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Anthropogenic Drivers of Forest Change in Miombo Ecosystems of South-eastern Tanzania: Implications for REDD+

Kassim Kulindwa,[*] Haakon Lein,[**] Aloyce S. Hepelwa[*] & Baruani I. Mshale[***]

Abstract

As the basic purpose of REDD+ is to avoid deforestation and forest degradation, a good understanding of processes that cause deforestation is obviously of importance. However, many REDD+ programs and policies have rather limited focus on the underlying processes behind forest change. Much of the on-going work within the REDD+ framework focus on building institutional capacity ('REDD readiness'), finding ways or measuring and monitoring carbon, developing institutional facilities, and on the international financing of REDD+. It appears that the discussion of what actually causes deforestation is seen as a more or less resolved and settled issue. This paper argues for a more contextualized understanding of the drivers of forest change in human-dominated Miombo ecosystems of southern Tanzania. This is achieved through addressing two basic empirical research questions: How is the forest changing; and what factors influence forest change? The study is based on quantitative and qualitative data covering both socio-economic and ecological aspects collected in 12 villages of Kilwa and Lindi districts in southern Tanzania. The study shows that there are considerable micro-level variations from village to village as regard both the extent and drivers of deforestation/forest degradation.

Introduction

As the basic purpose of REDD+ is to avoid deforestation and forest degradation, a good understanding of processes that causing deforestation is obviously of importance. However many REDD+ programs and policies have rather limited focus on the underlying processes driving forest change (Brockhaus, Di Gregorio, & Mardiah. 2013) as much the on-going work on focus within the REDD+ framework is on building institutional capacity ('REDD readiness'). It sometimes appears as if the discussion of what actually cause deforestation is more or less resolved, and that deforestation is caused by growing local populations and/or land investors, loggers, and cattle ranchers progressing into tropical rainforests. Although REDD+ activities may be based on a good understanding of the general drivers behind forest change, the need for a blueprint solution applicable on a larger scale may easily lead to a neglect of the complexity of local-level realities. A local and place-based understanding of change processes is thus needed.

[*] Department of Economics, University of Dar es Salaam Tanzania, Dar es Salaam, Tanzania: kulindwa@gmail.com or kulindwa@udsm.act.tz / ahepelwa@udsm.act.tz or ahepelwa@yahoo.com

[**] Department of Geography, Norwegian University of Science and Technology, Trondheim, Norway: haakon.lein@ntnu.no

[***] School of Natural Resources and Environment (SNRE), University of Michigan, USA: baruani.mshale@gmail.com

There exist multiple definitions of *deforestation,* but in general deforestation refers to a permanent or long-term conversion of forest to non-forest land, commonly—but not necessarily—attributed to anthropogenic influence (Schoene et al., 2007). The permanency of such conversion is sometimes uncertain, for example, as farmers may apply a mix of farming practices involving more both permanent cultivation and various types of bush and forest fallow practices, activities that in many cases lead to forest degradation and not necessarily deforestation. As with the term deforestation, there is no single universally accepted definition of *forest degradation* (ibid.). The Food and Agriculture Organization (FAO) has adopted a generic terms as it defines forest degradation as "…a reduction in the capacity of a forest to provide goods and services" (FAO. 2011: 1). The 'goods and services' normally linked to forest degradation are forest products, biodiversity and carbon. However, as these are not necessarily overlapping features, the term opens up for a wide range of interpretations and measurements.

Explaining Deforestation, Degradation and Forest Change

In a comprehensive review of literature, Geist and Lambin (2001; 2002) analyse how deforestation has been explained in 152 case studies carried out in Latin America, Africa and Asia. They separate between underlying and proximate drivers (or causes) of deforestation, and identify four types of proximate (direct) causes of deforestation and five underlying driving forces. Proximate factors tend to be immediate and local, whereas underlying factors are indirect, temporary and geographically distant (Carr. 2004: 588). The proximate factors are: *infrastructure expansion, agricultural expansion, wood extraction* and *other factors*; whereas the five types of underlying social processes are: *demographic*, (e.g., population density and change, migration), *economic*, (e.g., market growth and commercialization), *technological* (e.g., changing production factors, intensification), *policy and institutions* (e.g., policies, policy climate, property rights), and *cultural factors* (e.g., attitudes, values and beliefs, HH behaviour).

While Geist and Lambin (2001:16) do not distinguish between deforestation and forest degradation, Hosonuma et al. (2012) distinguish between proximate drivers of deforestation and proximate drivers of forest degradation. Here, logging, charcoal production and other types of use that do not lead to a permanent conversion of forest to another land use category are classified as forest degradation drivers; whereas permanent conversion to agricultural expansion, roads and infrastructure development, and urban growth are seen as proximate drivers of deforestation (ibid.).

Population change and in-migration is commonly identified as a significant underlying driver of deforestation (Carr. 2004). In-migration can be caused by land shortage in other areas leading people to search for land for subsistence production. But in-migration can also be driven by increasing demand for commercial products for a growing urban population or a world market. The demographic structure of a forest population depending on subsistence cultivation will have implications for deforestation rates. The size and composition of forest cultivator households will have implications for the demand for food as well as availability of labour, and this

may vary according to household cycles. Deforestation driven by outside demand for commercial agriculture may be less influenced by household demographics as it is not driven by subsistence needs. However, the availability of labour may still be a limiting factor at least in areas with smallholder farming.

DeFries et al. (2010) argue that it is urban-based and internationally driven demand for agricultural products and not rural population growth that has been driving deforestation in the period 2000~2005. This will also in the future be the most important driver of deforestation. The continue to argue that halting deforestation can best be achieved by focusing on increasing production on already non-forested areas to meet the increasing urban demand (ibid.).

Although studies emphasize the role of agriculture in driving deforestation, they also show that there are regional and country-wise differences as regard the relative importance of both proximate and underlying factors. Geist and Lambin (2002: 149) also focus on the interaction between various drivers, and conclude that "… tropical forest decline is determined by different combinations of varying proximate causes and underlying driving forces in varying historical and geographical context." Single factor explanations are not adequate as various drivers and underlying processes tend to operate in various combinations. Geist and Lambin find that a frequent combination of drivers and underlying processes are between road-building for logging; and the opening up of areas for rural settlement was again stimulated by state policies encouraging (credit, low tax etc.). Adding to the complexity is that various drivers tend to work in different combinations in various settings, so that drivers that cause deforestation in one setting may actually reduce deforestation in another (Kanninen et al., 2007).

Although Geist and Lambin (2002) identify a set of generic drivers of deforestaion, they underline that a "… a detailed understanding of the complex set of proximate causes and underlying driving forces affecting forest cover changes in a given location is required prior to any policy intervention" (ibid: 159). The studies of drivers discussed here focus on continental or country-wise differences, obviously providing useful insight for REDD+ assessments. However, national and local REDD+ activities should be based on specific understanding of the complexities of forest change, and to what extent various drivers operate differently within a country.

This paper argues for a more contextualized understanding of the drivers of forest change in Miombo ecosystems of southern Tanzania. We use the drivers for deforestation and forest change analytical framework, which recognises the underlying and proximate causes of deforestation and forest change and their outcomes. We identify the underlying factors as being demographic, technological, commodity markets and governance at national and local scales.[1] Proximate causes include agricultural expansion and practices, logging and charcoal-making. Two basic empirical research questions are addressed: how is the forest changing; and

[1]The international scale is only alluded to in the discussion to allow for concentration at the local scale.

what factors influence forest change? The paper is based on quantitative and qualitative data covering both socio-economic and ecological aspects collected in 12 villages of Kilwa and Lindi districts in southern Tanzania.

The Study Area

Kilwa and Lindi districts are both located in Lindi region in southern Tanzania (Figs. 1 and 2). Kilwa has a land area of 12,125.9km² and a population of 190,744; with a density of 15.7 people per km² (NBS. 2013). Lindi rural district, on the other hand, covers a total land area of 6,979km² and has a population of 194,143; with a density of 27.8 people per km² (NBS. 2005. 2013). The region has a bimodal rainfall with early rains (*vuli*) between November and January, and the main rainy season (*masika*) from March to May.

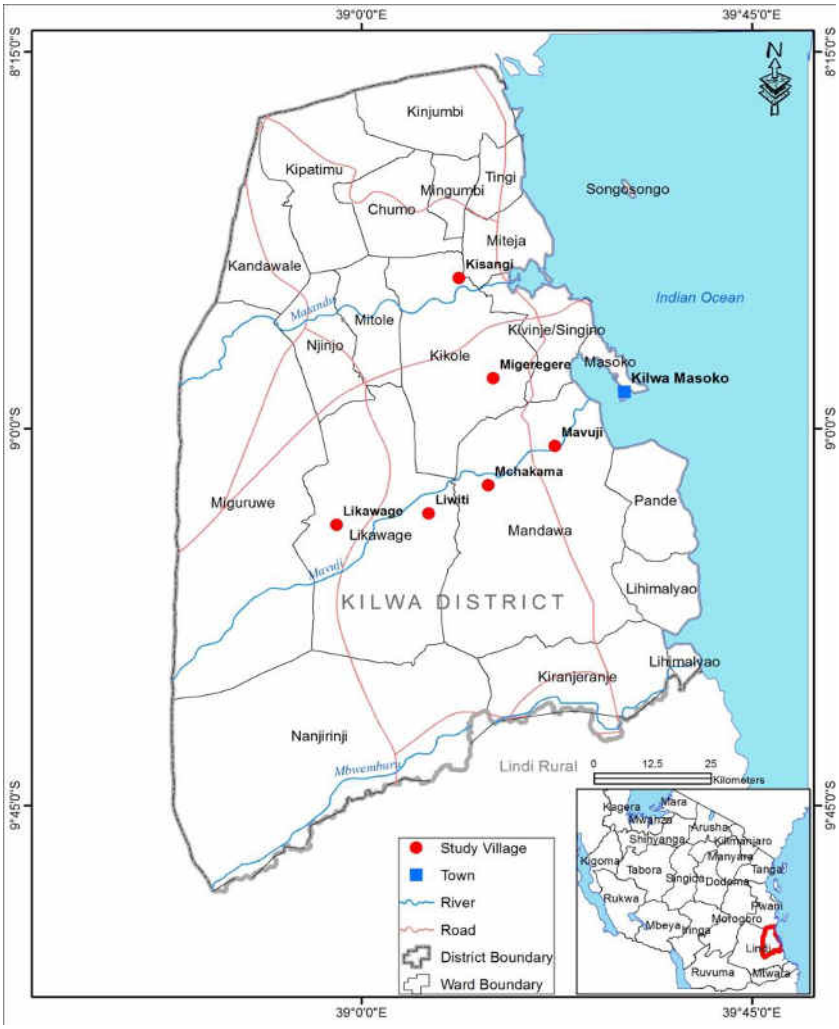

Figure 1: Map Showing the Location of Study Villages in Kilwa District

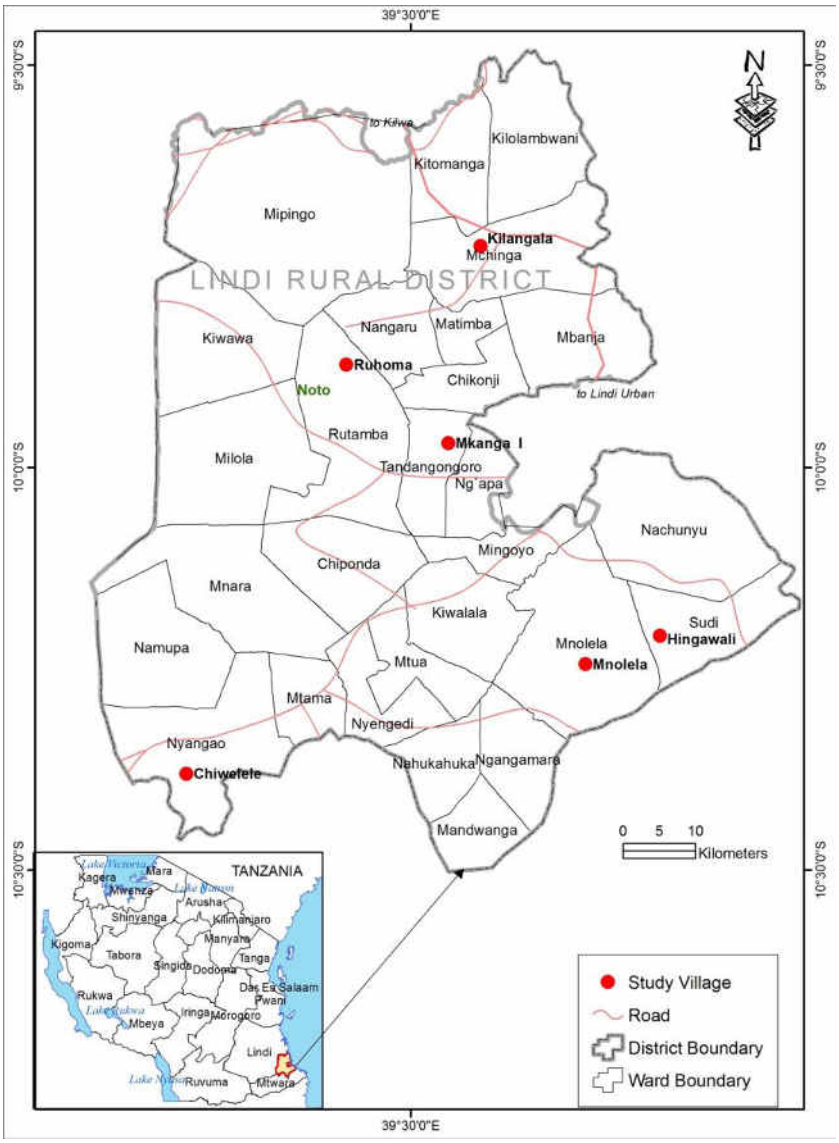

Figure 2: Map Showing the Location of Study Villages in Lindi District

Overall the two districts receive an annual average of 1000mm of rain, with considerable variation and slightly lower rainfall inland than on the coastal area. The average temperature ranges from 24 to 31^{0}C.[2] The vegetation of both Kilwa and Lindi rural districts is typical of the East Africa coastal forest, which is comprised of the African miombo woodlands and mangrove forests along the coast. The main economic occupations of the inhabitants of these two districts are

[2] http://www.lindi.go.tz

mainly farming and fishing. Most of the people in these districts are also reliant on forest resources to meet their daily needs, both socially and economically, including energy source from wood fuel; timber and poles for construction of houses and furniture-making; wild food such as bush meat, wild fruits, vegetables; and medicinal herbs.

Methodology

The research utilized a mixed quantitative-qualitative analytical approach in analysing factors causing forest change and their interaction. Quantitative and qualitative data from secondary and primary sources—which include socioeconomic and ecological data—was collected in 12 villages of Kilwa and Lindi. Being a REDD+ based feasibility research project, the choice of the two districts was influenced by the existence of REDD+ pilot projects being implemented by the Mpingo Conservation and Development Initiative (MCDI) that operates in Kilwa, and the Tanzania Forest Conservation Group (TFCG) that operates in Lindi. The distribution of villages between the two districts was equal in number, and was based on the comparative analytical approach aiming to study the effectiveness of the various incentives offered by three different forms of community-based forest management. The selection of villages within a district comprised of two villages where no community conservation measures or approaches have been introduced (i.e. NON-PFM villages); another two villages where Participatory Forest Management (PFM) has been introduced; and the last two villages where both PFM and REDD+ pilot projects are being implemented. A total of 12 villages were selected in both Kilwa and Lindi districts; 6 from each district. In Kilwa these were: Kisangi, Migeregere, Mavuji, Mchakama, Liwiti and Likawage; while in Lindi these were Kilangala A, Ruhoma, Mkangamoja, Chiwelele, Mnolela and Hingawali (see Figs. 1 and 2).

The study utilised ethnographic data collection approaches—including in-depth interviews with actors from the village, district and national level; oral-historical interviews, extensive literature review, on-site participant observations and focus group discussions—to provide thick-descriptions of how the various cultural/ ecological practices are performed, their changes over time, and factors influencing changes in their performance. The study also sought actors' etic and emic perspectives on whether and how the various cultural ecological practices cause deforestation and forest degradation, and a discussion of anticipated future trends in light of socio-economic, political, and environmental changes at the local to global scales.

For socio-economic data collection, semi-structured and structured household questionnaires were used to collect data to assess communities' association with proximate factors of forest change, including the extent of shifting cultivation, pole-cutting and fuel-wood collection and their interaction with the underlying factors of forest change. Random sample selection was used on stratified categories of occupation and wealth status. The final sample size used for analysis was of 576 households, represented by heads of households, of whom 69 per cent were male and 31 per cent female.

Forest Management Regimes

We compare three different forest management approaches (regimes for convenience) existing in the two districts to understand the factors contributing to their success or failure. These are the Community Based Forest Management (CBFM), Village General Land Forest Management (VGLFM), as well as REDD+ and CBFM regimes.

Participatory Forest Management (PFM), under which CBFM falls, was introduced in the early 1990s to pave way for community participation in the management of natural resources. The approach intended to improve rural livelihoods and thereby help reduce poverty, while at the same time protecting the environment and promoting equitable distribution of benefits (URT. 1998). The government recognized that, to secure the sustainability of PFM, focus should be on both conservation and economic incentives for communities. CBFM operates on community forest; termed Village Land Forest Reserve (VLFR).

This study was conducted in two districts that participate in the implementation of REDD+ pilot projects. Each district has a different Non-Governmental Organization (NGO) implementing the piloting activity for REDD+ readiness, using different approaches. In Kilwa district, the MCDI is promoting PFM through the forest stewardship council (FSC) model. The FSC model allows for limited logging under certification, while prohibiting hunting and restricting fires. It aims to reduce forest clearing for agriculture, and also reduce charcoal production. To achieve this, the MCDI use FSC certification allowing timber harvesting from the community forest. Incentives to the villagers in the MCDI model are mainly in the form of the money the village receives from the sale of certified timber. The MCDI implements the REDD+ pilot projects using the FSC certification for sustainable harvesting of timber, with the resources provided used not only to benefit involved village communities but also facilitate further expansion of CBFM in the district.

In Lindi district, the TFCG is piloting REDD+ through the PFM model as well. The benefits village communities expect from the TFCG approach are different from those of the MCDI in Kilwa. In Lindi villages the REDD+ pilot project money, apart from facilitating land use plans as is with the MCDI, is distributed to village communities as incentives for participating in the pilot project; along with training in conservation, conservation agriculture and livelihood diversification projects. In both approaches, villagers are allowed to continue harvesting some non-timber forest products (NTFP) under laid-down rules and procedures. It should be noted that in participating in REDD+, communities stand to lose some of the benefits they used to enjoy from the forests, which involves some level of opportunity costs consideration.

The last forest management approach is the VGLFM, overseen by the District Forest Officer (DFO). The DFO oversees monitoring, control of the forests, issues harvesting permits, and appropriates the proceeds. On the other hand, villagers benefit from the utilization of timber and NTFP through permits issued by the DFO through their Village Natural Resource Committees (VNRC).

In all the different forest management regimes described above there exist a VNRC that is responsible for developing a village management and harvesting plan. One notable feature of a VGLFM regime is it's 'open access' characteristic. Table 1 presents all the three regimes discussed above. Further salient feature of the regimes are given in Table A2.

Table 1: Forest Management Regimes description

Forests	Area (ha)	Population	Current forest management regime	Forest legal status	Forest management and harvesting plan	Forest manager
Kilwa District						
Liwiti	6,229	420	FSC. 2009	VLFR	Mandatory	VNRC
Kisangi	1,966	900	FSC. 2009	VLFR	Mandatory	VNRC
Likawage	17,000	-	REDD+	VLFR	Mandatory	VNRC*
Mchakama	3,000	1,313	REDD+	VLFR	Mandatory	VNRC*
Migeregere	-	1207	VGLFM	VGLF	Mandatory	VNRC/DFO
Mavuji	-	1444	VGLFM	VGLF	Mandatory	VNRC/DFO
Lindi District						
Mkanga Moja	1,548	780	REDD+	VLFR	Mandatory	VNRC
Ruhoma	3,062	601	REDD+	VLFR	Mandatory	VNRC
Chiwerere	-	-	PFM	VLFR	Mandatory	VNRC
Hingawali	-	-	PFM	VLFR	Mandatory	VNRC
Mnolela	-	-	VGLFM	VGLF	Mandatory	VNRC/DFO
Kilangala A	-	-	VGLFM	VGLF	Mandatory	VNRC/DFO

Key: VLFR = Village Land Forest Reserve; VGLF = Village General Land Forest.
DFO = District Forest Office; DFO = District Forest Office

Forest Change

From the ecological analysis, results based on the baseline data for Kilwa for this study (May 2013) found that forests under the VGLFM regime performed badly compared to forest under the REDD+ and FSC regimes. Using seedling density as a proxy for recruitment (forest regeneration) to test for the effects of forest governance and land use on tree regeneration, we found predicted recruitment was significantly higher in community-managed forests (FSC, REDD+) than centrally managed forests (VGLFM).

Household survey results for the perceived forest change in the study areas support the above conclusion. In this case respondents were asked to state if they have experienced changes in the quality and quantity of forest products from nearby forests. The results indicate that the forests are actually changing. In general respondents noted declining quality and quantity of most forest products in the area, but there were other noticeable improvements. Analysis of the change in the quality and quantity by categories of forest management regime indicates that there are variations according to REDD+, PFM and VGLFM regimes. With the exception of firewood, the quality and quantity perceived to

decline by equal measures in all the management regimes included timber quantity, which was seen as increasing for REDD+ by 80% of the respondents, while the opposite was the case for both PFM and VGLFM. Charcoal quantity was shown to decline by 100 per cent for both REDD+ and PFM; meaning that charcoal-making activities were prohibited under these regimes. At the district level, perception of change in the quantity for firewood, poles, timber and grasses were similar in both districts, with timber being perceived to decrease more in quantity in Lindi rural district (Fig. 3). The availability of charcoal, on the other hand, was perceived to have decreased by all respondents in Lindi rural district; while in Kilwa district the majority saw no change in quantity levels. This implies that more leakages in charcoal-making were happening in Kilwa district in villages under the VGLFM regime due to the enforcement prohibition in the other regimes.

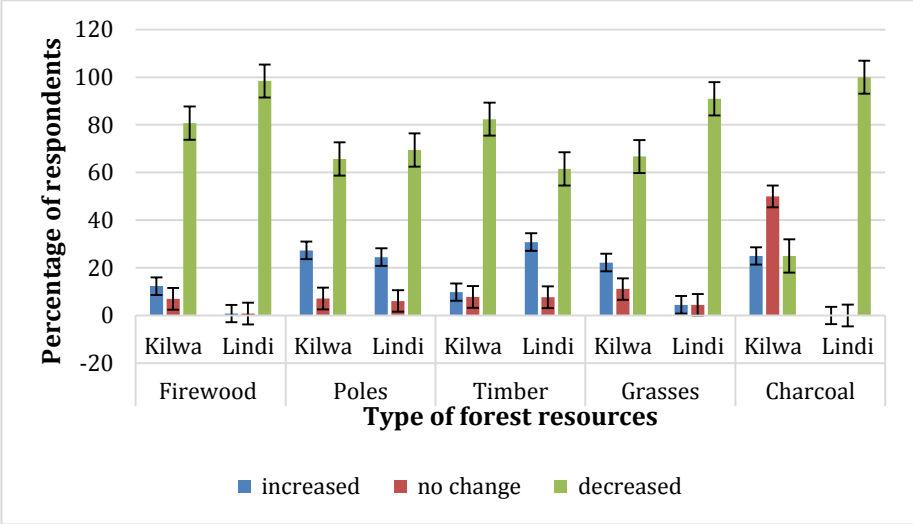

Figure 3: Perceived forest change in quantity by district

Proximate Factors Causing Forest Change

Farmers were asked what they perceive as the main direct driver of forest change. The results presented in Fig. 4 indicate that overall, for both Kilwa and Lindi districts, the main perceived proximate drivers of forest change in the study area were uncontrolled wild fire (43.75%), shifting cultivation (26.27%) and timber harvesting (19.89%). Other identified drivers include charcoal-making (10.3%), firewood-collection (1.34%) and infrastructural development (0.76%).

Closer inspection at the District level and management regime wise (Figs. 5 and 6), we find that the proximate drivers vary as follows; In Kilwa district the main factor is uncontrolled fires in second place is timber harvesting closely followed by shifting cultivation lastly charcoal making, firewood and infrastructure.

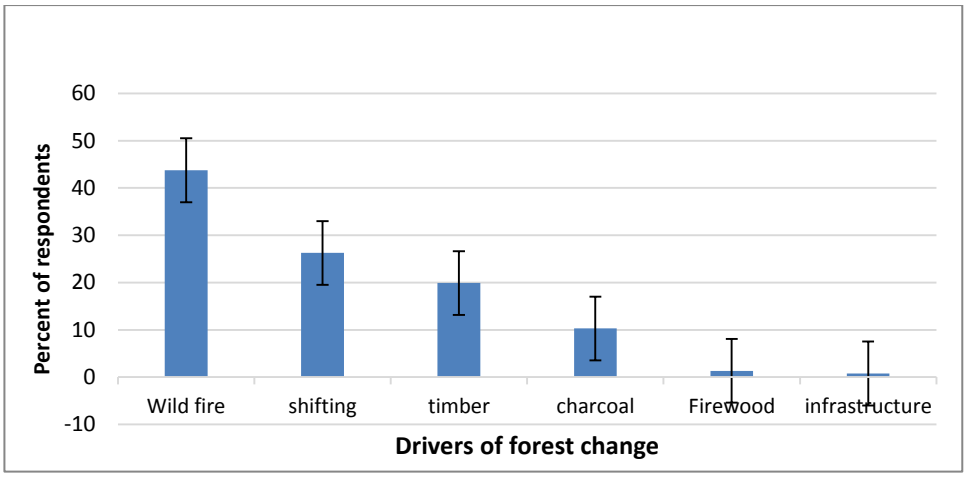

Figure 4: 1st Ranked Drivers of Forest Change for Both Kilwa and Lindi Rural Districts

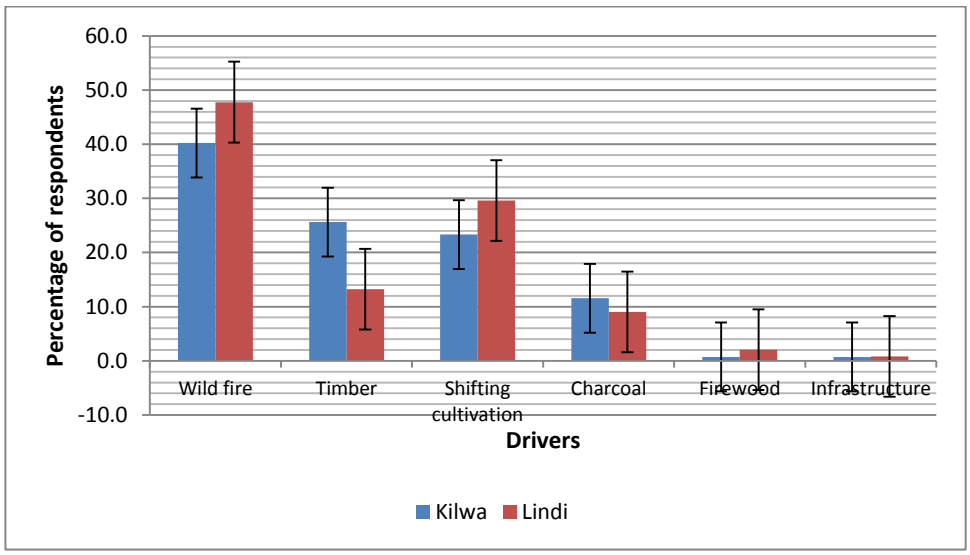

Fig. 5: Drivers of Forest Change by District

For Lindi rural district the picture is somehow different, with wildfire leading the way; followed by shifting cultivation for sesame, maize and rice, timber harvesting, charcoal-making, firewood, and lastly infrastructure. These findings are similar to those reported elsewhere for Lindi (Kibuga & Samwel. 2010; TFCG 2012), and for Kilwa (Miya et al., 2012; Ball & Makala. 2014). Results by FMRs show that less sesame cultivation is done in FSC and REDD+ villages as compared to VGLFM (non-PFM and non-REDD) villages.

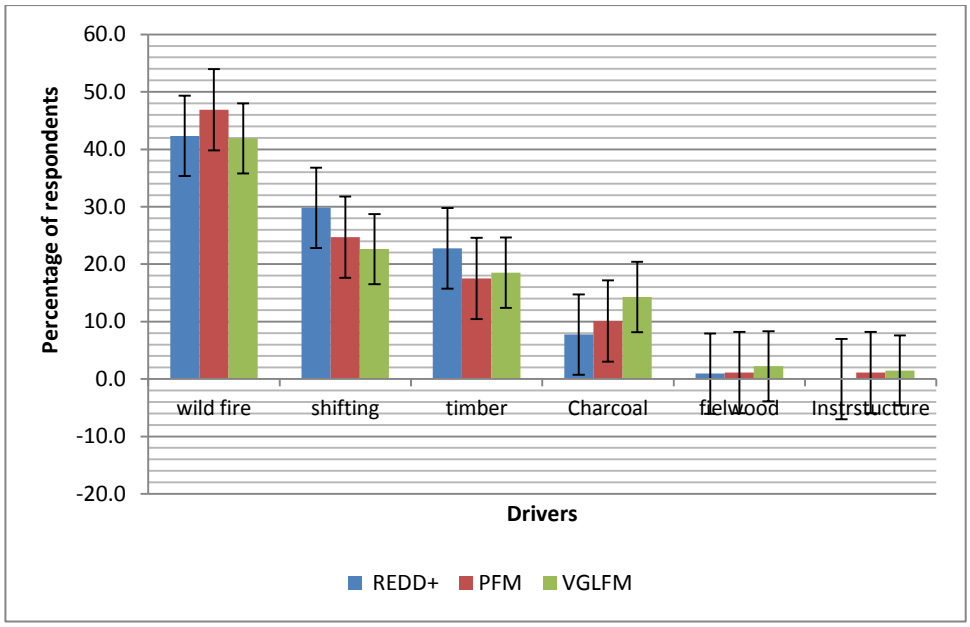

Fig. 6: Drivers of forest change by management

Wildfire

The main driver of forest change identified by the villagers was wildfire. Fire can be a natural factor caused by lightning or anthropogenic linked to shifting cultivation or charcoal production. We learned that traditional and current practice—especially for shifting cultivation and farm preparation—involves the use of fire. Fire is normally used to burn the trees and branches, or what is left of them after firewood has been extracted; as well as grasses after forest clearance ready for planting. There is a high frequency of wildfires in Lindi and Kilwa during the late dry season, which is associated with late preparations of farms (TFCG. 2012; Miya et al., 2012). Frequent exposure of miombo to these types of fires can cause dramatic species composition. When exposed to repeated intense late dry season fires, miombo can eventually be fully converted to grassland, with a few fire-tolerant tree species. Early burning, though, is far less damaging to miombo, and can yield good grass regeneration on the one hand, while limiting damage to newly sprouted trees on the other. If they occur late and uncontrolled, these fires usually spill over to adjacent forests and spread, causing great damage to flora and fauna therein. The use of fire for farm preparation is a deep-rooted cultural practice, which may take time and effort to stop (TFCG. 2012). This is because using fire makes it easy for farmers to clear farmlands instead of weeding using hand hoes, which is a gruelling and tedious job requiring the use of family labour. Other causes of wildfires may be due to hunting by block owners (Miya et al., 2012) who set fires to flush out animals.

Agriculture

Agriculture is the main economic activity for most households, with about 93% of the respondents reporting to do farming in the study area. Other livelihoods activities include petty business (3%), livestock keeping (0.35%) and causal labour (0.7%).

The main agricultural food crops in both Kilwa and Lindi are maize, sorghum, cassava and rice. In Lindi rural, sesame, cashew nuts, coconuts, pigeon peas and cow peas are cultivated as cash crops; while sesame, coconuts and cashew nuts are the main cash crops in Kilwa district. The farming systems practiced in both the Lindi and Kilwa study sights are similar to those described by the TFCG (2012) for Lindi rural.

Sesame cultivation is done mostly in areas with young regenerating forest, as high as five metres with grass and bushes (*'nyecha'* in local Kimwera); as well as in mature forest with large trees (*'kileme'* in local Kimwera), for a duration of one year before shifting. Maize is mostly cultivated in *kileme* areas for duration of two years before shifting. Sorghum is mostly cultivated in *kileme* areas as well for duration of 2 years before shifting. Cassava is mostly cultivated in regenerating forest of less than three years (*mafukutu* in local Kimwera), for an average of four years before shifting. Hill rice is mostly cultivated in *kileme* areas with for duration of one year before shifting. These farming practices entail clearing different types of vegetation with different levels of impact to forest change. The main reasons given for shifting was avoiding weeds, pests and decline in soil fertility. For sesame cultivation, the avoidance of weed and pests was the main reason for shifting to new land. Table 2 depicts sesame to be dominating most households' farming by the proportion of land allocated to it. Given the high rate of shifting of sesame, it implies that deforestation through agriculture is accounted for by sesame cultivation.

Table 2: Average Farm Size and Sesame Farming

	Name of Village	Forest management regime	Total farm size in 2010 (acres)	Total farm size in 2014 (acres)	Sesame farm size in 2014 (acres)	% of sesame farm size to total
Kilwa district	Liwiti	FSC	4.27	4.62	3.48	75.2
	Kisangi	FSC	3.17	4.71	3.18	67.7
	Mchakama	REDD+	4.05	4.49	3.59	79.9
	Likawage	REDD+	4.50	5.01	3.57	71.2
	Mavuji	VGLFM	5.31	5.05	3.77	74.6
	Migeregere	VGLFM	3.90	5.42	3.48	64.1
Lindi rural district	Mnolela	VGLFM	2.65	3.15	1.33	42.1
	Kilangala	VGLFM	4.77	5.76	2.43	42.2
	Chiwerere	PFM	3.74	4.10	1.85	45.1
	Hingawali	PFM	2.38	2.59	2.22	85.7
	Mkanga	REDD+	2.34	2.92	1.90	65.1
	Ruhoma	REDD+	2.86	3.54	2.36	66.7
	Total		**3.63**	**4.28**	**2.98**	**69.6**

The average farm size in the study area was found to increase during the period of five years. The average farm size before the implementation of the forest management programmes was 3.6 acres/household. However, the recent average farm size is 4.3 acres/household. Sesame farms differ in size by districts and across villages under different forest management regimes. Table 2 shows that households in Kilwa villages have an overall higher proportion of their farmlands under sesame compared to Lindi rural. Historically Kilwa and Rufiji districts have been the main sesame producers in the south-eastern part of Tanzania, probably due to having better soils. The introduction of conservation farming by the TFCG and favourable market conditions for the crop have motivated an increase in the production of the cash crop in some of Lindi district villages.

Using the Tobit regression model, the study aimed to establish factors influencing sesame cultivation in the study area. It used sesame farm size as the dependent variable, and a set of explanatory variables that includes migration, labour supply (represented by adult members in a household), main occupation (farming), sesame quantity harvested, age of the household head, education level of the household head, gender of the household head, household expenditure (proxy of the household income), forest management regimes (PFM or REDD), and household dependence on wood resources.

The estimated model was found to be significant in explaining the variations of farm sizes under sesame farming caused by the hypothesized independent variables (Table3). Factors influencing sesame farming included labour supply, quantity of sesame harvested and sold, income level, age of the household head, and the existing forest management regimes in the study area. Labour supply, quantity harvested and household income was found to affect positively sesame farm size. An increase in labour by one adult member in a household would result into an increase of sesame farm size by 0.5 of an acre. Also, the more the harvest of sesame, the more is the land put under sesame cultivation. An increase of quantity of sesame harvested by 1kg would result to an increase of farm size by 0.02 of an acre, holding other factors constant (Table 3).

Table 3: Factors Influencing Sesame Farming in the Study Area

Variable	Tobit	Std. Err.	t
Migration	0.3287	0.2746	1.200
Labour supply	0.5267*	0.1536	3.430
Farming occupation	1.0774	0.7186	1.500
Sesame harvest/sales (KG)	0.0258*	0.0057	4.550
Age of the head of household	-0.0148**	0.0089	-1.670
Education level of Head of household	0.0918	0.2860	0.320
Male gender of the head of the household	0.3470	0.7231	0.480
Household expenditure	0.4395*	0.1886	2.330
Management regime	-0.6136*	0.2610	-2.350
Household dependence on wood resources	-0.0973	0.4611	-0.210
_cons	-5.2135	2.8240	-1.850

Household income influences positively sesame farming in the study area, whereby well-off households were found to cultivate more sesame. An increase of income by 1% would increase farm size by 0.4 of an acre. On the other hand, two factors were found to affect negatively sesame farming. Households with older heads were found to engage less in sesame farming. This implies that sesame farming is more practiced by young people in the area. This result is in line with the information gathered from focus group discussions where it was revealed that sesame farming has attracted more young people in recent times than in the past, who are engaged more on cultivating it as the main source of cash income. The exiting forest management regimes in the study area was found to influence negatively sesame farming. In areas where PFM or REDD programs are implemented, there was lower rates of sesame farming. On average, the presence of forest management programs reduces land under sesame farming by 0.6 of an acre per household (Table 3).

Logging/ Timber Harvesting

Logging began to devastate the south-eastern coastal forests of Tanzania soon after the Mkapa Bridge over the Rufiji River was opened in 2003 (Milledge et al., 2005; Barclay, 2007). The improved transport infrastructure facilitated the opening up of the south-eastern region of Tanzania for development, and at the same time exposing coastal forests to the growing timber demands from local and foreign timber markets. Soon after the opening of the bridge and improvement of the roads, illegal timber trade flourished. Up to 96% of all timber from this area has been reported as being illegally harvested (Millage. 2007; Ball & Makala. 2014), and has found its way up to China. Illegal logging has since declined due to efforts to stem it by various stakeholders, including the government, TFCG, Mtandao wa Jamii wa Usimamizi wa Misitu Tanzania (MJUMITA) and MCDI. Research results from household respondents indicated that timber harvesting from REDD+ and FSC managed forests have decreased due to partly prohibition measure in REDD+ villages in Kilwa and Lindi, and sustainable harvesting approach in FSC regime villages in Kilwa. Timber harvesting is perceived to increase by 20% and decrease by 68% of VGLFM. This is due to declining resource in the VGLFM forests in both districts.

Charcoal

Charcoal-making is one of the major economic activities and is a coping strategy for a good number of households living in villages near roads and urban centres. Charcoal-making in most cases have a degrading effect as it involves clear cutting of forest unless it is a secondary activity after road construction or related or similar preceding activity. Charcoal is a major source of energy for cooking for urban dwellers, as firewood is for rural people. Over the past five years, charcoal-making was reported as continuing. In Kilwa, 62% of respondents indicated a decrease for the FSC regime and no change for the REDD+ regime, while the VGLFM regime had 27% respondents indicating increased charcoal-making and 31% indicating a constant trend. For Lindi rural, the situation was said to

improve for the REDD+ and PFM regimes. The decrease in charcoal-making was attributed to the fact that the REDD+, FSC and PFM programmes prohibit this activity in community forests by instituting patrols and fines to facilitate compliance. For the VGLFM, the situation worsened as capacity to enforce the rules was lacking, and eventually the Lindi district council abandoned the few patrols that were made due to their ineffectiveness.

Infrastructure Development

Infrastructural development such as road construction, which clears forested land on one hand, and facilitates access to forest resources (such as timber and charcoal0 on the other, has been quite low and remained constant over the past five years in all the study areas. According to the household data, more than 90% of the respondents across the regimes in Lindi stated that infrastructural development was unchanged. In Kilwa, however, 54% of respondents from the REDD+ project areas said that there was no change, 36% asserted that there was an increase in infrastructural development, while 85% from the PFM and VGLFM regimes saw no change of development in their areas.

Fuel-wood Collection

The study found that 86% of the households reported to have been collecting firewood in the last twelve months. On average, households reported to collect 3 bundles per week. This is equivalent to an average of 10 to 12 bundles per month. For the most part, fuel-wood collection remained unchanged between 2011 and 2014 across Kilwa and Lindi rural districts in the REDD+ and PFM, FSC regimes; while collection increased in the VGLFM regime due to increased clearing of land for sesame cultivation.

Underlying Factors of Forest Change

As discussed in the introduction, Geist and Lambin (2000) identify four broad underlying processes of deforestation and forest degradation: *demographic*, (e.g., population density and change, migration, etc.), *economic*, (e.g., market growth and commercialization), *technological* (e.g., change of production factors, intensification), *policy and institutions* (e.g., policies, policy climate, property rights) and *cultural factors* (e.g., attitudes, values and beliefs, HH behaviour).

Of these four factors, three appear to be of particular importance in our case. As regards *economic processes*, the increased demand due to availability of markets and better prices for sesame has prompted farmers to increase their farm sizes. There has been a marked increase in farmland size and the proportion of the total land dedicated to sesame production, and this is entirely a market driven demand as sesame seeds are used for commercial oil production and not for household consumption. Sesame land size dominates other cropland in all the villages surveyed. Both the household respondents and focus discussion groups (FDGs) were upbeat with the success sesame has brought to their communities, eagerly pointing at completed modern houses and construction projects in progress (see Table A4).

The major buyers of Tanzania's sesame from 2005 to 2009, by importance, were: China, Japan, India, Turkey and Switzerland (USAID. 2010), India, however, is increasingly becoming an important buyer for Tanzanian sesame. Market conditions, both local and global, may also affect the production of the crop. The declining producer prices offered by local buyers in the 2014 season of TZS2000/kg, and in some places down to TZS1,800/kg—which were below the price of TZS2,500/kg in the previous season—has had farmers contemplating reducing their efforts if the same trend continues. Together with the increased use of weed killers and pesticides, persistent declining sesame prices in the world market due to increased supply may result into reduced forest encroachment for sesame production. However, currently the prices, though falling, are still good enough to attract increased production of sesame in the region.

As mentioned earlier, the majority of youth engage in sesame farming as a way to earn capital to invest in the transport business by acquiring motorcycles, and then employing others to work on their sesame farms. At Kisangi village in Kilwa district, for instance, the number of motorcycles has increased from 0 to 25 in five years by July 2014. In a way, technology here works as an incentive for sesame cultivation, and hence an underlying factor for forest changes.

As regards *demographic* factors, the Lindi region has witnessed population growth well below national average in the period 2002 and 2012 (0.9 and 2.7% per year, respectively). However, there has been a substantial in-migration in the 12 villages as 34% of the household in Kilwa and 39% in Lindi were not native to their present village. In general, these in-migrants appear to be attracted by opportunities for farming as well as logging (Andresen. 2012). Migration results at FMR level for both districts show a high variation on average, with higher in-migrants into VGLFM villages (42%) and less in REDD+ (23%) and PFM villages (35%). This may imply that it is comparatively easier to secure agricultural land in VGLFM areas.

As regards *institutions,* the various management regimes discussed above undoubtedly have had an influence on forest change and the proximate drivers. Apart from global and local market factors, existing local forest management *institutions* governing the use and conservation of forests in an area do affect different outcomes at the local level. The study found that PFM, REDD+ and FSC regimes are more effective in forest conservation compared to the VGLFM regime. The FSC and REDD+ regimes have been found to perform better than the PFM regime. The PFM, REDD+ and FSC all employ PFM approaches in their formulation, only differing in the incentive structure and logic to forest conservation. There are several reasons for this result. Weaknesses in forest governance are among the major reasons why forests are being encroached and changed. The little capacity of village leadership and self-interest have resulted into a breakdown of trust among village community members in some villages, leading to falling participation in meetings and community-based decision making processes, and increasing illegal activities including timber harvesting, charcoal-making and agricultural encroachment of forests. This outcome may be

exacerbated by low incentives for participation due to high opportunity costs to some community members, and may result in the lack of interest in participating in forest management schemes, including REDD+. Furthermore, legacies of past conservation approaches have affected villagers' motivation for collaboration and participation in forest governance in some areas. Local people remain sceptical and question whether their participation is truly democratic since what is decided at the village meetings is not implemented accordingly. Issues of uncertainty of the sustainability of the schemes introduced by the government also haunts the minds of villagers with the experience of failed past schemes disrupting their way of life.

Furthermore, forests have been a major contributor to many households livelihood in different ways, so any management approach aimed at conserving forests, for any reason, has to also consider the opportunity costs of the current users of this resource and introduce alternatives. The current experience from Ruhoma, a village piloting REDD+ in Lindi rural district, shows that there is a danger of this particular village to revert to old open-access ways of forest utilization. The reason is that the expected carbon payments, which are used as incentives to lure villagers to participate in the programme, have declined substantially. The villagers received a total of TZS21.08 during the trial payment in 2012, but in the performance-based payments in 2014 they received a mere TZS2.5m, a 743% decline! The study gathered from the FGDs that the youth had decided to go back to their old ways of not taking measures to conserve the forest by indiscriminately cutting trees for making charcoal.

Conclusion

The main questions raised in the introduction were whether the forest has been changing, and what factors influence the change. Data from the household interviews shows that people perceive changes both in quality and quality of various types of forest products such as timber, firewood, grass and poles. In general, people reported reduction in both quantity and quality of forest products. However, a substantial share of the respondents reported an increase in access to poles used for buildings.

As underlined by Geist and Lambin (2002: 149), the decline of tropical forest is determined by combinations of different proximate causes and underlying driving forces on different historical and geographical contexts. Single factor explanations are not adequate, as various drivers and underlying processes tend to operate in various combinations.

The main proximate drivers of forest change reported by the households were fire, either caused by lightening or uncontrolled burning linked to farming practices. Agricultural expansion is listed as the second most important driver, whereas timber comes third. As regards the underlying drivers, both the demand for sesame and timber is linked to non-local urban and/or international markets. Also, shifting cultivation is practiced widely in the study villages. This is a form of cultivation that—both historically and even today—has been portrayed as a

main cause of both deforestation and forest degradation. This is based on the assumption that shifting cultivation is a practice primarily linked to subsistence production, and that increasing local population pressure will lead to declining fallow periods; thereby in the long-run leading to permanent change in land use. However, as pointed out by Ickowitz (2006), shifting cultivation is a concept that encompasses a wide range of practices. In our case, sesame production is a type of commercial and market-based production that is well suited to shifting cultivation practices. However, the driving forces primarily are non-local and delinked from direct local subsistence needs.

The situation in Kilwa and Lindi appear to be parallel to findings reported in a study from Makonde plateau, in south-eastern Tanzania (Kabanza et al., 2013) where the spread of commercial cashew production has led to substantial forest and land use changes. Increasing international demand for cashew nuts, combined with population growth and the villagisation program, have led to widespread transformation of land use since the 1960s. The result has been a 'more people more trees situation' as bush land, wooded grassland or woodland was converted into cashew orchards.

As regards demographic changes, there has been a considerable in-migration to the villages, and this appears to be driven by the potential for accessing land for cultivation as well as income from timber logging.

Besides sesame production, institutional factors seem to have the strongest influence on forest change. Forest lands in the 12 villages were managed under three different regimes, of which two involve various elements of community-based forest management (CBFM) practices. A claimed major aim of CBFM is to strengthen local forest users' property rights and powers to manage their forest resources. CBFM initiatives in Tanzania started early in the 1990s. However, few examples exist of successful, long-term, sustainable initiatives involving communities (Kologva et al., 2012). Silvano (2012) find that CBFM can potentially contribute to improved rural livelihoods and poverty alleviation; both in the form of improved environmental services, as well as certified commercial timber harvesting, user fees, and revenues from forest-related products. However, the needs and interests of the poorest, women, elderly and youth groups tend to be neglected in the existing CBFM arrangements.

Our findings indicate that the institutional set up for managing forest can have an effect on some forest use practices. Some villages under the FSC and REDD+ have imposed restrictions on charcoal production, thereby eliminating this as an immediate local cause of deforestation/forest degradation. However, as charcoal production is mainly for an urban market, the result of such bans is most probably leakage in the form of relocation to other areas that have no such restrictions on forest use.

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APPENDIX 1

Table A1: Forest governance regimes in Kilwa and Lindi rural Districts

Forest governance regimes	REDD+	PFM	FSC	VGLFM
Village Natural Resource Management Committee (VNRC)	Yes	Yes	Yes	Yes
Demarcated area of forest on village land	Yes	Yes	Yes	Yes
Undertake Participatory Forest Resource Assessment	Yes	Yes	Yes	No
Forest management plan which includes harvesting plan	Yes	Yes	Yes	No
Bylaws that support forest management plan	Yes	Yes	Yes	No
Bylaws compliance or enforcement	Yes	Yes	Yes	No
Bylaws monitoring or auditing	Third Party	Third Party	Third Party	Surveillance Unit
District Registers the forests as Village Land Forests	Yes	Yes	Yes	Yes
Forests gazettement	Yes	Yes	Yes	No
Identify and mark trees that are of harvestable size before harvesting	Yes	Yes	Yes	No
Timber harvesting license/permit issuance	Non	Village	Village	DFO
Supervision of harvesting operations	Yes	Yes	Yes	No
Transit Passes issuance to allow movement of timber	DFO	DFO	DFO	DFO
Access rights	*de jure*	*de jure*	*de jure*	*de facto*
Forest carbon benefits	Yes	No	Partly	Non

Source: Authors' research survey, Kalonga et al (2014).

Table A2: Descriptive analysis of variables used to assess shifting cultivation in the study area

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
farm_size2	Farm size under sesame farming	425	2.98	2.61	0.25	24
migration	Migration	582	0.36	0.48	0	1
labour	Labour supply	579	2.29	0.93	1	6
farming_occu	Farming occupation	582	0.96	0.20	0	1
sesame_harv	Sesame harvest (KG)	407	6.26	22.31	0.25	400
head_age	Age of the head of household	551	48.60	15.78	18	95
headeduc	Education level of Head of household	551	0.76	0.43	0	1
gender_head	Male headed household	551	0.94	0.23	0	1
lnexp	Household expenditure	582	14.32	0.76	10.95	17.81
PFM	Management regime	582	0.49	0.50	0	1
wood_dep	Dependence on wood resources	582	0.08	0.28	0	1

Table A3: FGD Perceptions on forest and livelihood conditions

Village	FMR	Forest condition	Social and Livelihood condition
Mavuji – (Kilwa)	VGLFM	Deteriorated and shrinking due to illegal harvesting of timber and NTFP. This is due to weak management by both the district and village governments, lack of ownership by villagers and the high dependence on forest resources. Forest encroachment through shifting cultivation and illegal harvesting goes on.	Livelihood improving due to sesame farming. More motorcycles- 'boda boda' (from 2 in 2010 to 50 2014), construction of modern houses (corrugated iron and cement and burnt bricks), more cell phone owners now. However, there are more ethnic groups now with different values than before.
Mchakama - (Kilwa)	REDD+	Improved since MCDI started work 2011 in the village, Forest boundaries known, however boundary conflict still exist (July 2014). Some illegal logging and farming still exists which causes the conflict areas to be degraded. Village governance has improved with the help of MCDI training on forest stewardship.	Sesame farming has gone up and has contributed to better modern housing (from 5 in 2010 to 40 in 2014), improve transportation by way of motorcycles (from 0 in 2010 to 20 in 2014), TV screens (from 0 to 20 in 2014), solar powered electricity (from 0 2010 to 30 in 2014).
Kisangi - (Kilwa)	FSC	Improved forest condition with certain type of birds and animals returning, however, forest area under FSC project is increasing prompting complaints of land scarcity for farming. Conditions for access of forest resources have changed now fees are required. Village collects logging fees and benefits but transparency is lacking for harvesting procedures and unclear benefits to villagers.	Agriculture has contributed greatly to the development of the village community through increased sesame farming. Weed killers and pesticides introduction has helped in sesame production and hence helped reduce shifting cultivation. Transportation has improved due to increased motorcycle ownership (from 0 2011 to 25 in 2014). Attendance to meetings is low making participation in decision-making processes poor. Villagers complain leadership does not implement decisions arrived at during meetings and hence they see no benefit in attending these meetings (high opportunity cost of time use).
Kilangala A (Lindi rural)	VGLFM	No improvement although villagers are more aware of importance of forest conservation through seeing villages implementing REDD+ and they would 'now' like REDD+ to be implemented in their village after seeing the trial payment benefits to implementing villages among others.	Food situation for some households not good due to drought in 2013 and wild animals' (particularly elephants) destroying crops (sesame), local government assistance lacking. In 2012, villagers received training on conservation farming and introduced weed killing spraying for sesame from the district that had resulted into increase income for some households. Overall, some progress has been made between 2011 and 2014. Motorcycles have increased from 2 to 15, Village shops increased from 4 to 10, modern houses on the increase.

Hingawali (Lindi rural)	PFM	Little improvement in forest condition, villagers undertake forest patrols. Lindi forest company (Green resources) has taken a big forest area and established a monoculture plantation.	Sesame production has improved some peoples' welfare not all. Some villagers also work in the Lindi forest as casual labour to clear forest, burn, planting and weeding. However, villagers are not satisfied with the way Lindi Forest appropriated their land. They also blame the village government for not implementing decisions arrived at during village meetings, something which has caused apathy towards participation in the community decision making process.
Mkanga 1 (Lindi rural)	REDD+	Forest has improved due to REDD+ awareness. Forest boundaries known which helps in stamping out illegal activity in the forest. Illegal harvesting minimized through awareness, patrols and heavy fines. Forest patrols are however facing challenges of resources for paying the patrol groups. Shifting cultivation has declined greatly.	Life has improved due to REDD+ through training in conservation agriculture for sesame and maize by TFCG. Income generating activities such as bee keeping, poultry keeping are established to diversify sources of livelihood. This is because access to forests is now by paying fees according to the type of forest product and only during three days of the whole week as opposed to before REDD+ where entry was free and at any time of the week.