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Determinants of Decision Making by Smallholder Farmers on Land Allocation for Small-Scale Forest Management in Northwestern Ethiopian Highlands

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Abstract: Smallholder farmers in the northwestern Ethiopian Highlands are highly engaged in small-scale forest management. Participation in this activity can provide a key source of income for the farmers as well as wider benefits to the environment. To gain a better understanding of how spatial and socio-ecological factors determine farmers' engagements in small-scale forest management, we conducted a comparative study in three Districts of northwestern Ethiopia. We used a mixed method approach including both quantitative (n = 375) and qualitative (n = 45) surveys to understand farmers' motivations and decisions in three Districts of northwestern Ethiopia. We found that there were a number of factors motivating farmers' decisions to participate, including land degradation and decline in crop productivity (in Fagta Lekoma District); adverse impact of adjacent woodlots (in North Mecha District); and increasing demand of wood products (in Guna Begemidir District). Further analysis on the extent of farmer engagement revealed that their decision to increase or decrease the share of land allocated to woodlots is heavily dependent on the comparative socio-economic benefits of woodlots and distance to markets. Other key (District-specific) determinant factors included wealth status, soil fertility status, gender, adult equivalent value, total land holding size, and annual crop production risk perception. Our findings suggest that to increase the uptake of woodlots, we would need to adopt a demand-driven forestry extension approach, which considers the heterogeneity of farmers and farm characteristics. Further research is required to quantify the optimal level of land allocation for small-scale forest management.

Keywords: forest management; agro-ecology; smallholder perceptions; socio-economic benefits; land degradation

Citation: Mulu, S.; Asfaw, Z.; Alemu, A.; Teketay, D. 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

Academic Editor: Hossein Azadi

Received: 16 April 2022
Accepted: 31 May 2022
Published: 3 June 2022

1. Introduction

Deforestation is the leading driver of global land use change. An estimated 129 million ha of forest were lost from 1990 to 2005 [1]. The highest rate of annual forest loss was observed in the global south, particularly in tropical regions of Sub-Saharan Africa (SSA) (e.g., Nigeria 4.5%) [1,2]. Many countries have adopted various measures to try and combat this global forest loss, particularly through the expansion of small-scale forests [3]. While the extent to which small-scale forestry is adopted differs between countries, it is mainly the decisions of the local smallholder farmers' who determine whether land is allocated for tree planting. The decision to allocate land to forest management is therefore heavily dependent on the perceived social, economic, and environmental benefits [4–6]. Many of the different land uses are always conflicting due to the supply of multiple ecosystem services (ESs). Smallholders in SSA are faced with difficult choices as they aim to meet multiple individual, household, community, and wider societal objectives.

Decision making is a process by which a person, group, or an organization identifies a choice or judgment to be made, gathers and evaluates information about alternative outcomes, and selects from among these options [7,8]. The likelihood of any given outcome is thus dependent on the biophysical and socio-cultural environment, as well as the characteristics of the specific decision maker and the relative values he or she attaches to it [8,9]. It is generally accepted that the decision maker chooses the outcome from which he draws the greatest relative happiness or utility [8,9]. The decision of farmers on land allocation to small-scale forest management is, thus, heavily dependent on the theory of random utility maximization. It is also affected by objectives, attributes of alternative livelihood strategies, and constraints. The utility derivable from the decision depends on a vector of farm and farmer attributes as well as economic and institutional factors [8–13].

Within the Sub-Saharan African context, it is widely understood that land allocation is affected by several key factors. Several studies have shown that the decision of farmers to allocate land to woodlots was driven by farm characteristics, biophysical factors, institutional factors, and economic factors. For example, it was reported that the size of land holding and soil erosion index have a negative influence while gender (being male) has a positive influence in decision making on the adoption of woodlot management in the farming system of Uganda [14]. Bernard [15] reported that adult equivalent, total land size, availability of market for farm forest products, and level of satisfaction with the current market price of farm forest products are positively and significantly influencing small-scale forest management in the high forest zone of Ghana. Fahmi et al. [16] also reported that land size, family size, and spatial difference were determinants of decision making of on-farm tree planting in Senar State, Sudan.

Furthermore, in some cases, it is the farmers' perceived risk itself that dictates whether or not to participate in small-scale forest management [12]. Altogether, the current evidence suggests that decision making at the household level is rather complex, varying a lot by country. This suggests that aggregating data across countries may be insufficient to inform decision makers at a country level.

In the northwestern highlands of Ethiopia, the increasing population pressure has raised the demands for various ESs, especially those which are derived from forest-based ecosystems. To fulfill the demand for various ESs, local communities have developed various forest management strategies, including small-scale forestry. Ethiopia could be taken as a model in terms of woodlot management as farmers are highly engaged in tree planting on their farmland allocating a considerable proportion of their total land to woodlot expansion by comparing alternatives to achieve multiple and competing goals [10,13].

Existing studies in Ethiopia have shown that decision making of farmers on small-scale forest management is very context dependent. For example, soil fertility is found to be a positive strong determinant of decision making on tree planting in some cases [17], while it affected farmers decision negatively in other areas [13] due to the difference in farmers' perception on the value of their land. Likewise, some studies reported that the labor force has a positive influence on the decision to plant trees [10], while others revealed that farmers with a large labor force are motivated towards annual cropland rather than tree planting [18]. Distance to market is reported to positively affect decisions on woodlot management [13], while distance to road and district administration had a negative influence on farmers' decisions regarding woodlot management [10,19].

Difference in agro-ecology is also reported to be determinant of the expansion of woodlots [20]. Other factors such as land holding size, comparative cash income, wealth status, and gender(male) consistently showed a positive influence on the decisions of farmers regarding woodlot management [10,13,18–20].

The above-mentioned contrasting reports of previous studies, except the report in [13], focused either on farmers' decisions on engagement or on absolute land size allocation to small-scale forest management without considering the share of land allocated. In the process of smallholders' decision making on forest management, relative land allocation (proportion of land allocated) is vital to understand the motivation of farmers as well as the strength of their decision on small-scale forest management. Without this information, we cannot accurately understand the importance of the various factors in the farmers' decision-making processes. For sustainable land use planning, there is a need to understand the strategy of farmers in making decisions on land allocation and land use transition whilst considering multi-objective optimization. Thus, the present study focused on investigating the trend, motivation, and determinants of farmers' decisions on relative land allocation to small-scale forest management by comparing cases across spatial and intervention differences in three Districts (Guna Begemidir, North Mecha, Fagta Lekoma). The aim of the study was to gain a better understanding of how spatial and socio-ecological factors determine farmers' engagements in small-scale forest management.

2. Materials and Methods

2.1. Study Area

The study was conducted in northwestern Ethiopia. This area was selected due to the fact that many farmers were involved in small-scale forest management intervention. A small-scale forest in this context is any eucalypt and *Acacia decurrens* wild woodlot establishment and management privately owned on a farm, around the village, on degraded land, or at a roadside. Three Districts/woredas (Guna Begemidir, North Mecha, and FagtaLekoma (Figure 1) were purposively selected considering the extensive presence of the woodlot management practices with different species (*Eucalyptus globulus* Labill in Guna Begemidir, *Eucalyptus camaldulensis* in North Mecha, and *Accaciadecurrens* in Fagta Lekoma) and representativeness of agro-ecological condition.

Guna Begemidir is one of the Districts found in the South Gondar Zone, Ethiopia (Figure 1) The agro-ecology of the District is cool humid highland, with an average annual rainfall of 1250 mm and temperature ranging from 9 to 25 °C. Mixed-rain-fed subsistence agriculture is dominantly practiced. The dominant crops grown include teff (*Eragrostis-abyssinica* (Zucc) Trtter), wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), beans (*Phaseolus vulgaris* L.), pea (*Pisum sativum* L.), potato (*Solanum tuberosum* L.), and common vetch (*Vicia sativa* L.). Farmers in the district are largely engaged in planting *Eucalyptus globulus* Labill and managing woodlots. Farmers in the District plant eucalypt trees on their farm land for diverse socio-economic benefits.

North Mecha District is found in West Gojam Zone (Figure 1). The agro-ecology of the district is categorized under cool sub-humid highlands. The mean annual rainfall is about 1589 mm and its mean temperature ranges between 16 and 20 °C [21]. In the District, a mixed farming system (crop, tree, and livestock production) is dominantly practiced. In addition to the rain-fed agriculture, the crop production is supported by the Koga Irrigation and Watershed Management Project found in the District. Food crops commonly grown include teff, millet (*Panicum milliaceum*), lupin (*Lupinusalbus* L.), beans, pea, potato, noug(*Guizotiaabyssinica* (L.f.) Cass), and other vegetables. Most of the farmers in the District have converted their croplands to *Eucalyptus camaldulensis* woodlot and have been participating in non-farm income generating activities.

Fagta Lekoma District is found in the Awi Zone (Figure 1). The District has a population of 151,220 in 2017 [10]. Altitudes range from 1754 to 2973 m. The mean annual rainfall is 2434.6 mm while the mean annual minimum and maximum temperatures are 9.4 and 25 °C [22]. Mixed subsistence farming systems include major crops such as barley, teff, wheat, potato, and finger millet (*Eleusinecoracana* (L.) Gaertn) and livestock. Farmers in this District practice the establishment and management of *A. decurrens* woodlots, with annual crops intercropping during the first year and/or in the earlier stages of the tree plantations. *A. decurrens* was originally introduced for soil conservation and roadside planting due to its fast growth and compatibility with annual crops [13]. Currently, the species is widely expanding for its income generation and as improved-fallow agroforestry practice [10,13,23].

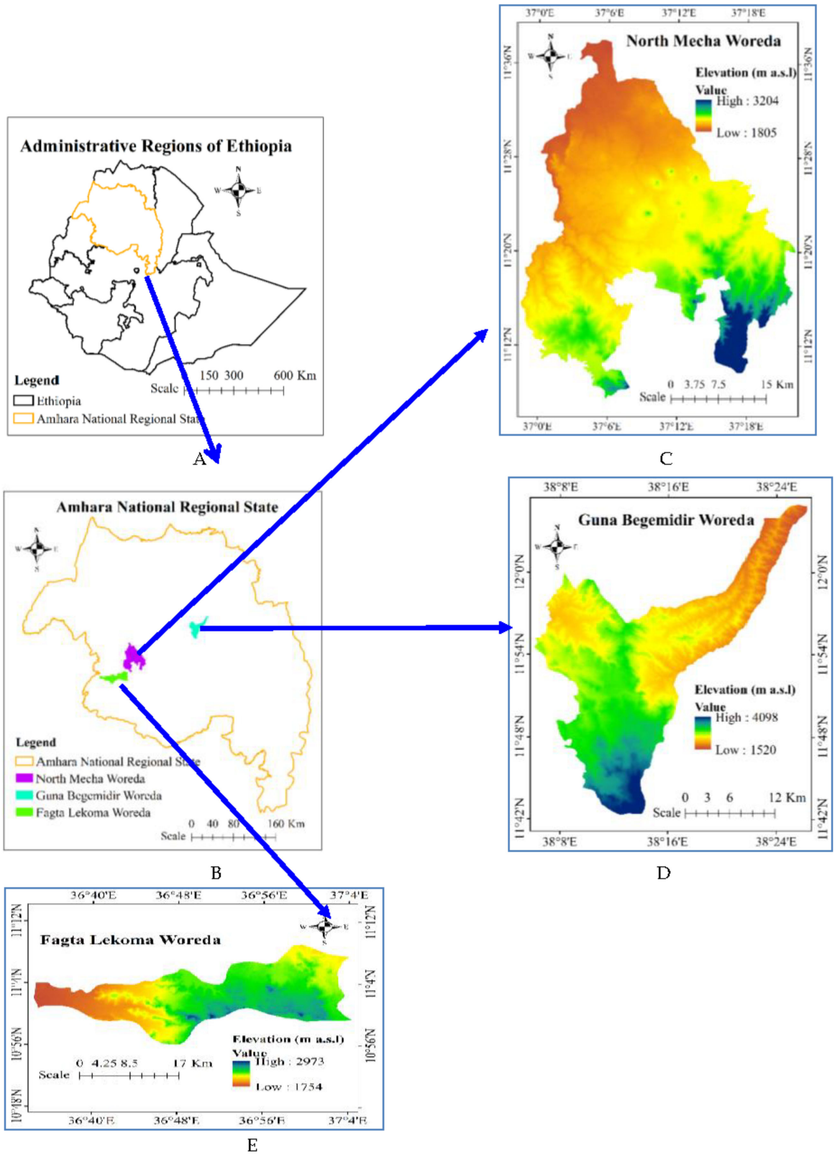

Figure 1. Location of the study areas: (**A**)Administration regions of Ethiopia, (**B**) Amhara National Regional State, (**C**) North Mecha Woreda, (**D**) Guna Begemidir Woreda, and (**E**) Fagta Lekoma Woreda.

2.2. Methods

This study employed a mixed methods approach comparing the three Districts [24,25] including both quantitative and qualitative approaches.

Qualitative approaches, specifically key informants interviews (KIIs), facilitated by a key informant interview guide were used to gather information on the trend of small-scale forest expansion and motivating factors for small-scale forest management by using checklists (open-ended questions). KI in this context refers to a person who has continuously lived for more than 30 years in the kebele and is knowledgeable about the historical trend of woodlot management and decision making on land use change as well as land allocation to small-scale forest management. Overall, the knowledge generated through the KII was used to develop a questionnaire for the quantitative data collection. Qualitative data collection was followed by a quantitative method through face-to-face interviews using a semi-structured questionnaire. Quantitative approaches provided information on the motivation strategies of different social categories on small-scale forest management, and land allocation for small-scale forest management and other land uses. Data were collected between November 2020 and February 2021.

Sampling Technique

A multi-stage stratified random sampling technique was used to select the primary unit of analysis (household) for the study [26,27]. In the first stage, Districts were selected purposively by considering the extensive presence of the woodlot management practices with different species and representativeness of agro-ecological conditions.

Kebeles (smallest administration unit in Ethiopia) in each District were stratified into three strata based on distance from the district administration center. Kebeles were near if they were situated less than 3.5 km (Guna Begemidir), if less than 8 km (North Mecha), and if less than 7 km (Fagta Lekoma), since Districts are of different sizes. Likewise, kebeles were considered as medium in Guna Begemidir if they were between 3.5 and 5 km, medium in North Mecha if they were between 8 and 15 km, and medium in FagtaLekoma if located between 7 and 14 km. Similarly, kebeles located above 5 km in Guna Begemidir, above 15 km in North Mecha, and above 14 km in Fagta Lekoma were categorized as far distance. In the second stage, one kebele was randomly selected from each of the strata described above for each District. A total of 9 kebeles (three kebeles per District) were selected for the study.

In the third stage, the households in the selected kebeles were categorized according to different wealth classes (strata) with the help of KIs. Criteria for wealth ranking considered by the key informants were land size, number of livestock, saving money in bank or not, type of household owned, area of woodlot owned, able to feed family member throughout the year or not, able to send children to school or not, and able to use technologies such as solar light or not. Accordingly, households in the selected kebeles were categorized as poor, medium, or rich in the category. Sample households were selected randomly from each of the wealth strata using a proportionate sampling technique in order to determine number of sample households relative to sizes of each stratum. The number of households was determined using a power analytic approach [28] in which: alpha (α) was set at 0.05; desired statistical power level was set at 0.80; and effect size, f^2, was set at 0.15. In total, data were collected from 375 households (125 per study site).

For the qualitative survey, a total of 45 KIIs (15KIs from each District) were selected by the snowball method and used for the interview.

2.3. Data Analysis

Combinations of descriptive and econometric analyses were used for the quantitative data. Descriptive statistics such as percentage, mean, and standard deviation were used to analyze and present the data. ANOVA was used to examine relationships between key variables. The results were presented in tables, figures, and radar diagrams. In this study, land allocation is described in two different ways, average and proportion of land allocated to small-scale forest management. Average land size refers to the absolute land size allocated for specific land use (cropland, small-scale forest management, grazing land) measured in hectares, while proportion of land indicates the share of land allotted for small-scale forest management and the alternative land uses. As it is computed by dividing the absolute land size of the land use by the total area of land owned by the household, it is unit-less or as a percentage. The qualitative data from the KIIs (perception on trends of woodlot expansion and motivating factors) were summarized and presented in the table. In addition, the explanations given for the listed factors were used to complement and strengthen the results and discussion part of the article.

The motivating factors influencing farmers to be engaged in small-scale forest management, identified through KIIs, were ranked by respondents of the household survey and presented in the radar diagram. Prior to considering the listed factors for the scoring analysis, the similarities and meanings of the listed factors were checked. Accordingly, some factors listed by few of KIs were found to have similar meanings with others (with only different way of expressions). Thus, to avoid ranking of factors with similar implications, we excluded some of them and included the more important and comprehensive factors in the scoring analysis.

Econometric Analysis

An econometric model was used to scrutinize the determinants for decision making of farmers on land allocation to small-scale forest management. A Fractional Logit model was used to model the effects of explanatory variables on decision of farmers to allocate their land to small-scale forest management. The response variable in this study appears as a proportion or fraction of land devoted to small-scale forest management. The independent variables hypothesized to affect the decisions of farmers on the proportion of land allocation to small-scale forest management are listed in Table 1 with their respective expected signs and sources. The bases for hypothesizing the explanatory variables were the theory of decision making and empirical evidence from previous studies.

Table 1. Hypothesized independent variables with their expected signs and sources.

Independent Variable	Expected Sign	Description	Sources
Gender(male)	+	Sexual category of respondent (0 female, 1 male)	[12–14,18–20].
Age	+/−	Age of respondent in years	[13,15,20]
Wealth	+	Wealth status of respondent (0 poor, 1 medium, 2 rich)	[10,13,18–20]
Adult equivalent	+	Index of household active and inactive labor force	[15]
Total land size	+/−	Respondents total size of land holding in ha	[12,13,15,18–20]
Tropical livestock unit	−	Index of household various livestock number	[19]
Distance of woodlot to main road	−	Distance of woodlots to main road measure in km	[10,19]
Distance of woodlot to market	−	Distance of woodlot to nearest market measured in km	[13]
Soil fertility	+/−	Soil fertility of field (0 poor, 1 medium, 2 high)	[13,17]
Annual crop risk perception	+	Farmers' perception on annual crop production risk (0 no, 1 yes)	[12,19]
Woodlot production risk	−	Farmers' perception on woodlot production risk (0 no, 1 yes)	[12,19]
Woodlot products market risk	−	Farmers' perception on woodlot products market risk	[12,15,19]
Perception on comparative socio-economic benefits of woodlots	+	Farmers' perception on comparative socio-economic benefits of woodlots (0 no, 1 yes)	[10,15]

Using a linear regression model for a dependent variable measured as proportions could produce predictions outside the [0,1] range which are illogical [29], yet values outside [0,1] intervals are not feasible for proportions data, which are bound between zero and one. Previous researchers have considered using censored normal regression techniques such as Tobit regression model on proportion data that contain zeros or ones [13]. In the present study, observations at the boundaries of a fractional variable are a natural consequence of individual choices and not any type of censoring. Papke et al. [30] proposed a fractional response model that extends the generalized linear model (GLM) literature from statistics.

The Fractional Logit model estimates the parameters when the dependent variable is a fraction ranging between 0 and 1 [30,31]. Thus, the Fractional Logit model was used to determine the determinants of farmers' decisions to allocate proportion of their land to small-scale forest management. According to Papke et al. [30], the conditional expectation of the fractional response variable is expressed as in Equation (1):

$$E(y_i|x_i) = G(x_i\beta), i = 1 \ldots N \quad (1)$$

where y_i denotes the dependent variable, x_i is a vector of explanatory variables of observation i, and β is the vector of model parameter to be estimated. Typically, $G(.)$ is a distribution function similar to the logistic function which maps z to the [0,1] interval as in Equation (2):

$$\boldsymbol{G}(z) = \mathbf{exp}(z)|(\mathbf{1} + \mathbf{exp}(z)\ ) \quad (2)$$

where z denotes the likelihood of the logistic function.

The Stata 14 command *fraclogit* is used to estimate the parameters of a fractional logistic model. The data were assessed for multicollinearity using variance inflation factor and pairwise correlation, and no problem was detected.

3. Results

3.1. Trends in Small-Scale Forest Management

The results of the household survey (quantitative analysis) showed that small-scale forest management is rapidly expanding in the study Districts (Figure 2). Notably, we found that farmers in Fagta LekomaDistrict started woodlot establishment 11 years later than the other two Districts. The result of the KIIs also confirmed that woodlot establishment in North Mecha and Guna Begemidir started 30 years prior, initially in the form of a boundary plantation (Table 2). This eventually expanded on farmland, replacing the annual food crop production, with the highest rates of expansion observed during the last 10 years (2009–2020).

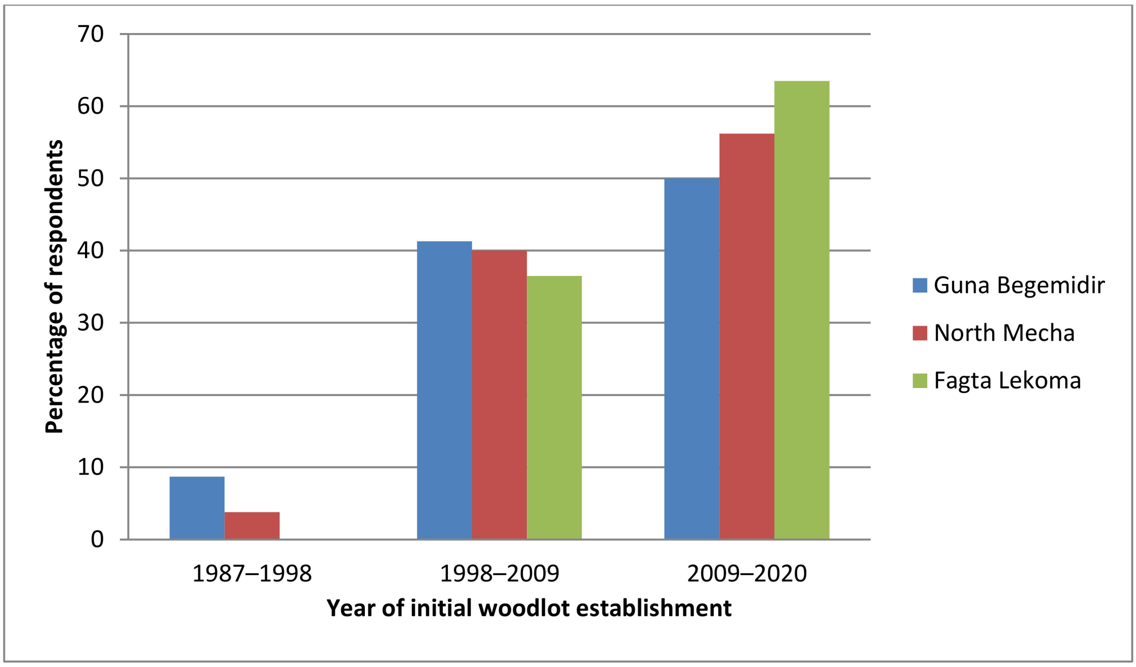

Figure 2. Percentage of respondents who started woodlot establishment at different periods.

Table 2. Key informants' perception on the trend and motivating factors of small-scale forest management in the study Districts.

Description	Guna Begemidir (n = 15)	% of KIs	North Mecha (n = 15)	% of KIs	FagtaLekoma (n = 15)	% of KIs
Trend of expansion and management ofsmall-scale forest	During 1987–1998 only in the form of boundary planting(low expansion).	100	Boundary planting 30 years ago (1987–1998).	93.3	Expansion of *A. decurrens* woodlot started in 1998 (15years ago).	53.3
	1998–2009 significant expansion.	86.6	Significant expansion during 1998–2009.	100	Expansion of *A. decurrens* woodlot started before 20years.	46.7
	High expansion observed during 2009–2020.	100	Massive exposition has been during period 2009–2020.	100	Massive exposition has been during period 2009–2020.	100
	Female-headed households are less likely to be engaged in woodlot management.	80	Currently, almost all farmers except female-headed households have woodlots.	100	Female-headed households are less likely to be engaged in woodlot management.	93.3
	Farmers sell their woodlot products at stand level and after processing.	93.3	Farmers sell their woodlot products at stand level and after processing.	100	The majority of farmers sell their woodlot products after processing to charcoal.	100
Motivating factors for small-scale forest management	High demand of wood products.	86.7	Adverse impact of adjacent woodlot.	86.7	Land degradation and decline in crop productivity.	80
	Land degradation and decline in productivity.	93.3	High demand of wood products.	80	High demand for charcoal.	80
	Adverse effect of others eucalyptus woodlot on adjacent crop lands.	86.7	High profitability of woodlots.	93.3	Special intrinsic and ascribed attributes of *A. decurrens.*	80
	High profitability.	80	Comparative socio-economic benefits of woodlots.	6.7	High profitability.	73.2
	Comparative socio-economic benefits of woodlots.	20			Comparative socio-economic benefits of woodlots.	13.3
					Soil fertility enhancement.	13.3
					Soil and water conservation.	6.7

Note: Figure in the column % of KIs indicate the percentage of KIs cited the listed motivating factors and trend of small-scale forest management in each study district.

The KIs further reported that planting *A. decurrens* in the FagtaLekoma District started 20 years ago, but high expansion was observed during 2009–2020 years (Table 2).

3.2. Land Allocation for Small-Scale Forest Management

The area of land allocated for the three land uses: annual crop, small-scale forest management, and grazing land increased significantly ($p < 0.001$) with wealth categories in the study Districts (Table 3). The rich farmers allocated significantly higher areas of land to annual crop than the households with medium levels of wealth, which in turn had higher annual crop land size than the poor households. With regard to land allocation to small-scale forest management, significant variation was observed in all three wealth classes in the three Districts (Table 3).

Proportion of land allocated for small-scale forest management significantly varied ($p < 0.001$) with the study Districts (Table 4). The proportion of land allocated for small-scale forest management in the case of Guna Begemidir District is significantly lower than the other two Districts (Table 4). During the period of 2011–2020, the proportion of land allocated for annual crop reduced from 81% to 65% in Guna Begemidir, 86% to 51% in North Mecha, and 64% to 39% in FagtaLekoma Districts. On the other hand, the proportion of land allocated for small-scale forest management increased from 18% to 25% in Guna Begemidir; 30% to 41% in North Mecha; and 40% to 43% in FagtaLekoma Districts within the ten year interval. A closer look at the last five-year interval (2016–2020) showed that the share of land for small-scale forest management increased from 22% to 25% in Guna Begemidir, 31% to 41% in North Mecha, and 41% to 43% in Fagta Lekoma Districts.

Table 3. Average land area in ha allocated to different land uses by households in the three wealth categories.

Land Use	Wealth Category			p Value
Guna Begemidir District (n = 125).				
	Poor	Medium	Rich	
Cropland	0.26 ± 0.19 [a]	0.53 ± 0.28 [b]	0.91 ± 0.32 [c]	0.000
Small-scale forest management	0.07 ± 0.03 [a]	0.13 ± 0.07 [b]	0.48 ± 0.18 [c]	0.000
Grazing land	0.06 ± 0.03 [a]	0.08 ± 0.04 [a]	0.19 ± 0.16 [b]	0.000
North Mecha District (n = 125)				
Land Use	**Wealth Category**			**p Value**
	Poor	Medium	Rich	
Crop land	0.42 ± 0.15 [a]	0.70 ± 0.30 [b]	0.94 ± 0.30 [c]	0.000
Small-scale forest management	0.30 ± 0.18 [a]	0.58 ± 0.21 [b]	0.90 ± 0.28 [c]	0.000
Grazing land	0.25 (na)	0.15 ± 0.10	0.26 ± 0.16	0.538
Fagta Lekoma District (n = 125)				
Land Use	**Wealth Category**			**p Value**
	Poor	Medium	Rich	
Crop land	0.24 ± 0.12 [a]	0.51 ± 0.23 [b]	0.89 ± 0.33 [c]	0.000
Small-scale forest management	0.32 ± 0.22 [a]	0.53 ± 0.24 [b]	1.14 ± 0.55 [c]	0.000
Grazing land	0.19 ± 0.09 [a]	0.31 ± 0.14 [b]	0.50 ± 0.15 [c]	0.000

Different letters along the rows show significantly different areas of land allocated for the different land uses.

Table 4. Proportion of land allocated for different land uses over different times in the study Districts (n = 375).

Land Allocation Type	Guna Begemidir	North Mecha	Fagta Lekoma	p Value
Proportion of land allocated to small-scale forest in 2020	0.25 ± 0.14 [a]	0.41 ± 0.15 [b]	0.43 ± 0.17 [b]	0.000
Proportion of land allocated to crop in 2020	0.65 ± 0.14 [a]	0.51 ± 0.17 [b]	0.39 ± 0.15 [c]	0.000
Proportion of land allocated for crop before 10 years (2010)	0.81 ± 0.16 [a]	0.86 ± 0.17 [a]	0.64 ± 0.26 [b]	0.000
Proportion of land allocated for small-scale forest before 10years (2020)	0.1 8± 0.11 [a]	0.30 ± 0.13 [b]	0.40 ± 0.23 [c]	0.000
Proportion of land allocated for small-scale forest before 5 years (2016)	0.22 ± 0.92 [a]	0.31 ± 0.14 [b]	0.41 ± 0.17 [c]	0.000

Different letters along the rows show significantly different areas of land allocated for the different land uses.

3.3. Motivation of Farmers in Small-Scale Forest Management

The results of qualitative analysis complemented by the household survey revealed that land degradation and decline in crop productivity had a strong influence in motivating farmers of the Fagta Lekoma and Guna Begemidir Districts (Figure 3). In addition, special attributes of tree species are ranked as having strong influence in motivating farmers of Fagta Lekoma. In contrast, these appear not to be a determining factor in the North Mecha District, where the adverse impact of woodlots is ranked as having a strong influence. Furthermore, high demand of wood products and high profitability are ranked as having a strong influence in motivating farmers of Guna Begemidir and North Mecha for small-scale forest management. Low management cost in Fagta Lekoma and the special attributes of tree species in Guna Begemidr Districts were categorized as factors having negligible influence (Figure 3).

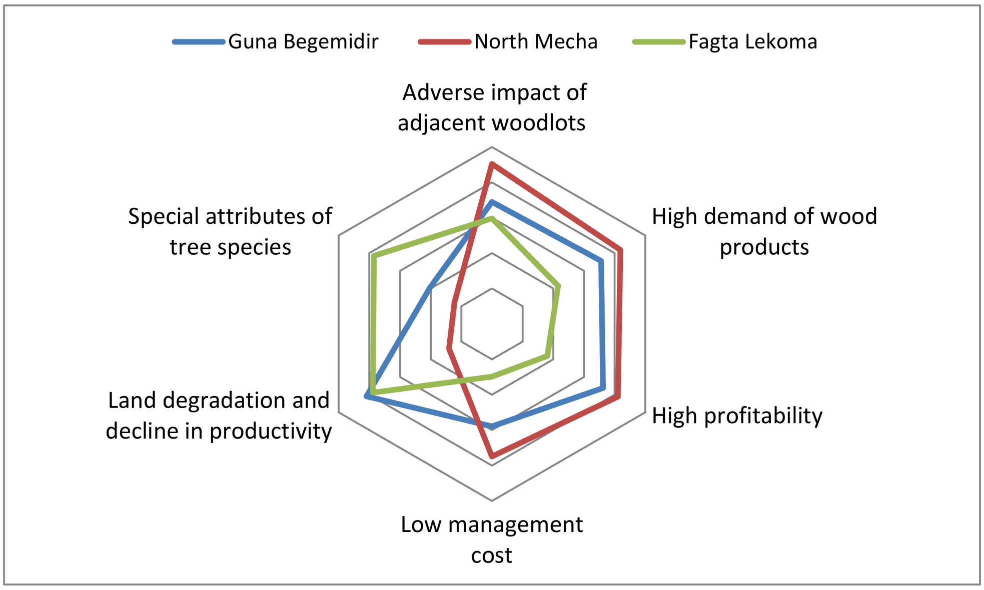

Figure 3. Influence of different motivating factors on small-scale forest expansion across the three study Districts.

3.4. Determinants of Proportions of Land Allocated for Small-Scale Forest Management

Table 5 presents the results of the quasi-maximum likelihood estimation of the Fractional Logit regression model specified for the decision to allocate proportion of land to small-scale forest management by sample households in the three study Districts. The model Chi-square values were significant in all the cases ($p = 0.000$) thereby suggesting that the explanatory variables, considered collectively, do influence the decision of farmers on allocation of proportion of their land to small-scale forest management.

The result of the fractional logit regression model indicated wealth status, total land holding size, distance of woodlot plots to nearby market, soil fertility status of the field, annual crop production risk perception, and perception on comparative socio-economic benefits of woodlots all significantly ($p < 0.01$) influenced the decision of farmers on proportion of land allocation to small-scale forest management in Guna Begemidir District (Table 5). In the case of North Mecha District, the significant predictor variables were distance of woodlot plots to main road ($p < 0.01$), distance of woodlot plots to nearby market ($p < 0.01$), soil fertility status of field ($p < 0.05$), and perception on comparative socio-economic benefits of woodlots ($p < 0.05$) (Table 5). By contrast, gender ($p < 0.1$), wealth status ($p < 0.01$), adult equivalent value of household ($p < 0.01$), distance of woodlot to market ($p < 0.01$), and perception on comparative socio-economic benefits of woodlots ($p < 0.1$) were significant predictor variables in the Fagta Lekoma District. From the significant predictor variables identified in the three study sites, distance of woodlot plots to market and perception on comparative socio-economic benefits of woodlots were common to all the three study Districts; while wealth status was common for Guna Begemidir and FagtaLekoma Districts; and soil fertility status was a significant predictor variable for Guna Begemidir and North Mecha Districts.

Table 5. Fractional regression analysis of proportion of land allocated for small-scale forest against explanatory variables in the three study Districts.

Independent Variable	Guna Begemidir Guna Begemidir (n = 125, Wald chi^2 (15) = 1277.92, Prob > chi^2 = 0.0000)		North Mecha (n = 125, Wald chi^2(15) = 1512.60, Prob > chi^2 = 0.0000)		Fagta Lekoma (n = 125, Wald chi^2 (15) = 676.74, Prob > chi^2 = 0.0000)	
	dy/dx	Std. Err	dy/dx	Std. Err	dy/dx	Std. Err
Gender	0.005	0.021	0.018	0.017	0.048 *	0.027
Age	0.000	0.000	−0.000	0.001	−0.000	0.001
Wealth Medium Rich	0.000	0.014	0.003	0.003	−0.080 ***	0.029
	0.056 ***	0.021	0.002	0.024	−0.063	0.038
Adult equivalent	0.004	0.003	0.005	0.006	−0.019 ***	0.007
Total land size	−0.051 ***	0.012	0.005	0.012	−0.000	0.017
Tropical livestock unit	0.001	0.003	−0.004	0.003	0.001	0.003
Distance of woodlot to main road	−0.005	0.005	−0.060 ***	0.020	−0.015	0.021
Distance of woodlot to market	−0.079 ***	0.010	−0.035 ***	0.007	−0.067 ***	0.023
Soil fertility Medium High	−0.037 ***	0.008	0.025 **	0.012	−0.028	0.022
	−0.014	0.011	0.013	0.024	−0.022	0.036
Annual crop risk perception	0.051 ***	0.015	−0.000	0.016	−0.026	0.030
Woodlot production risk	0.018	0.055	−0.006	0.020	0.002	0.023
Woodlot products market risk	0.055	0.052	0.023	0.018	−0.023	0.017
Perception on comparative socio-economic benefits of woodlots	0.049 ***	0.016	0.044 **	0.017	0.065 *	0.038

Note: Significant variables affecting the decisions on allocation of proportion of land for small-scale forest management: at 0.01 (***), 0.05 (**), and 0.10 (*) levels of significance.

4. Discussion

4.1. Trends in Small-Scale Forest Management

In all three study Districts, high proportions of respondents were engaged in woodlot management during 2009–2020. This indicates that rapid expansion of small-scale forest management has occurred during this period, especially in the last decade and at the expense of cropland. Similar findings of eucalyptus woodlot expansion have been reported in ArsiNegelle District, South Central Ethiopia, over the last four decades [18].

4.2. Land Allocation for Small-Scale Forest Management

With regard to absolute area of land allocation to small-scale forest management, significant variation was observed across the three wealth categories in all the three study Districts. The rich allocated significantly more land size for small-scale forest management. This is in line with finding of other studies [18,20], and is partially explained by the fact that better-off farmers have better capability of financial and other resources and mental readiness to allocate more resources to long-term investment such as small-scale forest management in anticipating long-term profit. On the other hand, poorer households often concentrate on subsistence food production due to lack of resources and confidence to engage in long-term farm investments; instead favoring activities which generate cash income for immediate short-term needs.

The proportion of land allocated for small-scale forest management in the case of Guna Begemidir District is significantly lower than the other two Districts. The likely reason for the lower proportion of land allocated for small-scale forest management in the stated district could be associated with the difference in the level of perception of farmers on the comparative benefits of small-scale forest management. Moreover, the difference in the tree species used and the agro-ecological variation of the Districts could also affect the productivity and return of small-scale forest across the Districts.

The consistent increment in proportion of land allocated for small-scale forest management within the last ten years (2011–2020) in all the three study Districts coupled with the decline in the respective share of annual crop land revealed that the source of land for expansion of small-scale forest management in the area was the land previously used for annual crop. Moreover, in North Mecha and FagtaLekoma Districts, during the latest five years interval (2016–2020), the rate of small-scale forest management expansion was more rapid than the previous five years (2011–2015), indicating the farmers' recent high motivation towards the emerging small-scale forest management activity.

4.3. Farmers' Motivation on Small-Scale Forest Management

Land degradation and decline in crop productivity had a strong influence in motivating farmers of Fagta Lekoma District to expand small-scale forest management. As it was confirmed by KIs in the district, the productivity of agricultural land had declined prior to the adoption of the *A. decurrens* woodlots, and the local communities were not able to satisfy the subsistence food consumption needs. As a result, planting *A. decurrens* on their degraded farmland has significantly improved the soil fertility of their land and the level of fertilizer use has reduced significantly. Therefore, the local communities in the District consider the establishment of *A. decurrens* woodlot as a means of soil fertility management, as well as the potential for high economic return. Similar findings have been reported in other studies [13]. Likewise, farmers in Guna Begemidir District also used steep slopes and degraded lands for small-scale forest management.

In the case of North Mecha District, adverse impact of adjacent woodlots is ranked to have strong influence in motivating farmers, as a push factor, for small-scale forest management. The majority of KIs in the district also pointed out that the negative environmental impact of eucalypt woodlots, especially the shading and root competition effect on adjacent food crop, has forced the local community to convert their land to small-scale forest management. In contrast, some KIs noted that the negative impacts of trees in the woodlots to the adjacent annual food crops could be minimized by special management practices such as digging the land to a small depth and cutting the roots of eucalyptus trees to avoid root entrenchment towards the adjacent crop land.

High demand of wood products is ranked as having strong influence in motivating farmers of Guna Begemidir and North Mecha Districts for small-scale forest management. The KIs noted that the ever-growing market demand for wood products and the associated price was the major pulling factor for switching to small-scale forest management in the District.

4.4. Determinants of Proportions of Land Allocated for Small-Scale Forest Management

The result of the fractional logit regression model indicated that wealth status is significant factor ($p < 0.01$) in influencing the decisions of farmers on the proportion of land allocation to small-scale forest management in Guna Begemidir and Fagta Lekoma Districts. The sign of the coefficient is positive in the case of Guna Begemidir while it is negative in Fagta Lekoma District.

The model showed that, other things being equal, rich farmers are more likely to allocate a larger proportion of land for small-scale forest management than the medium wealth class category in Guna Begemidir District. This result is similar to that reported in other studies [18,20]. The rich are effectively able to allocate a larger share of their land to small-scale forest management because they have more capability in terms of resource endowment, can manage risk associated with crop failure, and are less constrained in terms of food production to meet immediate household requirements [13]. There is a trade-off between food security and long-term investment opportunities [32]. Interestingly, smallholder food secure farmers are more likely to pursue long term investment activities such as small-scale forest management while food insecure farmers are more risk averse. In addition, better-off farmers have more technical and market information and have full readiness in all aspects to allocate more resource to small-scale forest management that requires long pay-off periods. In contrast, poor wealth class farmers in Fagta Lekoma are more likely to allocate a larger proportion of land for small-scale forest management than the medium wealth category farmers do. The possible reason for the contradictory result in this District could be associated with the high level of land degradation and the associated annual crop productivity decline in the district. As it is revealed by KIs in the

District, the poor lack enough financing to use inputs (fertilizer and improved seed) for crop land management; as a result, they use a higher proportion of their land to woodlot management and engage in other off-farm activities.

As expected, distance of woodlot plots to nearby market was negatively correlated ($p < 0.01$) with farmers' decision on allocation to higher proportion of land for small-scale forest management in all three study Districts. The closer the woodlots to the nearest market, the slightly higher the farm gate price. On the other hand, as the distance of woodlot plots to market increases, farmers have to pay additional money to transport their woodlot products, which constitutes an additional cost in the woodlot management. In addition, household managing woodlots which are far from the nearby market will have less bargaining power to sell their woodlots at stand level. Thus, distance of woodlots to nearby market discourages farmers from allocating a larger share of their land to small-scale forest management. This finding is supported by von Thünen'stheory of the isolated state [11], which posits the importance of distance to markets in land use decisions. However, this finding contrasts with other studies [13]. The possible reason for the contradictory report could be the difference in the model used for the studies and the associated difference in predicting power of the models.

Distance of woodlot plots to main road is significantly and negatively correlated ($p < 0.01$) with the decision of farmers on proportion of land allocation to small-scale forest management in North Mecha District. This result is in line with other similar studies [10,19]. As revealed by the KIs in the District, farmers sell their woodlot products both at stand level and after harvesting and processing. In both cases, the return from the woodlot management declines as the woodlot plots are far from the main road due to the additional transportation cost to the nearest and central market. Consequently, farmers are less motivated to allocate a higher share of their land to small-scale forest management when their plots to be used for woodlots are far from the main road.

The model indicated that the soil fertility status of the field is a significant factor in influencing farmers' decision on the proportion of land allocation to small-scale forest management in Guna Begemidir ($p < 0.01$) and North Mecha ($p < 0.05$) Districts. The signs of coefficients are negative in Guna Begemidir and positive in North Mecha District. As it is revealed by the model, those households with a medium fertility status field are more likely to allocate a lower proportion of land to small-scale forest management than those who possess lower fertility status land in Guna Begemidir District. In addition, farmers with better soil fertility status are motivated to allocate the land to annual crops in the district. The possible reason for this result could be that households with less fertile land have more incentive to allocate more land to small-scale forests as the returns from cereals on less-fertile soil land are lower than that of small-scale forests [13]. This finding is also supported by the response of the KIs. In contrast, in North Mecha District, farmers with medium soil fertility land are more likely to allocate a higher proportion of their land to small-scale forest management. The possible explanation for the contradictory result in this District could be associated with the perception of farmers on higher return of converting fertile land to woodlots, a result found in a wide number of other global, regional, and local studies [14,17,19,33]. At a broader scale, this indicates that farmers' perception on the value of their land determines the type of land to be allocated for specific land management activity.

Perception on comparative socio-economic benefits of woodlots had a positive and significant effect on the decision of farmers on proportion of land allocation to small-scale forest management ($p < 0.01$, 0.05 and 0.1 in Guna Begemidir, North Mecha and FagtaLekoma Districts, respectively).The explanation for this result is straightforward [10]: according to the theory of random utility maximization, any decision maker chooses the alternative from which he/she draws the greatest happiness or utility. As supported by the KIs' responses, households who have a positive perception of the comparative socio-economic benefits of woodlots would allocate a higher proportion of their land to small-scale forest management. According to other studies [11], the key concept explaining the allocation of land among competing uses is land rent, i.e., the reward paid for the use of land to its owner.

Gender of the household is significantly correlated ($p < 0.1$) with farmers' decisions on land allocation to small-scale forest management in FagtaLekoma District. The result showed that in the stated District, male households are more likely to allocate a higher proportion of their land to small-scale forest management than females. As was noted by the KIs of the District, female-headed household are less likely to be engaged in woodlot management due to the difficulty in obtaining resources (land, labor, and money) as well as technical and market information on small-scale forest management [13,14,19].

Adult equivalent value of household is significantly and negatively correlated ($p < 0.01$) with farmers' decision on land allocation to small-scale forest management in FagtaLekoma District. The model indicated that households with more adult equivalent value allocate lower proportion of their land to small-scale forest management. This result has been reported in similar studies [18]. The possible explanation for this result could be that households with higher active labor force would be motivated to annual crop production, which requires intensive management so as to cover the household food requirement. On the other hand, those with scarce active labor in the family could go for tree planting which may not require high labor for management. The effect of active labor force size is thus related with the need for extra food and opportunity for agricultural activity that needs high labor. However, this finding is in contrast with the report of other studies [10,15,16,34]. The possible reason for the contrasting results could be associated with the difference in the analysis method (the model and the dependent variable used) and the difference in the farming system and socio-economic setting between the studies.

Total land holding size was significantly and negatively correlated ($p < 0.01$) with the decisions of farmers on land allocation to small-scale forest management in Guna Begemidir District. This finding is in line with other studies [14]. The possible reason for this result could be that farmers in the district have a limit to allocate area for small-scale forest management even if they have a large farm size, possibly due to market risk perception and other associated factors. Thus, the area of land allocated for small-scale forest management may not proportionally increase with land holding size. This was observed by the negative sign of the coefficient land size in the model. This finding, on the other hand, contradicts the findings of other previous studies [10,13,18–20]. However, these studies either did not consider the share of land allocation or used a different data analysis model.

Annual crop production risk perception is positively and significantly correlated ($p < 0.01$) with households' decision on land allocation to small-scale forest management in Guna Begemidir District. In addition to economic criteria, smallholder farmers invariably consider risk in their farming system decision making. Where farmers perceive possible failures in food crops, which arise from environmental variations and natural causes such as outbreaks of disease and drought, they tend to diversify their farming systems by also incorporating tree planting in their livelihood strategy. This is also supported by the theory of the risk-averse peasant, which states that the objective function of a peasant household is to ensure the survival of the household by avoiding risk and switching to less risky or risk-free alternatives [8,11,19].

Although the fundamental decision-making framework established in this study can be applied on a larger scale, careful adaptation to specific local farming systems is required. The data for the study were gathered from a single year cross-sectional survey. Thus, they do not account for any changes in household demographic and/or resource endowments that might have happened over time. Future research can include a time dimension to look into its' impact on farmers' decision making on land allocation to small-scale forest management.

5. Conclusions

The proportion of land allocated for small-scale forest management rapidly increased during 2011–2020 in all three Districts. Coupled with decline in the share of cropland during this period, it indicates that the farmers are motivated by the opportunities to increase small-scale forest management. This expansion has increased during the last few years (2016–2020). This will have an implication on enhancing forest-based ESs and largely contributes to the achievement of sustainable development goals. Variation in tree species used, agro-ecology, and level of perception on the comparative socio-economic benefits largely affected the motivation for the scale of land allocation to small-scale forest management across the three study Districts. The decision making process of smallholders is greatly dynamic and highly dependent on household characteristics, farm characteristics, resource endowment, socio-economic, and institutional factors. The decision strategy of farmers on land allocation can be considered as an important tool for sustainable land use planning.

Amore diversified and demand-driven extension program that considers farm level and household level factors is needed to assist further expansion of small-scale forest management. Government and non-governmental institutions' involvement is highly needed to work on moving forward village level road access to encourage transportation of wood products from small-scale forest management. The extension program should also take the lead in developing and distributing innovative solutions that have multiple (social, economic and environmental) effects. Furthermore, in order to balance ESs from multiple land uses, more research is needed on the ideal degree of area allocation to small-scale forest management, given existing resource constraints and mixed farming systems.

Author Contributions: This article is part of a Ph.D research of the lead author S.M. (Solomon Mulu): Conceptualization, S.M.; methodology, S.M., Z.A., A.A. and D.T.; software, S.M.; validation, S.M., Z.A., A.A. and D.T.; formal analysis, S.M.; investigation, S.M.; resources, S.M.; data curation, S.M.; writing—original draft preparation, S.M.; writing—review and editing, S.M., Z.A., A.A., D.T.; visualization, S.M.; supervision, Z.A., A.A., D.T.; project administration, S.M.; funding acquisition, S.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by UK Research and Innovation (UKRI) through the Global Challenges Research Fund (GCRF) program, Grant Ref: ES/P011306/under the project Social and Environmental Trade-offs in African Agriculture (SENTINEL) led by the International Institute for Environment and Development (IIED) in part implemented by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The lead author would like to extend his gratitude to University of Gondar for the financial support for the PhD research. The lead author also would like to extend his gratitude to RUFORUM for the delivery of continuous short-term trainings on Geographic Information System and Remote Sensing as well as socio-economic data analyses methods. The authors extend their grateful thanks to the local people of the three study Districts for sharing their fruitful ideas and abundant experience. The authors extend their grateful thanks to Adam J.M. Devenish and Robert Asiimwe for editing the draft manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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