Environmental Implication of Sesame Production in Tanzania: A Case Study of Kilwa District, Lindi Region

Razack Lokina, Julieth J. Tibanywana & Michael O. A. Ndanshau*

Abstract

This paper analyses the possibilities for sustainable land use management at farm level to preserve the tropical rainforest in the Lindi region, Tanzania. It investigates the implication of agricultural production, in particular a high valued sesame production on household deforestation in Kilwa district, in Lindi region. The choice of the study area is because Lindi region is one of the leading sesame producers in the country. The analysis is based on data collected in Kilwa district, from a sample of 310 households in six village. The key question in the questionnaire administered to heads of households was, among others, factors that influenced their decision to clear new land for sesame farming in the previous crop season. Thus, the study set out to understand drivers of deforestation in Lindi region at the household level. Using bivariate Probit model it investigated whether sesame production influenced clearance of new area. The main findings of this study indicate that even though sesame production influence household welfare positively, it is also likely to affect the environment negatively. It recommends the need to put in place appropriate policies and infrastructure such that farmers can increase productivity without the need to expand farm land.

Keywords: *sustainable land use, agriculture, forest, deforestation, welfare*

JEL Classification: Q1, Q17

1. Introduction

Agriculture is the most of important source of wealth to most of the countries in the developing world. In these economies, the agricultural land base is expanding rapidly through conversion of forests, wetlands, and other natural habitat (Barbier et al., 1991). In today's world, the importance of forest and forest services cannot be overemphasized because of the many services provided by tropical forest (Costanza et al., 1997). Hence, the rapid increase in tropical deforestation has put forest at the centre stage of the agenda for developers, conservationists, and policy-makers. Factors influencing deforestation, such as the opening of new roads (Chomitz & Gray 1996; Reid 2001), land property right issues (Alston et al., 2000; Godoy et al., 2001), the spread of industrial cash-cropping (McMorrow & Talip 2001), slash-and-burn agriculture, cattle ranching, and logging activities (Palm et al., 2005) are widely discussed in the literature. Many studies have addressed the various causes of deforestation, but very few have focused on the effect of high-valued cash-cropping on deforestation using household level data. The impact of cash-cropping on

* The authors are academic staff members of the Department of Economics, University of Dar es Salaam: rlokina@udsm.ac.tz; juliethjulius@ymail.com, and ndanshau@udsm.ac.tz

deforestation have been discussed in the literature (McMorrow & Talip 2001; Angelsen & Kaimowitz 2001; Pendleton & Howe 2004; Lopez et al., 2012). The high degree of integration of rural areas with national and international economies, as well as population pressures are the main cause of this widespread land and resources conversion in many of these areas. Poor intensification of agriculture in many of these tropical developing economics, low productivity, limited use of irrigation also spur agricultural land expansion (Lopez et al., 2012).

Some of the literature focusing on the effect of high-valued cash-cropping on deforestation agree that cash-cropping increases deforestation. For example, Dearden (1995) showed that the intensification of cash-cropping of cabbage increased deforestation because cabbage has a low value compared with opium, which it was replacing. Similarly, in a household-level study in Cameroon, Mertens et al., (2000) showed that deforestation increased as the marketing of food crops increased in response to economic crisis. High-valued crops have relatively higher rate of deforestation compared to normal agriculture because they are introduced and highly promoted, thus luring people to rush into producing them in high quantities, which implies the need for more land. Although the newly introduced crops may not survive that long, damage on forests may already have been done before ceasing their production.

Sesame farming is a particularly destructive form of agriculture, because cultivators burn huge swaths of forests to create their farms, which they only use for two or three seasons. Evidence has shown that farmers prefer virgin land because the soil is easier to work on, and requires little maintenance. There is a belief among local farmers that virgin land produces higher yields, which to a larger extent has contributed to shifting cultivation. However, the traditional shifting cultivation method practiced by many sesame farmers is severely damaging the land.

Tanzania is one of the developing countries whose economy depend heavily on agriculture that comprises crop production, livestock keeping, forestry and hunting (MAFAP, 2013). The agricultural sector, which is predominated by smallholder crop production for food and traditional cash crops for export, account for about 26.4% of the Gross Domestic Product (GDP). It also employs 80% of the total labour force, and account for about 30% of foreign exchange earnings from the export of traditional cash crops that include coffee, tea, cotton, sisal, cashew nuts, tobacco, and also oilseeds that has evolved as non-traditional export crop in Tanzania.

Smallholder farmers dominate in agricultural crop production. Their farming technology and practices is quite traditional as it is dominated by simple farming tools that include hand hoes, matchets, with very low level of mechanization. It is also characterised by shifting cultivation in small pieces of land of between 0.2ha to 2 ha, use of poor-quality seeds, and very low return (productivity) to labour (MAFAP, 2013). Most (96%) smallholder farmers depend on rainfall, and only a few uses irrigation schemes (MAFC, 2008). It is this low-level use of technology and farming practices that characterize agricultural crop production, coupled with poverty at the household level, that have been instrumental in deforestation in Tanzania (Kibuga & Samweli, 2010, Miya et al., 2012; Vadez et al., 2005). The established adverse effect of agriculture on deforestation in Tanzania is not unique. Estimates by UNFCCC (2007) suggests that agriculture is responsible for 80% of deforestation in developing economies, followed by commercial logging and energy demand.

Generally the literature has revealed that there are different approaches and methodology that have been used to examine how human activities, especially agricultural activities, influence deforestation either alone or in addition to its link with natural resources and peoples' welfare. The estimated models variably included socio-economic and demographic factors (see, e.g., Nakyagaba et al., 2005; Babigumira et al, 2014; Kissinger et al., 2012; Lokina and Lwiza, 2018). In this study we focus on the consequences of total area of forest clearance, household labour requirements, and for fallow duration. We contribute to the debate on the causes of deforestation in two areas. First, the study is using household-level data: very few studies have been conducted using this method. Second, we show evidence of deforestation by indigenous peoples. Indigenous peoples are considered more conservationist, and therefore do not account for a large share of deforestation, but this is changing very fast as indigenous people become more integrated into the market economy (Godoy et al., 2001).

2. Economics of Sesame Production and Land Use in Tanzania

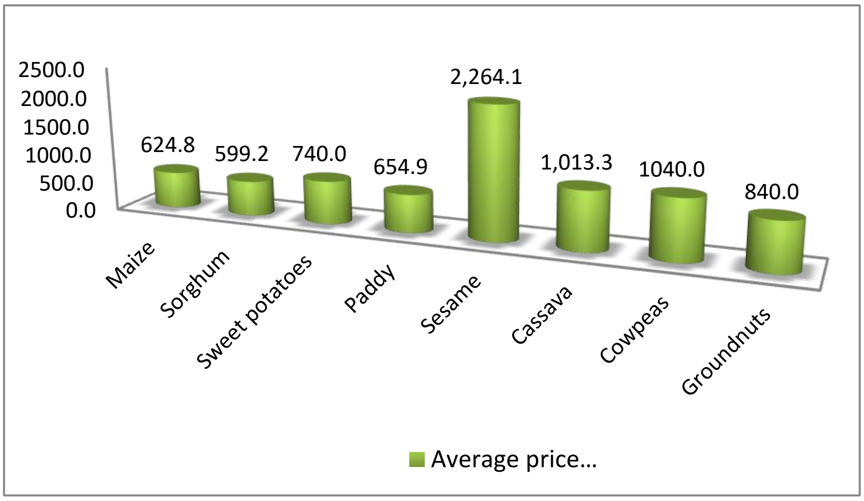
Sesame is one of the non-traditional cash crops for export in contemporary Tanzania. It is produced in Lindi and Mtwara regions. The crop is mostly grown in a separate farm or mixed with other crops in areas that originally were forests (Miya et al., 2012). In Lindi, and also Mtwara, sesame production has grown to become a very popular and a high-return cash crop among households in Kilwa district. This is partly explained by the relatively better producer price of sesame when compared to other food and cash crops, among others, maize, paddy, sorghum, millet, Irish potatoes, and beans. The sustained increase in producer price and thus high returns from sesame production has translated into better socio-economic wellbeing for its producers (Mashindano & Kihenzile, 2012). The sustained increase in the producer price for sesame is explained by its sustained demand in the international market.

Due to its profitability, the number of smallholder farmers growing sesame has been increasing. In tandem has been an increase in the abandonment of production of other crops, such as cashew nuts, in favour of sesame production. However, due to scarcity of land for expanding land under sesame cultivation of in Lindi, specifically in the village under the REDD+ programme in Kilwa district, slash and burn shifting cultivation is becoming a common practice. A forest patch, usually an old or regenerating forest is cleared and burnt before crops are planted. Most farmers would abandon an area after one or two harvests and clear another. This practice results in deforestation and forest degradation, which in turn have long-run welfare impacts.

It is possible for the degraded forest to regenerate into a new forest when degradation is not critical, but once deforestation occurs then it becomes impossible for the forest to regenerate. Deforestation in Tanzania is largely influenced by agricultural activities where community produce for subsistence and commercial purposes. The declining forest cover has wide range of implications such as low crop production, carbon storage, timber production, and even the availability of non-timber forest products. Economically, deforestation leads to shortage of timber products, which in turn reduce foreign currency earnings. Moreover, agricultural productivity decline because of soil erosion and desertification caused by deforestation. Deforestation also reduces peoples' incomes that accrue from forest products like medicines, honey, and wild fruits which they sell and earn income. All these will have negative impacts on peoples' long-term welfare.

Environmental impact such as increase in soil erosion, which in turn affects water resources indirectly, can also arises because of deforestation. When water catchment area is affected then all human activities, such as agricultural activities, suffer, which basically hinder development at individual and nation level. Also, since declining carbon storage capacity due to deforestation regional and global climate will be affected, and this may result to greenhouse gas emissions that negatively impact weather conditions.

Generally, sesame crop is leading in terms of number of households engaged in its farming, crops as well as its average price. Sesame oils seeds have high minimum price per kilogram (TZS1500), high maximum price per kilogram (TZS3000), and high average price per kilogram (TZS 2264.103) when comparing with other crops grown in the area as shown in Figure 1.



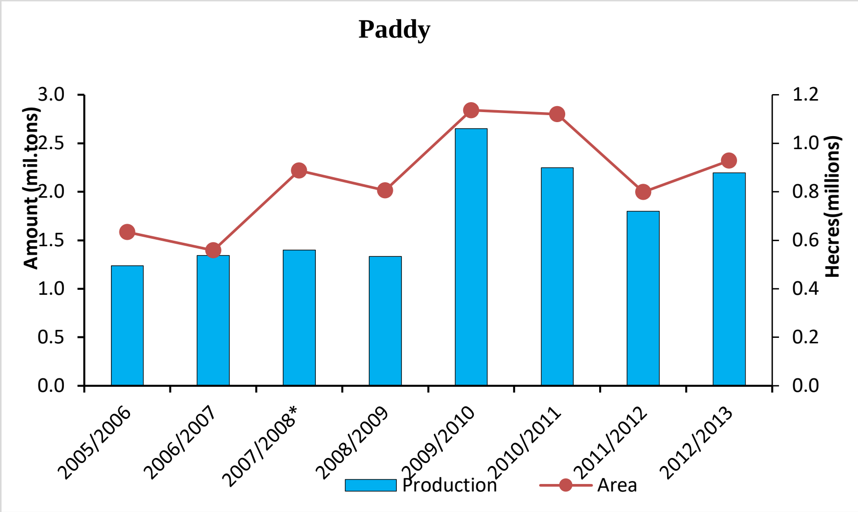
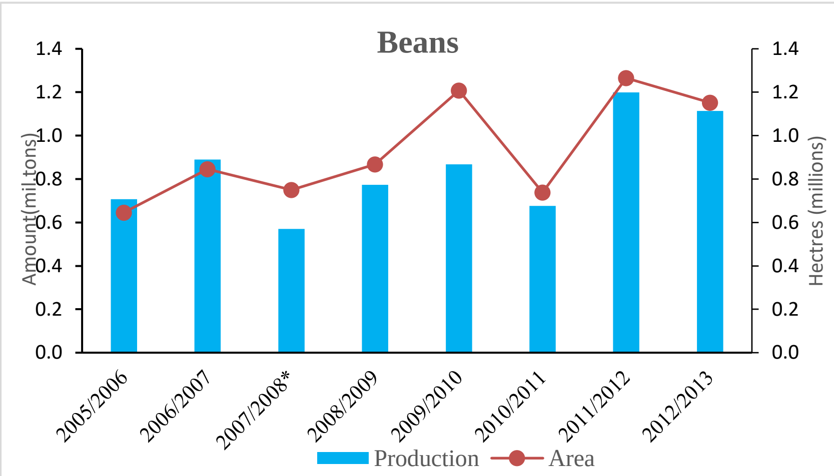


Figure 1: ***Comparison of Crops Grown by Prices and Number of Farmers in Kilwa***

Source: Author's computation (2015) using field data

Looking at crop production and area cultivated of some selected crops, there have been fluctuating trends for paddy, beans and sorghum as seen in Figure 2. The trend is different when looking at sesame, especially from 2008 when production as well as area under its cultivation began to increase. This increase may mean that, to increase its production, farmers clear more land instead of applying modern inputs to increase productivity. Most sesame farmers are not aware of the fact that there is a potential of increasing the productivity of sesame without necessarily expanding farm sizes. Thus, what they might need are the extension services to guide them on the better way of farming sesame without causing deforestation.



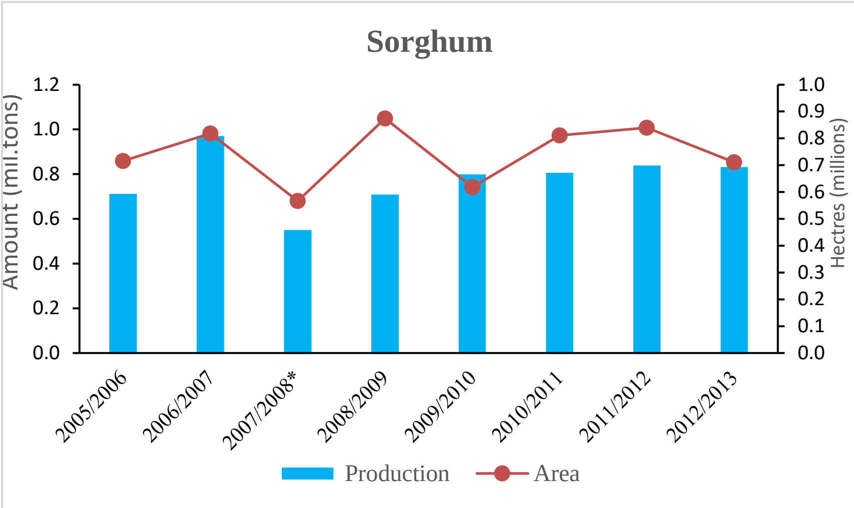


Figure 2: ***Trends of Production and Areas cultivated for Selected Crops***

Source: NBS(2013).

3. Methodology

3.1 Study Area

The study was conducted in Kilwa district in Lindi region, in the southern zone of Mainland Tanzania. The district, which covers an area of about 13,347km^2, borders Liwale District and the Selous Game Reserve on the west. On the north is Rufiji district in Coast region; while on the south it borders Lindi Rural District.

Land cover and vegetation found in the area is sparsely populated, covered with natural vegetation. Miombo woodland dominates the district. Scattered trees, scrubs and thickets characterize vegetation in the area. Large animals like elephant, hippopotamus, and lion to mention few, are found within the district. The grazing of these big animals in the area has had a big impact on vegetation cover. In addition, frequent fires caused by villages also pose challenge to vegetation cover.

The district constitutes of 97 villages (Table 1). Like so many other rural areas in the country, most of the population (85%) rural-based areas, practising agriculture as the main economic activity. Agriculture account for about 75% of the income earned by the sampled households in Kilwa District. Other sources of income earned in Kilwa District include forest extraction, livestock keeping, fishing/ hunting, and gathering. The main agricultural food and cash crops produced, by order of importance (based on planted area), include maize, cassava, cashew, sorghum, paddy, sesame, coconuts, cow peas and Bambara nuts. Other minor crops grown includes pulses, mangoes, citrus and vegetables. The average land area utilized per crop is around 1.8 ha (Table 2).

Table 1: Area, Population and Households in Lindi Region by district

District	Area	Population	Household size	Number of households	Villages
Kilwa	13,347	190,744	4.4	43,351	97
Lindi district council	7,538	194,143	3.7	52,471	134
Ruangwa	2,580	178,464	3.7	48,234	89
Nachingwea	7,070	91,380	4.3	21,251	126
Liwale	36,170	131,080	3.5	37,451	76
Lindi municipal council	945	78,841	3.5	22,526	20
Total	67,650	864,652	23	225,284	541

Source: 2012 Population and Housing Census.

Smallholder's farmers dominate the sector; a majority producing for subsistence and very few for commercial purposes. Farmers use poor tools during cultivation, with shifting cultivation and agricultural expansion are the best practice in the area. Recently, price appeal has played a big part in influencing shifting cultivation and agricultural expansion. As such, the area under cultivation in the district has been expanding overtime. For example, between 2010/11 and 2012/13 the average area put under cultivation increased by 14.75%, suggesting increase in deforestation (Table 2).

Table 2: Area Under Cultivation, Crop Production and Average Yields in Kilwa

Crop	2010/11			2011/12			2012/13		
	Area (ha)	*Production (tones)*	*Aver. yield (T/ha)*	*Area (ha)*	*Production (tones)*	*Aver. yield (T/ha)*	*Area (ha)*	*Production (tones)*	*Aver. yield (T/ha)*
Sorghum	20,210	24,252	1.2	18,171	25,712	1.2	18,471	18,471	1
Cassava	16,616	33,232	2	18,533	37,067	2	15,977	23,966	1.5
Rice	8,134	13,828	1.7	9,072	10,025	1.7	7,821	7,821	1
Maize	10,770	18,309	1.7	12,013	13,274	1.7	12,013	12,013	1
Cashew	5,366	8,049	1.4	6,235	9,337	1.4	5,366	8,046	1.5
Sesame	23,696	18,927	0.8	27,487	21,990	0.8	23,696	18,967	0.8
Coconut	7,472	114,700	7	7,470	92,800	7	1,723	8,615	5
Cowpeas	16,938	11,856	0.7	16,286	9,948	0.7	16,286	9,948	0.6

Source: Field data, (2015)

Table 2 shows that there an increase in the area under cultivation, increase in the volume of crop output, which is however contrasted by very low level of yield per hectare. This indicates that production is increased by cultivating more land and increasing farm size, which is only possible through encroaching into forested areas. Miyaet al. (2012) has also reported that agricultural expansion exerted by population pressure and economic growth, fire, land use change, livestock keeping, timber trade and charcoal production to be also the other main drivers of deforestation in the district.

3.2 Data Type and Sources

This study was based on both primary and secondary datasets. The primary data was collected using a structured questionnaire that was administered to a randomly selected sample of households in Kilwa District.

Sample of 6 wards and 6 villages were surveyed for data collection. In each village number of households interviewed was calculated using rationing method according to number of households in each village as shown in Table 3. Within the village random sampling was used to obtain the required data.

Table 3: Population Structure and Sample Size per Village

Name of Village	Household Size	Household Interviewed	Percent
Nangurukuru	670	40	12.9
Miteja	923	53	17.1
Somanga	1236	72	23.23
Kiranjeranje	430	28	9.03
Mandawa	1,376	81	26.13
Nakiu	586	36	11.61
Total	**5221**	**310**	**100**

Source*:* Field data, (2015).

3.3 The Estimation Model

To estimate a model of the household's decisions to clear new land for farming sesame, rests on its utility maximization principle. In this regard, a utility index of gains/benefits from clearing new land presented by an unobserved Y^*(latent variable), is determined by a set of household-based factors (X).

$$Y^* = X'\beta + \varepsilon \qquad (1)$$

Where (1) is expressed as a Probit model:

$$\text{Pr}\ (Y = \frac{1}{x} = \phi(x'\beta \qquad (2)$$

where Y is a binary variable that takes on values of unity (1) and zero (0) with respect to the household decisions to clear new land for cultivating sesame; X is a vector of factors that are likely to influence households decisions to clear new land for agriculture, sesame production, in particular. Specifically, X is defined to include, among others, demographic, cost of clearing new land or the nature/ types of crops cultivated by respective households.

Given, (2) the estimation model to capture household behaviour with respect to the clearing of land for crop production can be specified as:

$$Pr(L = 1) = F(AGE, EDU, SEX, HHA, CAP, D) \qquad (3)$$

AGE is the number of years of the head of the household in the sample; expecting that young households will be more physically able to clear/cultivate new land than the older ones. Education (*EDU*) of a household is measured in the number of years spent in school, which is assumed to negatively affect the demand for more land, i.e., higher education is accompanied by more opportunities for non-farm activities such that it would be negatively related to the clearing of new land for farming.

It is also assumed that higher education could open opportunities for accessing agricultural loans and use of basic technology for land clearing such that its impact on clearing of new land for crop production would be negative. *Sex* is a dummy variable that takes on value of 1 for males and 0 for females. *A priori,* this variable is expected to be positive given the African tradition that men are likely to engage more in activities that can potentially be considered high-valued. Household assets (*HHA*), which are measured as the market value of financial and physical assets, are expected to have an ambiguous effect on clearing of new land for farming. Capital (*CAP*) of a household is measured as the sum of financial assets, which are considered as assets against income fluctuations, and are expected to be associated with high land clearing.[1]

On the other hand, physical capital of a household (*HHA*) is measured as the total market value of all equipment used in crop production during the previous crop season. Ideally, households with good equipment for cultivation are likely to clear more land than households with poor equipment for cultivation. Thus, the effect of *HHA* on a household decision to clear land for crop production is expected to be positive. Crop cultivation dummy D is also likely to positively influence a family's decision to clear new virgin land. The variable takes the value of 1 if a household is engaged in sesame production, and 0 otherwise.

3.4 Estimation Technique

Different studies in deforestation use different methodology to examine the impact or likely effects of agricultural practices on deforestation. The most applied methodologies for studies that focus at household levels include simulation analysis, simple or multinomial logit/Probit analysis, and ordinary least squares (OLS) estimation, depending on the nature of the dependent variable. The commonly used response variables include amount of forest cleared, amount of primary forest cleared, size of the cultivated land in the survey year, percentage of land still in forest, and average forest cleared per year. In this study we apply two models—simple binomial Probit model, and production functions—to examine the influences of sesame production on household's decisions to clear forested area, and the welfare impacts of agricultural practices.

In the Probit model we use binary dependent variables indicating whether the households cleared new land for agricultural season underlying the survey year.

[1]Financial assets at households are measured by livestock holding.

The Probit model of a household decision to clear new land (forested areas) for agricultural purposes is estimated using robust estimation (robust standard errors) to cater for multicollinearity problem and the presence of extreme values for some variables such as the value of wealth.

4. Empirical Results

4.1 Exploratory Data Analysis

Tables 5 present the descriptive statistics of the 310 households covered in this study in Kilwa district. About 73% of the households in the sample were male, and the remaining 27% were female. The average size of a household in the sample is 5 persons, which is slightly less than the national average of 6 persons. The mean age of a household head covered by the study is about 45 years, whereby the youngest household head is 20 years old and the oldest is 100 years old. The average size of the farm owned and cultivated by the sampled households is 1.8 acres.

Table 5: Descriptive Statistics

	Units	Obs.	Mean	Std	Min	Max
Output per worker	TZS	260	397788.60	459236.30	0	2595000
Capital Per worker	TZS	260	15026.74	87493.35	500	1403000
Land Per worker	Acres	251	1.83	1.64	0.125	11.5
Land Clearance	1 or 0	310	0.44	0.50	0	1
Sesame	1 or 0	310	0.63	0.48	0	1
Household head Sex	1 or 0	310	0.73	0.45	0	1
Household Size	Number	310	5.32	3.10	1	21
Household head Age	Number	310	45.07	14.35	20	100
Age^2	Number	310	2236.97	1452.53	400	10000
Primary	1 or 0	310	0.91	0.29	0	1
Secondary	1 or 0	310	0.08	0.27	0	1
Livestock holding	1 or 0	310	0.31	0.46	0	1
Dependency	Ratio	310	35.36	24.64	0	85.71429
Capital Inputs	TZS	310	34877.42	240157.70	0	4209000
Wealth	TZS	310	1844205.00	2675173.00	0	22400000

Source: Computations based survey data.

About 17% of the household heads sampled had no formal education. Nonetheless, 74% had between 1 to 7 years of schooling. Only 1% of the household heads had education above secondary level. This implies that about 91% of the household heads had at least 7 years of primary school education; and about 10% had more than primary school level of education.

Most (84%) households in the sample earned income from agricultural activities, especially crop production. The remaining (16%) households earned income from non-farm economic activities, such as employment and own business. Sesame crop was the most predominant cash crop grown by most (about 63%) of the sampled households in Kilwa district.[2] In addition, about 57% of the interviewed households

[2] Other crops included maize, paddy, sorghum, cassava, sweet potatoes, and groundnuts etc.

also engaged in growing of maize, which is a food and (sometimes) a cash crop. The size of farms cultivated by the sampled households averaged 4.4 acres, with the smallest being 0.25 acre and the largest being 25 acres.

The survey established that about 52% of the households in the sample cleared new land in the previous farming season. This was motivated by the desire to increase production to take advantage of high prices, and address issues of soil exhaustion. Other factors said to have been behind the increase in clearance of new lands for crop production included the availability of a ready market for the produce, and the intention to earn more income.

Moreover, increase in the clearing of new land for farming could also be attributed to poor-cum-crude agricultural crop production technology used by most of the sampled households. All sampled households were using hand hoes for cultivation. For example, about 56% were using *pangas* (machetes) to clear forests. Also, most of the sampled households depended on rain-fed rather than irrigated agriculture. In all the villages studied application of modern inputs, such as pesticide and herbicides, was very low.[3] Furthermore, most of the households were using manual labour-based implements, and limited hired labour. Also, more than 97% of the sampled households did not use fertilizers. Instead, they preferred the virgin forest soils; arguing that high costs of fertilizer prohibited them from using it. Others claimed that their lands were more fertile, and so they do not see any need for fertilizer application.[4] The survey also established that sesame producers cleared new area for cultivation when compared with the non-sesame producers; and the difference is statistically significant.

More than 60% of the 310 households surveyed were engaged in the production of sesame. The results show that the sesame producers had larger family sizes, and were more educated than non-sesame producers. Nevertheless, the difference in demographic characteristics was not statistically significance. Most of the household heads covered reported to have devoted more resources into the production of sesame because it was the most paying crop during the period. As reported earlier, the market for sesame has improved dramatically in recent years compared with the past. Consequently, the acreage land size put under cultivation in Kilwa district rose from 1.9 acres in 1975 to 4.04 acres in 2014. The increase in production, especially since the mid-2000s, resulted from good market prices. The land used to cultivate sesame was mostly the one encroached from the forest. Specifically, about 62% of the respondents reported to have cleared land encroached from the forest; and 21% claimed to own the land cultivated. About 6%

[3] In previous years, farmers did not use sprays such as pesticides in their cultivations. The training which was provided by Amsha Institute of Rural development in recent years (2000's) has changed farmer's attitude since they respond positively and start using pesticides in their farms though the use is still very low because of the high purchasing costs of these pesticides as claimed by majority farmers.

[4] The survey established that, on average sesame farmers grow the same land for about two years then abandon the land and clear new area for cultivation. The reason for them to abandon the land was due to loss of soil fertility and weed invasion in their farms.

of the households reported to have obtained land from friends and relatives; while others said they rented or bought the increased land. A few of the household (2%) obtained the land from the village government. Figure 3 summarizes the details.

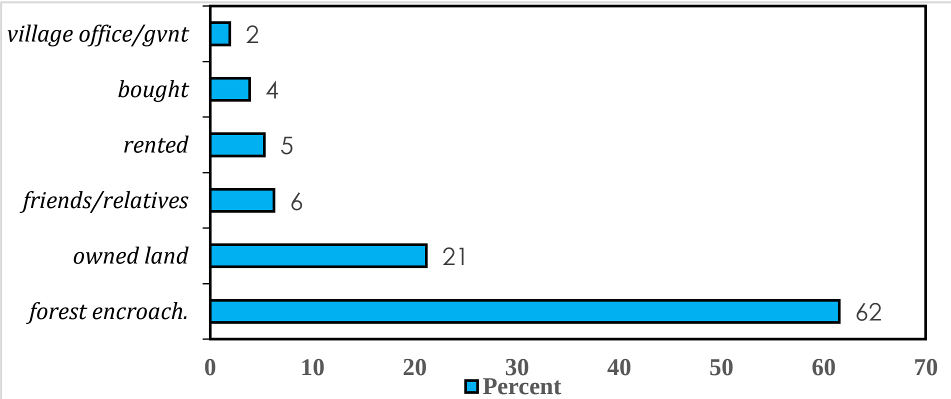


Figure 3: ***Sources of Land to grow sesame (in percentage)***

Source: Author's computation using field data

The expenditure of the surveyed households differed depending on the type of crop they cultivated, with sesame producers having higher expenditure compared with non-sesame producers. Sesame producers spent about TZS219,153.30 per month compared to non-sesame producer who spent TZS182,356.50 per month. The households in the sample were also differentiated on the scale of wealth, measured as the total value of all asset owned, which included a mobile phone, motorcycle, television, radio, house, bicycle, etc., during the year of the study. Using asserts ownership as an indicator for wealth revealed sesame producer in the sample as wealthier than non-sesame producers (see Table 6 for detail).[5] About 69% of the household heads expected to increase the production of sesame in the coming growing season; while about 34% were neutral on whether they would increase or reduce the production of sesame in the coming crop season.

Table 6: Comparison of Sesame Producers and Non-Sesame Producers

	Family size	Education head	Land ownership	Household expenditure	Household wealth	Age head	Livestock keeping
Sesame producer	5.451	5.903	4.793	219,153.8	2,332,354	44.9	1.67179
Non-sesame producers	5.104	5.504	3.629	182,356.5	1,016,474	45.4	1.71929
Total	**5.322**	**5.755**	**4.411**	**205,503.2**	**1,844,205**	**45.1**	**1.68932**

Source: Author's computation using field data

[5] The market value of the assets was obtained by asking households the value that they are willing and able to accept to sell their assets since they are the ones who know their conditions and qualities.

4.2 Regression Diagnostic Tests

We conducted a diagnostic test to test for heteroscedasticity, multicollinearity, and specification error in the estimation model. Specifically, the heteroscedasticity test was carried out using the Breusch-Pagan/Cook-Weisberg approach.[6] The null hypothesis (H_0) that the variance of the variables is constant (homoscedasticity) could not be rejected. The test for multicollinearity was carried out by using simple correlation method. The results showed there was an evidence of higher correlation among the variables (Table 7).[7]

Table 7: Specification Test Results

	Age	Age2	Wealth	Sex	Primary	Secondary	Landcl	Ssm
Age	1.0000							
Age2	0.9806	1.0000						
Wealth	0.0957	0.0543	1.0000					
Sex	-0.0016	-0.0166	0.0595	1.0000				
Primary	0.1023	0.0963	-0.1492	-0.1403	1.0000			
Secondary	-0.0644	-0.0664	0.1603	0.1292	-0.5466	1.0000		
Landcl	0.0283	-0.016	0.1188	0.0483	-0.1271	0.1021	1.0000	
Ssm	-0.0184	-0.0384	0.2603	0.0982	-0.0412	0.0677	0.0151	1.0000

Source: Author Computations from survey data

4.3 Interpretation of Results

We focus our interpretation on the marginal effect of the estimated Probit model. Table 8 presents the estimation results of the marginal effect after the Probit model.

Table 8: The Marginal Effects After Probit Regression

Variable	dy/dx	Std. Error	P-value
Sesame*	0.2360***	0.0622	0.0000
Sex*	-0.0312	0.0719	0.6640
Age	0.0490***	0.0143	0.0010
Age2	-0.0005***	0.0001	0.0000
Primary*	-0.5128***	0.1547	0.0010
Secondary*	-0.3724**	0.1528	0.0150
Livestock*	0.1822***	0.0647	0.0050
Dependency	-0.0012	0.0014	0.3650
Household Size	0.0292*	0.0124	0.0180
Capital	0.0000	0.0000	0.7880
Log(Wealth)	0.0019	0.0208	0.9260

Note: ***, **, * represents significance value at 1%, 5% and 10% per cent respectively; (*) dy/dx is for discrete change of dummy variable from 0 to 1.

[6]The presence of heteroscedasticity causes the estimated coefficients to be inefficient though they will still be unbiased Gujarat and Porter, (2005).

[7]that the variables used in estimating the specified model were performed to detect the presence of liner relationship between the independent variables. According to Gujarati and Porter, (2009) the rule of thumb is that if the pairwise or zero order correlation coefficient between two regressors is high, say in excess of 0.8 then multicollinearity is a serious problem.

The estimated marginal effects of the Probit model presented in Table 8 shows the magnitude (probability) change in land cleared for cultivation caused by each of the right-hand determinants ceteris paribus. Specifically, the coefficient on sesame production is positive and statistically significant at the conventional level. This suggests that a switch from a non-producer to a producer of sesame would increase the probability of clearing forest for new land for cultivation by approximately 23.6%.This result suggests that a household that engages in the production of sesame would have higher net benefits, and hence increase the probability of clearing new land compared to non-producers of sesame. The result is consistent with evidence in previous studies, among others, Kibuga et al., (2010), Nganyagwa et al., (2008), and Mwamsamali (1997); which suggests that agricultural production is likely to affect the environment negatively—i.e., cause deforestation.

The age of a household head has a negative sign and it is a statistically significant coefficient. This finding suggests that the likelihood to clear more forest-land for sesame production decline with the age of a household head. This result should be expected since most rural farmers use hand hoes, hence the inability to expand farm size as one gets older. The estimated parameter suggests that an increase in the age of a household head decreases the probability of clearing new land by 4.9% from the mean. This result is consistent with *a priori* expectations; and can be attributed to labour intensive nature of agricultural activities in the areas. This finding is consistent with that obtained by Babigumira et al. (2014), which showed that at higher ages, household decisions to clear new land were minimal.

As expected, the coefficient on livestock holding, used as proxy for financial assets, has a positive and statistically significant values. This implies that household involvement on livestock farming in the sample areas was positively correlated to the decision to clear new land for cultivating sesame. The households switch to livestock holding increases the probability of clearing new land by about 18%.

Of the two levels of education included in the estimation model, only the primary education category influenced households' decisions on the clearance of new land for cultivation at 10% statistically significant level. The result of this study is inconsistent with that of Babigumira et al. (2014), which found education as an insignificant determinant of a household decision to clear new land.

Also, the results show that an increase in a household size increases the probability of clearing new land. This is consistent with the *a priori* expectation that household size increases the number of workforces, and hence the decision to clear more land.

5. Conclusion

This study examined the impact of sesame production on the environment (deforestation) in Tanzania by specifically focusing on Kilwa district in Lindi region, southern Tanzania. The analysis was based on a sample of 310 randomly sampled households in 6 villages in Kilwa district. A Probit model (deforestation model) was used to estimate the household decision to clear new land with respect to a set of factors, among others demographic ones.

The study established that a majority (80%) of the sampled households depended on agricultural activities as their main source of income. Income from non-farm activities was by and large limited in most of the sampled households. The results indicated that sesame was the major crop grown for commercial purposes, while maize is the major food crop. About 52% of the household surveyed indicated to have cleared and cultivated new land for crop cultivation in the last preceding crop season. The land was cleared to increase acreage in the thirst to increase output, and thus take advantage increases in crop prices and address loss of soil fertility. Other causes for the clearance of additional land for cultivating sesame included the evolution of sesame as a cash crop that was a good substitute for subsistence farming, the availability of a ready market, and the intent to earn more income. Most households still depend on traditional inputs for cultivation, such as manual labour, hand hoes, etc.

The survey established that sesame production was likely to results into deforestation as most farmers obtained additional land for its cultivation by encroaching on the forest, which was motivated by the potential benefits sesame production. When compared to non-sesame producers, sesame producers had bigger family size, higher education level, owned bigger land areas, and had higher household expenditure. In general, sesame producers appeared to have a relatively higher welfare than non-sesame producers.

The empirical findings for the Probit model showed that sesame production had a significant probability of acreage expansion by clearance of new land. The potential deforestation was explained by high benefits to households realised from the production of sesame. The study established other factors that accounted for the significant positive effect on the likelihood of deforestation by clearance of new land. They included age of household head, livestock keeping, primary education, and household size. Capital, wealth, gender, secondary education, and dependency ratio positively had statistically insignificant effect on land clearance at the conventional test level.

Our findings suggest that there was very limited use of fertilizers and pesticides in the study area. Furthermore, farmer do not have access to extension services. This could partly explain why farmer prefer shifting cultivation. Therefore, there is a need for policy initiatives for sustainable environment conservation as well as maintenance of people’s welfare. For example, the use of modern inputs such as fertilizers and herbicides could help avoid deforestation in the study area, and at the same time increase crop productivity that would enhance farmers’ income earning capacities. Moreover, extension services, improvement of crop marketing channels, provision of education, good crop husbandry practices should be provided for both agriculture and forestry to promote good practice of agriculture that would avert environmental degradation in the area.

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