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Titel: Socio-economic impacts and lessons learned of a large-scale biofuel project in Madagascar

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1. Introduction and background

Jatropha as a source of biofuel appears in the literature from the early 1990s on (e.g. Jones et al., 1992; Foidl et al., 1996; Heller, 1996). Hopes were high in the early 2000s, when Jatropha was promoted as a means to make use of unused or underutilized land and therefore would possibly reduce the competition between fuel and food and environmental impacts (e.g. Francis et al., 2005; Renner, 2007). According to Achten et al. (2014) economic incentives in a few industrialized countries triggered big Jatropha investments, which in turn increased attention which further enhanced promotion and investments. Policy assumptions however often contradicted with real practices (Achten et al., 2014; Franco et al., 2010). Wahl et al. (2012) provide an up-to-date overview of Jatropha projects based on interviews with producers in 2011. They found that despite many failed projects, Jatropha production is still being promoted and new projects are still undertaken (see e.g. Ethiopian or Brazilian government biofuel program). In Madagascar the authors identified five Jatropha projects with a total area of 8300 hectares. In 2012, the Land Matrix was introduced as a tool to build a transparent database on large-scale land transactions (Anseeuw et al., 2013). The Land Matrix reports six biofuel projects with land transfers of a total of 21.558 hectares (contract size) and 4220 hectares (updated production size) to international investors in Madagascar in July 2015.

Numerous authors discussed possible benefits and trade-offs of biofuels for poor smallholders. Von Braun et al. (2006) argue that in order to make environmental, economic and social contributions, biofuel technology would need further advancement, as well investments and policies facilitating agricultural innovation and trade. Brüntrup et al. (2010) vote for a sober reflection, a prioritization of food security and poverty reduction, a focus on private enterprise as well as essential political support. Bindraban et al. (2009) argue that large-scale biofuel production will unlikely be sustainable, because the needed additional land will have negative effects on biodiversity, GHG emissions and food production. According to them, development impacts will depend among others on employment possibilities created and price effects. Like Von Braun (2008) they expect a deterioration of food security of the poor. Small-scale biofuels production and production on marginal lands might have different effects, but would not contribute significantly to global production of biofuels. While most of the authors suggest better outcome indicators for smallholders in outgrower systems, Achten et al. (2014) recommend to only involve individual smallholder farmers until genetic material is chosen and monitoring systems are in place. According to the authors, new and rapidly emerging species pose opportunities like poverty reduction and rural development, but also different risks for the involved stakeholders. Social risks can occur when investments in the booming crop are stopped and farmers are left idle with the plants, or when people have migrated, attracted by the booming business and associated labor demand. The discontinuation of projects affect communities through income losses and fostering more negative attitudes towards new projects.

Analysis based on cross-sectional data found mostly positive socio-economic benefits of Jatropha production. Peters et al. (2009) studied the impacts of a Jatropha plantation in Mozambique and found, one year after establishment an increase in income, expenditures, and working time, but a decrease in food production and in other cash generating. The company provided above average wage and monthly contracts to workers. Portale (2012) found that participation in biofuel supply chains improved the subjective wellbeing of Jatropha farmers in Tanzania. Schut et al. (2014) compare the food security effects of large-scale and smallholder Jatropha production systems in Mozambique. They found positive as well as negative effects for both types of projects, with large-scale production more closely monitored and employing less endowed households compared to smallholder systems, where adopters have more capital available (see also Mogaka et al., 2014). Yet, these studies do not control for selection into the program and omitted variable bias. One exception is Negash et al. (2013) who used a two-stage model and found that participation in a castor bean outgrower scheme increased farmers' food consumption and narrowed their food gap. Furthermore, the time of the impact assessment is likely to be relevant, as labor demand is significantly higher in the set-up phase and revenues from oil production occur only several years after the first plantation (see e.g. Acheampong et al. (2014).

De Yong et al. (2011) conclude that Jatropha has a comparative advantage in agriculturally marginal areas with low-input farming systems, abundant land and high fossil fuel prices due to poor infrastructure. They argue that as millions of farmers live in such areas with few development options, Jatropha has the potential to play an important role in alleviating poverty for this target group and it is therefore important to continue adaptive research. Several authors (Achten et al., 2009, Eckart et al., 2012) argue that Jatropha, although failed as solution to global energy needs, can still be a solution for local energy supply and merits further research. Hodbod et al. (2013) review the literature on the social impacts of biofuel production and processing at the local level and find very limited evidence, most of the literature under review remains at high level and hypothetical when it comes to local impacts. Van Eijck et al (2014) applied a meta-analysis of existing studies on Jatropha projects. They found hardly any study quantifying social impacts comprehensively.

We therefore try to contribute to filling this knowledge gap by making use of an extensive panel data set collected from 2008 – 2013 from 390 households in three villages in the vicinity of a large-scale Jatropha project. By using panel data, different than the majority of socio-economic studies conducted on Jatropha production, we control for selection into the program and omitted variable bias and are able to test the sustainability of the formerly shown positive effects on income and living standard of the households over time as well as further and medium-term effects. The main objective of this study is to provide insights into the relationship between employment for the Jatropha project and household food security. We want to inform political as well as private decision-makers about social sustainability and social feasibility of biofuel projects on marginal areas.

2. Data and Methodology

The Jatropha project in question has been operating since 2007 on an area of 3000 ha, with 1000 ha planted until 2010. As production of Jatropha oil has only started on a trial basis and no marketing chain has been set up yet, we focus on the impacts of employment for the Jatropha project as well as more indirect impacts on households and their communities. The study is based on primary data collected during 5 household surveys from 2008 to 2013. The final household panel contains 390 randomly selected households in three villages representing originally the majority of households working for the project and the majority of people living within a distance of 10 km from the plantation. To assess the project's impacts on surrounding communities, personal interviews with relevant stakeholders as well as semi-structured focus-group interviews were conducted in four villages in all five years. These interviews were conducted with about 10 to 20 villagers representing different areas, including former and current plantation workers, farmers, traders and local government.

Next to food shortage, the most prevailing problem in the region is low dietary diversity. We therefore include dietary diversity as indicator of a household's food security. We use diet diversity for 7 days prior to the interview (WFP 2008). Moursi et al. (2008) showed that dietary diversity is a good predictor of the micronutrient density of children in Madagascar. As indicator for Jatropha plantation work we use the number of household members working for the Jatropha project in the reference periods.

For the impact assessment we have to deal with several drawbacks of the data. Jatropha plantation operations started in 2007, first wage work was offered beginning of 2008. The first household survey captured the period from February 2008 to February 2009. Therefore no baseline data is available. Furthermore, all households were aware of the possibility to work as daily laborers at the plantation. As the plantation management accepted everybody coming to the site in the mornings, households are free to choose whether they want to work or not. Therefore this study has to deal with a selection bias consisting of the fact that households differ in socio-economic characteristics which influence their decision to work for the plantation or not. Households who decided to work might have had different outcomes than the control group even in the absence of the plantation.

Former studies in the area came to the conclusion that in particular poor households benefitted from the labor for the Jatropha project, they could increase their low income significantly. The results showed furthermore that if wages on the level of agricultural wage work are paid, there can be positive income effects for rural households (Grass and Zeller, 2011). As these additional incomes were mostly earned by poorer households in the surrounding villages, income inequality decreased (Bosch and Zeller, 2013). Having a more extensive panel data set available a fixed effects model can be applied. Benefits of panel data are an improved efficiency of econometric estimates by increasing data points and degrees of freedom and therefore reducing the problem of multicollinearity and controlling for omitted variable bias (Hsiao 2003) Individuals serve as their own controls.

A simple panel data model is $Y_{it} = \beta X_{it} + \alpha_i + u_{it}$, where Y_{it} is the dependent variable observed for household i at time t, here different indicators for food security, X_{it} is a vector of explanatory variables for household i at time t, including the main variable of interest, the number of household members working for the Jatropha project, ß is a vector of coefficients, α_i denotes unobserved household specific effects which in a fixed effects model are assumed to be fixed over time and vary across household i and u_{it} is the error term.

3. Preliminary results

Results from focus group discussions show that income derived from daily wage work for the project, in particular during off-season and droughts, helps to increase households' resilience against climate variability and poverty. However, labor demand declined substantially after build-up phase in 2010, very few regular jobs have been created. Incomes are mostly used for food and other necessities and only a small percentage is invested in agriculture or business. Table 1 shows descriptive, Table 2 the econometric results.

Table 1: Outcome and explaining variables – Variable means

	2008	2009	2010	2012	2013
Diet diversity (8 Food groups, weighted, past 7 days)	9.83	9.50	8.51	13.6	10.1
Lack of food (number of days in past 30 days)	7.7	5.06	3.38	3.46	2.42
HH members working for Jatropha project (Number)	0.91	0.82	1.1	0.54	0.29
Total land per capita (in ha)	0.55	0.42	0.41	0.52	0.43
Crop diversity (Number of crops grown)	4.4	4.7	3.8	8.0	7.4
Agricultural equipment (Dummy)	0.47	0.45	0.53	0.63	0.64
Storeroom for agricultural products (Dummy)	0.26	0.29	0.34	0.37	0.38
Livestock sales (Dummy)	0.48	0.39	0.23	0.61	0.26
Public employment (Dummy)	0.04	0.03	0.04	0.06	0.06
Own Business (Dummy)	0.22	0.34	0.25	0.32	0.23
Employment as agricultural labor (Dummy)	0.37	0.30	0.18	0.56	0.31
Dependents (Number, <10 and >65)	2.0	2.1	2.1	2.0	2.3
Labor force (Number, >=10 and <=65)	3.2	3.3	3.4	4.2	4.2
Total rice yield (kg)	1331	1430	542	1632	944

Total cassava yield (kg)	2267	767	642	1666	1991
Total maize yield (kg)	316	135	45	380	158
Total pulses yield (kg)	143	127	14	260	91
Agricultural workers (Dummy)	0.24	0.42	0.34	0.31	0.38
Mutual help (Dummy)	0.28	0.83	0.85	0.86	0.82
Number of observations	735	613	473	418	390

Table 2: Estimation results of the regression model

	Diet diversity		**Lack of food**	
	Coefficient	S.E.	Coefficient	S.E.
HH members working for Jatropha project (Nbr)	0.22**	0.10	-0.03	0.29
Total land per capita (ha)	0.32*	0.17	-0.74**	0.36
Crop diversity (Nbr)	0.08**	0.03	-0.18**	0.08
Storeroom for agricultural products (Dummy)	0.50**	0.20	-1.25*	0.67
Livestock sales (Dummy)	1.2***	0.21	-0.28	0.51
Own Business (Dummy)	0.26	0.21	-2.39***	0.52
Labor force (Nbr, >=10 and <=65)	0.19**	0.09	-0.10	0.19
Rice yield (kg)	0.0001	0.00	0.0003	0.00
Cassava yield (kg)	-0.0002	0.00	-0.0001**	0.00
Pulses yield (kg)	0.0004	0.00	-0.0003**	0.00
Agricultural workers (Dummy)	0.20	0.20	-1.34**	0.56
Mutual help (Dummy)	0.46*	0.24	-0.82***	0.67
R-sq within	0.39		0.09	
R-sq between	0.20		0.06	
R-sq overall	0.33		0.09	
Number of observations	1633		1979	

Results show that employment on the Jatropha project contributes to short-term diet diversity, but not to more mid-term and more subjective shortage of food.

For rural development, we recommend besides promoting off-farm employment investments in storage, crop diversification, livestock and savings. For the Jatropha project we recommend better monitoring of employment, meet local energy needs and intercropping with food crops. Ongoing research is looking at other benefits from participation in biofuel value chains, namely spillovers to agriculture, better access to relevant information and innovations in agriculture, higher input use in agricultural production, and changes in the value chain of agricultural products, i.e. more storage and later sales and therefore an improvement in the bargaining power of farmers towards traders.