset

Section: Assets

Number of assets in total 14000 hh-table

I will now ask you about the household assets aquistion and disposal (selling or discarding of assets)

0 Which of the following assets do the household own?	1 Existing? Mark with X	2 Number of assets owned today *number*	3 Year of aqusition *year*	4 Costs of asset at date of aqusition *TZS*	5 How much money have you spent to repair the asset in the last Masika and Vuli rain season? *TZS*	6 How much money you would obtain if selling it today? *TZS*		7 Did the household sell any asset of this type in the last Masika and Vuli rain season?? **Codes:** *0=no* *1=yes*	8 How much money was obtained from selling this asset? *TZS*	9 Where? **Codes:** *1= in the village* *2= outside the village*
Radio / Tape Recorder	14001		14002	14003	14004	14005	ASK QUESTION 6 to 8 AFTER ASKING QUESTIONS 1 TO 5 FOR ALL ASSETS	14006	14007	14008
Bicycle										
Motorcycle										
mill maschine										
Hand cart										
oven / stove										
Efficient stove										
Water pump										
power generator										
Storage for harvest										
mobile telephone										
television										
Badgagi										
dalla dalla										
Solar panel										

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Table T_risk Shocks Dummy 15000 hh-table

Section: Risks and shocks

Number of shocks 15001 hh-table

When cosidering the last 2 years, has there been any event causing a big problem (shock) affecting the household? Please think of any problems related to your family, farm, house or job.

0 ID	1 Type of event that happened TO THE HOUSEHOLD *Relate to codes underneath*	2 When did the event occur? *year*	2 Estimated loss of income in the household due to the event? (only for the year of occurrence) *TZS*	3 Estimated loss of assets? *TZS*	4 What was your major coping activity to deal with the event? **Codes:** *0=Did nothing* *1=Took up additional occupation* *2=Diversify agricultural portfolio* *3=Took children out of school* *4=Sent children to relatives* *90 = other, please specify*	5 Does the household still have to reduce household consumption expenditures because of the event? **Codes:** *0=no* *1=yes*
1	15002	15003	15004	15005	15006	15007
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
	job losses	*flood*	*high input prices*	*theft*	*high food prices*	*low output prices*
	death					

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Table T_health

Section: Health

Does this household has any kind of health insurance? 16000 hh-table

I will now ask about illnesses and injuries household members have suffered since.... 16001 Number of ill-members hh-table

0 ID	1 Did any household member suffer from any illness or injury...in the last Masika and Vuli rain season?? *name*	2 For how many weeks was ... unable to pursue his / her main occupation? *number of weeks*	3 How much money was spent in total on this individual for all illnesses and in the last Masika and Vuli rain season?? *TZS*	4 Who received the payment? **Codes:** *1= traditional healer* *2=hospital* *3=doctor* *4=Duka la Dawa* *90 = other, please specify*	5 If 1= in the village: Please name the person. *name (surname) of the household*	6 Does Jatropha have any positve effects on health? *keywords*	7 Does Jatropha have any negative effects on health? *keywords*
1	16002	time: 16003	16005	16006	16007	16009	16010
2		Unit: 16004					
3							
4							
5							
6							
7							
8							
9							
10							

16008 health Comment

Section: cash and access to credits Table t-credit

borrowing

0 ID	1 Does the household participate in the village financial service (SACCOS)? **Codes:** *0=no* *1=yes*	2 Does the household has a possibility to get credits / loans? **Codes:** *0=no* *1=yes*	3 If not, why? **Codes:** *keywords*	4 ID	5	6 Does the hh have any credits / loans that have not been fully repaid? **Codes:** *0=no* *1=yes*	7 When did you apply for this credit / loan? **Codes:** *year*	8 Purpose? **Codes:** *1=farm inputs* *2=buy land* *3=buy cattle* *4= food and clothing* *5=non-farm buisness* *6=education* *90 = other, please specify*	9 In the village? **Codes:** *1= in the village* *2= outside the village*	10 Amount of loan applied for? **Codes:** *TZS*
17000 hh table		17001	17002	1	Saccos	17004	17005	17006	17007	17008
17003 Credit hh Level				2						
				3						

Table t-Shop

lending 18000 Lending on hh-Level

11	12	13	14	15	16	17	18	19	20
Payments you made in the last Masika and Vuli rain season??	Remaining debt as of the end of in the last Masika and Vuli rain season??	What did you have to give as a collateral?	Did you lend out cash or goods (rice, fertilizer etc.) in the last Masika and Vuli rain season?	Value in TZS	Who did you lend to?	In the village?	If 1= in the village: Please name the person.	Payments you got in the reference period?	Remaining debt as of the end of in the last Masika and Vuli rain season?
		Codes: *1= number of trees* *2=house* *3=livestock* *4=land* *90 = other, please specify*	**Codes:** *1=food* *2=farm inputs* *3=money* *90 = other, please specify*		**Codes:** *1= relatives* *2= households* *90 = other, please specify*	**Codes:** *1= in the village* *2= outside the village*	*name (surname) of the household*		**Codes:** *1= not yet* *2= the full amount* *3= half* *4= no debt existing*
TZS	*TZS*			*TZS*				*TZS*	
17009	17010	17011	18001	18002	18003	18004	18005	18006	18007

Table t-savings

Section: Savings Savings at hh-Level 19000

We reassure you that all information given is strictly confidential. It will not be given to others and will only serve scientific purposes.

0	1	2		3	4	5
ID	Savings	Does the household have any kind of these savings?	Money saved in last Masika and Vuli rain seasone?	How much is the current value of those savings?	For what do you expect to use savings in the future. Please state three most important expectations?	~~Does this household have any kind of insurance~~
	19001	**Codes:** *0=no* *1=yes*	*TZS*	*TZS*		~~**Codes:**~~ ~~*0=no*~~ ~~*1= health*~~ ~~*2= wheother*~~ ~~*90 = other, please specify*~~
1	Cash at home		19002	19003	19004	
2	SACCOS					

Section: Water consumption

0	1	2	3	4
	How much water for household consumption do you have per day?		How often do you go for water fetching?	**Codes:** *1= per day* *2= per week*
	quantity	*unit*	*number*	*unit*
1	20000	20001	20002	20003

Type of water 20004

Water fee 20005

Table t-hh

Section: Household cash expenditures

Please indicate how much cash in general you spend on the following items in the indicated period?

0	1	2	3	4
ID	Item	Period	Total amount in TZS	Where did you buy this?
	Codes:	**Codes:** *1=per week* *2=per months* *3=per year*	**Codes:** *TZS / unit*	**Codes:** *1= in the village* *2= outside the village*
1	Clothing / Footwear 21001	b	a	c
2	Family events / social occasions (funerals, weddings etc.) 21002	b	a	c
3	In kinds / payments for church / mosque 21003	b	a	c
4	care products 21004	b	a	c
5	Gifts / payments for friends 21005	b	a	c
6	market fees / levies / taxes 21006	b	a	c
7	transport in bus, dalla dalla, pikipiki... 21007	b	a	c
8	How much time does it take you to reach the local market in Tandai on foot?	21008		
9	How much time does it take you to reach the forest?	21009		

Table t-hh

Section: Time preferences

Try to clarify this hypothetical question. The question is, which amount of money the household prefer now instead of waiting one year!

If you were told you have the choice between an amount of money today and the amount of 100.000 TZS in one year from now, which amount of money would you prefer to get now instead of 100.000 TZS in one year?

1	Do you prefer 90.000 now or 100.000 in one year?	22001	if yes, go next question, if no: stop
2	Do you prefer 80.000 now or 100.000 in one year?		if yes, go next question, if no: stop
3	Do you prefer 70.000 now or 100.000 in one year?		if yes, go next question, if no: stop
4	Do you prefer 60.000 now or 100.000 in one year?		if yes, go next question, if no: stop
5	Do you prefer 50.000 now or 100.000 in one year?		if yes, go next question, if no: stop
6	Do you prefer 40.000 now or 100.000 in one year?		if yes, go next question, if no: stop
7	Do you prefer 30.000 now or 100.000 in one year?		if yes, go next question, if no: stop
8	Do you prefer 20.000 now or 100.000 in one year?		if yes, go next question, if no: stop
9	Do you prefer 10.000 now or 100.000 in one year?		if yes, go next question, if no: stop
10	Do you prefer 5.000 now or 100.000 in one year?		if yes, go next question, if no: stop

22002 Comment on Preferences