Factors Influencing Land Allocation Decisions to Food Crops - Trees Production in Mufindi, Tanzania: A Fractional Multinomial Logit Approach (FMNL)

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Abstract

Understanding of factors influencing land allocation decisions to food crops - trees production is vital for improving the welfare gain from land allocation decisions smallholder farmers make. This article aimed to investigate the determinants of land allocation decisions by smallholder farmers between food crops - tree production in selected villages in the Mufindi District in Tanzania. The study adopted a cross-sectional research design approach to collect data. The target population was 4896 farm households, from which a total of 413 households were randomly selected to constitute a sample size from which primary data were collected. Data from this study were analyzed quantitatively using the fractional Multinomial Logit model (FMNL). Variables included in FMNL were sex, age, education, household size, labor, and land size, access to market information, and awareness to land use policy. Major findings show that sex, household size, land size, awareness of land use policy, access to market information, and labor were influencing land allocation decisions more to tree farming than food crops. The study suggests that the government should create awareness among farmers through educational programs on, land use policy and market information, labor and land use allocation for improved farmers' welfare.

Keywords: Allocation, Food Crops, fallow, Trees, Fractional Multinomial Logit.

Introduction

Analysis of land allocation decisions among different uses has gained particular interest among researchers worldwide (Adebayo *et al,* 2020; Adjimoti, 2018; Mwaura and Adong, 2016; Tefera and Lerra, 2016; Ngunyen *et al,* 2017; Mulu *et al,* 2022 and Allen & James, 2014). The major reason behind the growing interest is that land use allocation should aim at maximizing social, economic, and ecological benefits to allocators who are mostly farm households (Liu *et al.,* 2016 Hettig *et al.,* 2016).

Land allocation to different uses in Tanzania is also a policy issue. For example, the National Land Policy of Tanzania (URT, 2016) and the National Agricultural Policy of Tanzania (URT, 2013) pinpoint the importance of land in poverty reduction and that the pace of land use planning and management is slow while there is growing environmental concerns and land use conflicts between various sectors, including farming and forests. The National Land Use Planning Commission (URT, 2017) also indicates that sustainable use of land is vital for economic development, food security, and poverty reduction in Tanzania. Moreover, the Tanzania Village Land Act of 1999, and the Land-use Planning Act of 2007 mandate that land is allocated for a variety of uses, such as farmland and forestland, to enable effective and orderly regulation of land use and give users the power to make better and more productive use of their land (Ng'elenge *et al.,* 2022).

In the Mufindi district, smallholder farmers for decades, have had to allocate land at their disposal majorly to the production of tree plantations and food crops, and that allocation of land to tree plantation is growing rapidly coupled with the conversion of arable land to tree farming (Ng'elenge, *et al,* 2022; FDT, 2015; PFP, 2016 and Ngaga, 2011). Ng'elenge *et al,* (2022) show that, in the district, on average smallholder farmers have allocated about 3.62 acres of land to food crop production, 4.28 acres to tree plantations, and 0.39 are left fallow. While the allocation of land by farmers to both tree plantations and food crops is vital for their livelihoods, as tree plantations provide income to farmers in the long run while food production is crucial to ensure food security and regular income for farmers in the short-run, a crucial question arising is, what are the factors that influence this land share allocation decision between food crops, tree plantations, and fallow. An understanding of these factors is vital for policy formulation geared at improving the welfare gained from land allocation decisions smallholder farmers make.

The land allocation studies have a historical background from the theoretical model on agricultural land location and allocation developed by Thunem, in 1826. The fundamental assumption was that farmers will allocate land based on their access to the market. While the theory has good insights to explain land allocation decisions, it ignores other important attributes such as socio-economic factors that could also determine land allocation.

Adebayo *et al,* (2020) did a study to investigate the determinants of expanding the land area under commercial Tree crop plantation in Nigeria and found that tangible land markets, rural infrastructure, agro-services, and improved land tenure security were influencing land share allocation to tree crops. Other studies found that sex, age, education, household size, land size, access to the market, labor, and income determine land allocation decisions for various uses (Mwaura and Adong, 2016; Adjimoti, 2018; Allen and James, 2014; Gebresilassie and Bekele, 2015; Ndhlove, 2010; Alam *et al.* 2016; Amare *et al.* 2018; Jianhong *et al.* 2013; Nguyen *et al.* 2017 and Grise and Kuishreshtha, 2016).

These studies on land allocation decisions provide insight to investigate the factors influencing land share allocation decisions between food crops, tree farming, and fallow in the Mufindi district in Tanzania, where land use competition between them is increasing, and little has been done to explain the situation. In the model, awareness of market information and awareness to land use policy that was not considered in previous studies has been added to investigate their influence on land share allocation decisions. The analytical framework of the study is guided by the agricultural household model developed by Berker (1965). The model assumes that "agricultural households strive to maximize utility which is a function of both consumptions of agricultural goods, consumption of non-agricultural goods and leisure. Moreover, the model depicts that, the output (yield) from agricultural production is a function of several attributes such as household characteristics, land size, labor input, and perceived riskiness associated with the production of a crop.

Adjimoti (2018) presents the structural form of the agricultural household model as follows:

$$Max\ U=F(C_a, C_m, C_l)\ \text{(Utility maximization)} \quad (1)$$

$$S.t{:}\ P_a(Q_a-C_a)-P_zZ-wL+Y=P_mC_m+wH\ \text{(Budget constraint)} \quad (2)$$

$$Qj=f(Zj,L,A,X)\ \text{(Production constraint)} \quad (3)$$

$$T=H+F+O\ \text{(Time constraint)} \quad (4)$$

$$Ca,Cm,Q\geq 0\ \text{(Non-negativity)} \quad (5)$$

Where a farmer attempts to maximize his utility from the consumption of agricultural commodity (Ca), non-agricultural goods (Cm), and leisure (Cl) subject to budget constraints derived as profit from agricultural production and income from off-farm activities, and secondly; production constraints such as household characteristics (Z) such as sex, age, education, household size, labor and land size (A). Other variables included in the model were access to market information and awareness to land use policy. The production constraints on the other hand determine agricultural output (Q) which is estimated as land share allocation to that particular crop.

Adjimoti (2018) reported that, in agricultural production, it is difficult to estimate output, hence due to this complexity supreme supply response models have been used to model land share allocated to a particular crop as a proxy for output. Therefore, in this study, the output in the production function conceived within the agricultural household model will reflect land share in various production systems practiced by farmers. Therefore, this study tested the hypotheses that, land share allocation decision to food crops, tree plantations, and fallow is influenced by factors such as sex, age, education, household size, land size, awareness of land use policy, access to market information, and availability.

Materials and Methods

Description of the study area

The study was conducted in Mufindi District, a pioneer in the country in timber plantations (PFP, 2017), as well as the production of food crops. Mufindi is one of the four district authorities of the Iringa region located 80 km South of Iringa Municipal. It is bordered by the Njombe region to the south, the Mbarali district (Mbeya region) to the West, and Iringa rural district to the North. To the Northeast lies the Kilolo district. In terms of international identification, the district lies between latitudes 8°0' and 9°0' south of the Equator and between longitudes 30°0' and 3°0' east of Greenwich. Mufindi is divided into five divisions namely Ifwagi, Kibengu, Kasanga, Malangali, and Sadani. Agriculture is the main economic activity employing about 95% of its population (URT, 2013). Major agricultural activities practiced by smallholder farmers in the Mufindi district include the production of food crops such as maize, beans, round potatoes, wheat, finger millet, and green peas, and the growing of timber trees.

Research design

This paper adopted a cross-sectional research design approach to collect data. This design was found to be more appropriate because it is cost-effective and can generate useful information for descriptive purposes and determine relationships among variables. In this study, the major focus is on a farmer possessing agricultural land from which the decision to allocate land to food crops, tree plantations production system, or fallow can be made. A farmer is a rational agent who can decide to allocate all the land to food crops, trees, and fallow or allocate a share of the land to food crops, trees, or fallow. Therefore, the unit of analysis is a household possessing agricultural land used to produce food crops, and trees, or leaving the land fallow.

Study Population

The target population for this study was 4896 households in three divisions: Ifwagi, Kibengu, and Kasanga. The major and common characteristic of all these households is that they own land and are engaged in the production of food crops as well as tree.

Sampling procedures and sample size

The study adopted a multistage sampling technique involving the selection of three divisions from the district based on their potential in food and tree production, followed by a purposive selection of eight villages in each division that are potential in food crops and tree growing, and finally, a random sampling technique was used to select 413 households.

The sample size was estimated using Yamanes' sample size estimation formula for a finite population (Yamane, 1967);

$$n = \frac{N}{1 + N(e^2)}$$

Where; 'N' is the population size and 'e' is the level of precision desired (0.05); while 'n' is the sample size to be estimated.
Hence;

$$n = \frac{4896}{1 + 4896(0.05^2)} = 370$$

To cater to non-responses, sampling errors, and other survey problems, the sample was inflated by 11.6%. Hence the sample size is;

$$370 + \left(\frac{11.6}{100} * 370\right) = 413$$

Thus, 413 households were sampled from the study villages based on the proportionality (percentage) as specified in Table 1. Random selection was then applied to select respondent households from each village.

The eligibility of the household to be involved in the sample size was the possession of land from which allocation to either food crops, trees, or fallow was made. The sampling frame of the study from which the sample size was estimated, was established through the assistance of the Village Agricultural Extension Agent.

Table 1. Sampling Distribution

	Ifwagi Division				Kibengu Division		Kasanga Division		Total
Villages →	Ifwagi	Ludilo	Igoda	Luhunga	Nundwe	Vikula	Mninga	Ikwega	
Households	569	424	593	571	589	329	1145	676	4896
(%)	12	9	12	12	12	7	23	14	100
Sample	48	36	50	48	50	28	96	57	413

Source: Author computations based on NBS (2012)

between food crops and tree production by farm households. In using the FMNL model, the present study assumed that a farmer having a piece of land allocates the land for food crops production, trees, and fallow where all fractions add up to a unit 1. Modeling such fractional dependent variables can be conveniently done within the fractional multinomial logit (FMNL) framework. FMNL model is mostly preferred over the ordinary multinomial logit model as FMNL is capable of modeling fractions lying between 0 and 1.

Analytical Framework

To analyze land share allocation, a household is assumed to allocate all available agricultural land to either food crops, tree plantations, or fallow or to all production activities simultaneously in such a way that for whatever allocation a farmer makes, the total allocation should add up to one (1).

Data Analysis

Collected data for this study were analyzed quantitatively. Descriptive analysis was conducted to summarize socioeconomic variables that are continuous where statistics such as mean, standard deviation, and range were generated. The fractional Multinomial Logit model (FMNL) was used to estimate the determinants of land share allocation decisions

The fractional multinomial logit model assumes that $0 \leq y_{qi} \leq 1$ and, $\sum_{i=1}^{l} y_{qi} = 1$ where i is an index that represents the activity type and q represents land share allocation to food crops, trees, and fallow. One (1) is the total of the fractions of land allocated to various uses and yq is the proportion of land allocated to a specified use out of the total land cultivated by a farmer. The explanatory variables are the factors

Table 2: Description of explanatory variables used in the Fractional Multinomial Logit Model

Independent Variable	Variable Definition	Measurement	Expected signs
Sex (X_1)	Sex of the household head (dummy)	1 if male and 0 otherwise	+
Age (X_2)	Age of household head in years	Continuous	+
Education (X_3)	Years of schooling by the household head	Continuous	+
Household size (X_4)	Total number of people living in the household	Continuous	+
Land size (X_5)	Total land owned by a household (acres)	Continuous	+
Policy (X_6)	Whether the household is aware of the land use policy (dummy)	1 if yes and 0 otherwise	+
Market access (X_7)	Whether the household has access to market information (dummy)	1 if Yes and 0 otherwise	+
Labor availability (X_8)	Whether the household allocates land based on available farm labor	1 if yes and 0 otherwise	+

that simultaneously determine land allocation decisions for the production systems. Papke and Woodridge, (1996) present the FMNL model which was also used by Ye and Pendyala (2005) as described in equation 1 below:

$$E(log[y/(1-y)]/x) = x\beta \quad (1)$$

This log-odds ratio only applies when y is strictly between 0 and 1 and is estimated using a quasi-maximum likelihood estimator as described in equation 19.

Thus,

$$E(log[y/(1-y)]/x)=\beta_1+\beta_2X_2+\beta_3X_3+...\beta_8X_8 \quad (2)$$

$=\beta_0+\beta_1 sex+\beta 2age+\beta 3education+\beta 4Household\ size+\beta_5 Land\ size+\beta_6 land\ use\ Policy+\beta_7 access\ to\ market\ information+\beta_8 labour$. Table 2 shows a description of explanatory variables used in the farctional multinomial logit model.

Results

An assessment of the socio-economic characteristics of the respondents is of paramount importance as it gives a prediction of the response to different stimuli subjected to them. The socioeconomic variable included in this study were household head sex, age, education, household size, land size, awareness of land use policy, access to market information, and farm labor.

Results in Table 3 show that respondents consisted of 77% and 23% male and female-headed households respectively. Farmers who were not aware of land use policy (73.4%) against 26.6% who were aware, farmers with access to market information consisted of 75.3%, while those who were not aware were 24.7%, and those who had easily available farm labor 71.2%). Moreover, the respondents had a mean age of 44.6 years (23-72 years), education level ranged between 0–18 years of schooling with a mean of 7.1 years (primary school leavers), and household size was found to range between 1-10 people (mean 4.5 people). This means household size is just above that reported in the national statistics (URT, 2013) which was 4.3 in Mufindi District. The land size was moreover found to range between 0.5–47 acres, with a mean of 8.25 acres.

Land Allocation

Table 4 shows that the mean land allocated to food crops by households was 3.57 acres, ranging from 0.5 to 18 acres with a standard

Table 3: Descriptive summary of independent variables

Variable	Variable		Frequency		Percent
Category					
Sex	Male		318		77
	Female		95		23
Whether aware of land use policy	Aware		110		26.6
	Not aware		303		73.4
Whether have access to market information	Yes		311		75.3
	No		102		24.7
Labor availability	Yes		294		71.2
	No		119		28.8
	Obs	**Mean**	**Std. Dev**	**Min**	**Max**
Age	413	44.64	12.64	23	72
Education	413	7.11	2.95	0	18
Household size (Hhsiz)	413	4.5	1.78	1	10
Land size (Landsize)	413	8.25	7.53	0.5	47

Table 4: Land use share allocation

Variable	N	Min	Max	Mean	Std. Dev
Food crops (Acres)	413	0.5	18	3.57	2.81
Tree plantations (Acres)	413	0	42	4.28	5.99
Fallow (Acres)	413	0	15	0.39	1.45

deviation of 2.8, while the mean for trees was 4.28, ranging from 0 to 42 acres with a standard deviation of 5.9, and that of fallow was 0.39, ranging between 0 to 15 acres, and having a standard deviation of 1.44. These results imply that households in the Mufindi district have generally allocated more land to tree plantations, followed by the production of food crops and fallow. The reason could be attributed to the utility in terms of profit tree growers get from tree production.

Determinants of Land Share Allocation Decisions

The fractional multinomial logit model results converged on a log pseudo-likelihood of -282.43098 with a Wald chi-squared of 222.79. Moreover, the chi-square result has a probability of 0.0000 meaning that it is globally highly significant. Data analysis started first with finding a maximum likelihood (ML) fit of fractional multinomial logit FMNL, upon which, the average marginal effects of the independent variables on land shares were calculated from the FMNL fit (Table 5). Food crops' land share was used as a reference category as it was found to be produced by all households. Results were statistically significant at 1% and 5% and were used to explain the relationship between dependent and independent variables. The income variable was not included in the model due to the presence of outliers, hence inconsistent results.

Discussions

Variable sex is found to significantly influence land share allocation decisions to trees. The results were expected as females are mostly responsible for the production of food crops for family consumption than males and therefore are likely to invest more in food production than in trees. These findings are

Table 5: Average marginal effects derived from the Fractional Multinomial Logit (FMNL)

	Tree plantations' land share			Fallow land share		
Variable	**dy/dx**	**Std. Err.**	**P>z**	**dy/dx**	**Std. Err.**	**P>z**
Sex	-0.1690***	0.0385	0.000	0.0014	0.0122	0.912
Age	-0.0021	0.0011	0.057	0.0006	0.0003	0.060
Education	0.0042	0.0046	0.365	-0.0025	0.0014	0.079
Hhsize	-0.0121	0.0076	0.114	0.0051**	0.0024	0.029
Landsi	0.0262***	0.0023	0.000	0.0019***	0.0005	0.000
Policy	0.0617*	0.0294	0.036	-0.0071	0.0084	0.402
Market	0.0954***	0.0307	0.002	-0.0121	0.0111	0.273
Labour	0.1164***	0.0294	0.000	0.0035	0.0075	0.636

Key: *Significant 10% **significant 5% ***significant 1%.

Number of Observation = 413

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Log pseudo-likelihood = -282.43098

Wald chi2 (16) =222.79 Prob > chi2 = 0.0000 in-line with Adebayo et al, (2020), who found that female-headed households were less likely to invest in commercial tree crop farming. Villamor *et al.* (2014) also reported that males while motivated to grow trees also incorporate food crops, while females' interest is in food production and consumption.

The household size coefficient indicates that a one-unit increase in the number of household members will result in a 0.51% increase in land share allocation to fallow. This finding brings a new insight that requires more investigation, as it was expected that, fallow land would decrease with an increase in household size. While counter-intuitive, this could be caused by the engagement of some family members in petty and other off-farm activities created by fast-growing and commercialized tree farming, hence farmers engage in those activities to meet the daily households' requirements, leaving land fallow.

Household land size coefficients signify that, a one-acre increase in household land size is associated with a 2.62% increase in the relative log odds of land share allocation to the tree against food crops. It is also, associated with a 0.19% increase in relative log odds of land share allocation to fallow versus food crops. This means that a household having additional land is likely to allocate it to trees while bearing some for fallow as a way of replenishing soil fertility. Adjimoti (2018) also found that the share of land allocated to major food crops was significantly decreasing compared to other crops while increasing that of industrial crops. On the other hand, it is expected that, if a farmer has a large piece of land, given the resources at his/her disposal, it is possible to fallow some land.

The coefficient on households' awareness of land use policy shows that an additional one unit increase in households' awareness to land use policy is associated with a 2.94% increase in the relative log odds of land share allocation to trees versus food crops. This situation is likely to be associated with the awareness created by various tree stakeholders including both international Companies such as Green Resource and other local institutions like Southern Paper Mills, Twico, carbon credit, timber traders, and the government, which are likely to contribute to increased land share to trees because of its perceived benefits. Hettig *et al.* (2016) also pointed out that global markets and focus on global cash crop markets have created incentives for agents to switch their land use towards cash crop cultivation and for raising households' incomes. Thus, policies such as carbon credit might have resulted in a switch to allocating more land for trees.

Results in Table 5 show that, the variable access to market information by the household influences positively the land share allocation to tree plantations. The results suggest that one-unit additional access to market information is associated with a 9.54% increase in the relative log odds of land share allocation to trees against food crops. These results signal that households who have access to agricultural market information allocate 9.54% more land to timber trees than households without market information. Arvola *et al.* (2019) found that two-thirds of interviewees growing trees stated that they had already an idea of their sales strategy at the time of planting the trees. The same results were also found by Allen and James (2014) who reported that villages with better market access were correlated with a much higher share of secondary crops. Ahimbisibwe (2019) also reported that a household's decision to select perennial and annual crops depends on the market price of the crop. Hence households are likely to make more land allocation decisions to trees for which market is readily available than food crops.

Results in Table 5, also show that farm labor is positively influencing land share allocation to tree plantations. The result indicates that a one-unit additional farm labour is associated with an 11.64% increase in the relative log odds of land share allocation to trees versus food crops, while it is not significant for fallow. Based on the findings above, labor is an important variable in tree production as compared to food crop production. This could be attributed to the fact that; the tree industry has created off-farm activities that attract more labor. These results are found to be related to Mponela et al. (2011), Coxhead and Demeke, (2004), and Perz, (2002) who reported the availability of farm labor to be among the factors that influenced land allocation to various crops.

Conclusions

Land share allocation decisions among different uses are increasingly drawing the attention of researchers, practitioners, and policymakers worldwide. Evidence from previous studies indicates that land allocation decisions should aim at maximizing social, economic, and ecological benefits to allocators who are mostly households. The current study investigated the factors influencing land share allocation decisions in food crops, tree production, and fallow by smallholders in the Mufindi district. A Fractional Multinomial Logit Approach model (FMNL) was used to estimate the parameters. The model treated land share allocation to food crops, trees, and fallow as dependent variables influenced by factors such as sex, age, education, household size, labor, land size, access to market information, and awareness to land use policy.

Prior results indicated that smallholder farmers in the study area have allocated more land share to tree plantations, followed by food crops and a small portion to fallow. While results from the Fractional Multinomial Logit model showed that, sex was significantly influencing land share allocation to trees, whereas male-headed households were found to be more prevalent than female-headed households. Household size was found to be associated with an increase in land share allocated to fallow as compared to food crops. While, land size (acreage), access to market information by households, awareness to land use policy, and availability of labor were all found to be significantly influencing land allocation decisions to trees more than food crops. The major reason for more land share allocation to trees as compared to food crops and fallow could be due to the profitability of trees and the ready market for tree products.

Based on the study findings, it is suggested that the government should create awareness through educational programs on, land use policy, market information, labor, and land use allocation for improved farmer welfare.

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References

Adjimoti, G, (2018). Analysis of cropland allocation in rural areas Benin: A fractional multinomial approach. Cogent Food & Agriculture, 4(1). doi.org/10.1080/23311932.2018.1488339

Adebayo B.A., Abiodun E.O., Milu M., Thomas J., Adesoji A., Titus A., Omotoso O.O. and Olatokunbo H.O. (2020). Expanding land area under commercial Tree crop plantation in Nigeria (APRA Working Paper No. 41). https://www.future-agricultures.org/publications/working-papers-document/working-paper-41-expanding-land-area-under-commercial-tree-crop-plantation-in-nigeria/.

Ahimbisibwe, V., Auch, E., Groeneveld J, Tumwebaze, S.B. and Berger U, (2019). Drivers of Household Decision-Making on Land-Use Transformation: An Example of Woodlot Establishment in Masindi District, Uganda. Forests 10(8):619. doi.org/10.3390/f10080619

Alam, S., Kowsari, M., Chowdhury, N., Islam, M., & Haque, S. (2016). Factors affecting land allocation for maize cultivars in Lalmonirhat District of Bangladesh. Progressive Agriculture, 27(3): 346-354. DOI. https://doi.org/10.3329/pa.v27i3.30830.

Allen, M.S., and James, E, (2014). Determinants of Land Allocation in a Multi-Crop Farming System: An Application of the Fractional Multinomial Logit Model to Agricultural Households in Mali. Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 28, 2014.

Amare M., Mavrotas G and Edeh H, (2018). Farmers' Crop choice decisions: Trends and Determinants in Nigeria and Uganda. IFPRI Discussion Paper 01716, March 2018.

Arvola A, Malkamäki A, Penttilä J and Toppinen A (2019). Mapping the Future Market Potential of Timber from Small Scale Tree Farmers: Perspectives from the Southern Highlands in Tanzania. Small-scale Forestry (2019) 18:189–212

Becker, G.S. (1965). A Theory of the Allocation of Time. *The Economic Journal,* 75(299), 493. doi:10.2307/2228949

Coxhead, I., and Demeke, B, (2004). Panel Data Evidence on Upland Agricultural Land Use in the Philippines: Can Economic Policy Reforms Reduce Environmental Damages?" *American Journal of Agricultural Economics, Agricultural and Applied Economics Association,* 86(5): pp 1354-1360.

Forest Development Trust (FDT), (2015). Baseline Tree Growers Survey Report. Uendelezaji Misitu Tanzania. Gatsby. Tanzania. 65pp.

Gebresilassie L and Bekele A, (2015). Factors determining the allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia. *Journal of Development and Agricultural Economics.* 7(3):105 – 112. DOI: 10.5897/JDAE2014.0621

Grise, J., and Kulshreshtha, S. (2015). Farmers' Choice of Crops in Canadian Prairies under Climate Change: *An Econometric Analysis. Journal of Earth Science & Climatic Change,* 07(01). doi:10.4172/2157-7617.1000332.

Hettig, E., Lay, J., & Sipangule, K. (2016). Drivers of Households' Land-Use Decisions: A Critical Review of Micro-Level Studies in Tropical Regions. Land, 5(4), 32. doi:10.3390/land5040032.

Jianhong E. Mu & Bruce A. McCarl & Anne M. Wein, (2013). Adaptation to climate change: Changes in farmland use and stocking rate in the U.S. Mitig Adapt Strategy Glob Change (2013) 18:713–730. DOI 10.1007/s11027-012-9384-4.

Liu Y, Peng J, Jiao L, (2016). A Heuristic Land-Use Allocation Model Using Patch-Level Operations and Knowledge-Informed Rules. PLoS ONE 11(6). https://doi.org/10.1371/journal.pone.0157728.

Mponela, P., Jumbe, C.B., and Mwase, W.F, (2011). Determinants and Extent of Land Allocation for Jatropha Curcas L. Cultivation among Smallholder Farmers in Malawi. Biomass and Bioenergy, 35(7): 2499 – 2505.

Mulu, S.; Asfaw, Z.; Alemu, A.; Teketay, D, (2022). Determinants of Decision Making by Smallholder Farmers on Land Allocation for Small-Scale Forest Management in Northwestern Ethiopian Highlands. Land 2022, 11, 838. https://doi.org/10.3390/land11060838

Mwaura, F.M. and Adong, A, (2016). Determinants of Households' Land Allocation for Crop Production in Uganda. *Journal of Sustainable Development* 9(5). DOI:10.5539/jsd. v9n5p229.

Ndhlove, (2010). Determinants of farm households' cropland allocation and crop diversification Decisions: The role of fertilizer subsidies in Malawi. MSc. in Development and Natural Resource Economics Norwegian University of Life Sciences.77pp.

Ngaga, Y, (2011). Forest Plantations and Woodlots in Tanzania. A Platform for Stakeholders in African Forestry. African Forest Forum Working Paper Series. African. 80pp.

Ng'elenge, H., Damas, P. & Kilima, F. (2022). Farm profit-maximizing food crops and tree combination in Mufindi district: A multi-period programming approach. Global *Journal of Business, Economics, and Management: Current Issues*. 12(2): 168-179. DOI: https://doi.org/10.18844/gjbem.v12i2.6167.

Ngunyen T.T., Ngunyen L.D., Lippe R.S and Grote U, (2017). Determinants of Farmers' Land Use Decision Making: Comparative Evidence from Thailand and Vietnam. World Development 89: 199-213. DOI: 10.1016/j.worlddev.2016.08.010.

Papke, L.E., & Wooldridge, J.M, (1996). Econometric methods for fractional response variable with an application to 401 (k) plan participation rates. Journal of Applied Econometrics, 11(6): 619–632. https://doi.org/10.1002/(SICI)1099-

1255(199611)11:6<619

Perz, S.G., (2002). Household demography and land use allocation among small farms in the Brazilian Amazon. Human Ecology Review 9(2):1-16.

PFP, (2016). Private Forestry Programme: Forest Plantation Mapping of the Southern Highlands. Final report. Iringa, Tanzania. 56pp.

URT (2013). Mufindi District Socio-economic profile. Dar es Salaam, Tanzania. 184Pp.

URT (2016). Draft National Land Policy. Ministry of Lands Housing and Human Settlements Development. Dar es Salaam, Tanzania. Pp 28.

URT (2017). Strategy for addressing land use planning challenges in Tanzania. National Land Use Planning Commission. Dar es Salaam, Tanzania. Pp 65.

Villamor G., Noordwijk. M,V., Djanibekov, U., Javier, M.C. and Catacutan, D, (2014). Gender differences in land-use decisions: Shaping multifunctional landscapes? Current Opinion in Environmental Sustainability 6(1): 128-133. http://dx.doi.org/10.1016/j.cosust.2013.11.015

Yamane, T, (1967). Statistics: An Introductory Analysis, 2nd Ed., New York: Harper and Row.

Ye, X. and R.M. Pendyala, (2005). A Model of Daily Time Use Allocation Using Fractional Logit Methodology. In H.S. Mahmassani (ed.) Transportation and Traffic Theory: Flow, Dynamics, and Human Interaction. Pergamon, Elsevier Science Ltd., Oxford, UK, pp. 507-524.

Yigezu A.Y., Tizale C.Y., Kassie G.T. and Hassan A, (2018). Modeling land-use decisions in Production Systems involving multiple crops and varieties. *African Journal of Agric Econ*. 13(3): 240–250. DOI. https://hdl.handle.net/20.500.11766/8386.