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DRIVERS OF SMALL HOLDER FARMERS' DECISION TO ADOPT AGROFORESTRY IN RULINDO DISTRICT, RWANDA

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***Abstract**: The main objective of this study was to investigate the drivers of small holder farmers` decision to adopt agroforestry in Rulindo. This study used data from a survey of 270 smallholder farmers selected using a two stage sampling technique and interviewed using semi- structured questionnaires. Descriptive statistics and a Probit model were applied in data analysis. Probit model analysis showed that size of the land, livestock husbandry and additional labor in household influence adoption of agroforestry, while Gender and farmers occupation had an inverse relationship. Inadequate knowledge and skills on Agroforestry is a limitation for the farmers to plant more trees on their farms. These findings provide useful insight on what factors need to be targeted to stimulate more adoption of Agroforestry on small holder farmers in Rulindo. Strengthening extension services and capacity building of local actors in agroforestry should be targeted. Government should invest in informing and sensitization women`s role and responsibilities in decision making, emphasizing uses and benefits of agroforestry products.*

***Keywords**: Agroforestry, Adoption, Probit model, small holder farmers*

1. Background Information

In Rwanda, a little less than 65% of population depends on agriculture as an economic activity. Land clearing to create room for agriculture is rampant and the rate of deforestation has been very high. The annual rate of deforestation was almost 7% between 2000 and 2005 which was very high compared to the average of annual deforestation rate reported for Africa at 3.9% (FAO, 2006). This led to environmental degradation which comes with associated problems like degradation of soil fertility, climate change, soil erosion, biodiversity depletion and poverty. This negative affect was greatest among poor households who depend on natural resources only as a source of income, energy and building materials.

Leakey (1996) has defined agroforestry as a dynamic, ecologically based natural resource management system that, through the integration of trees in farmland and rangeland, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. In Rwanda agroforestry system may be defined as the presence of scattered trees on farm, planted trees along contour or erosion control ditches, boundaries of farm, or set as rotational woodlots or blocks (Balasubramaniah and Egli, 1986; Den Biggelaar, 1996; Den Biggelaar, C; Gold, MA, 1996). These trees are maintained in combination with crops

in agroforestry systems. These trees provide a number of economic and ecological functions related to the trees in forests (Kleinn, 2000).

Although adoption of trees on agricultural land provides a lot of opportunities as potential source of income, in Rwanda the main motivation for small scale farmers to plant trees on less than 1 ha for 80% of farmlands is largely unknown (NISR, 2010). Farmers' decision to grow trees on their farms depends on many factors including social, economic, household characteristics, behavior and environmental factors. Local situations are important to consider when investigating reason why farmers grow trees in association with crops because they are regional specific and cannot be easily generalized all agricultural households at national scale (Ndayambaje et al, 2012). This paper provides a micro-perspective of effect of household socio-economic characteristics on decision to adopt agroforestry system on farm in Rulindo District, Rwanda.

2. Review of Literature on Agroforestry adoption Technology

2.1.1 Impact of Agroforestry Adoption at Global Scales

The new technologies adoption is not an end method for research in agriculture, policymakers to manage natural resources. Therefore, the outcomes in change of technology should be assessed in terms of their contributions to extensive targets of sustainable development (Knox *et al*., 2002b).

Izac (2003) recognized the need of conservation of soil and water on the tropical working lands and the potential of agroforestry to rehabilitate degraded land.

Knox *et al*., (2002) reported that to convince farmers to adopt new technologies, the appreciation of economic and social dynamic is necessary in order advocate the benefits of adoption. It was again suggested by Izac (2003), that policy measures will be needed to bridge the gap between individual and societal benefits and between individual costs and societal benefits.

2.1.2 Determinants of Agroforestry Adoption

Farmer`s adoption of agroforestry system on small scale is based on different factors and vary from one region to another, one farmer to another (Ndayambaje et al., 2012). From an extensive literature on agriculture and forestry technology, five groups of determinants are categorized to be used for agroforestry adoption: *Preferences*, *Resource endowments*, *Market incentives*, *Bio-physical factors*, *Risk and uncertainty*. Pattanayak *et al*., (2003).

Generally, preferences describe the objectives and motivations of the economic agents when choosing technologies. Resource inheritance enable their technology choices while market incentives and biophysical factors help the timing and the nature of the technology choices. Finally, risk and uncertainty can sabotage the payment of investments to dividends in long run.

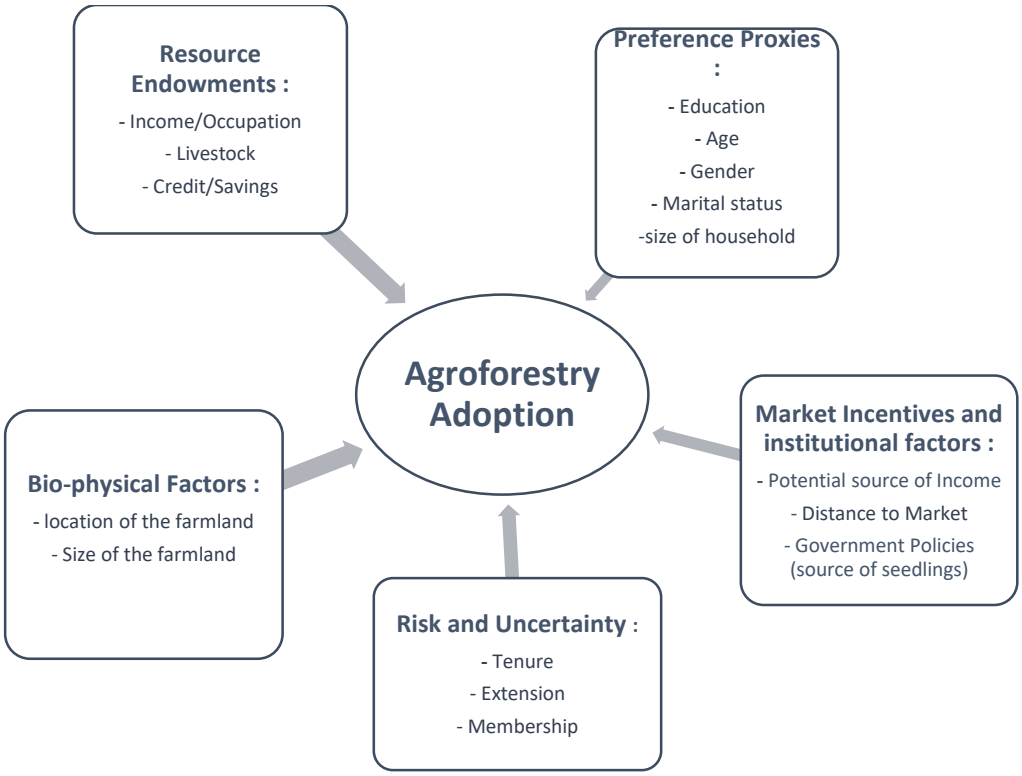

Figure 1: Conceptual framework for examining drivers of agroforestry adoption in Rulindo

Source: Adapted from Pattanayak *et al*., (2003)

3. Methodology

A research design is adopted and this was suitable for the case study providing insights and understanding effect of socio-economic household characteristics on decision to plant trees on farm in Rulindo District. The study used primary data collected from randomly sampled farmers who grow agroforestry trees in Rulindo District. 270 individual farmers were selected from six sectors namely Base, Bushoki, Tumba, Ngoma, Rusiga and Ntarabana. This method was suitable as it guarantees representativeness of the population of interest and is cost-saving (Anderson et al., 2007). Face-to-face interviews were conducted as they enable real-time clarification of questions (Doyle, 2005). This study also reviewed literature to collect secondary data.

3.1 Data Analysis Model

The decision of a farmer to practice agroforestry can be modelled as a choice between two alternatives; whereby a farmer can make the choice of practicing agroforestry or not. The random variable Y is a binary choice that takes the value of 1 = practice agroforestry and 0 = otherwise. Logit and probit models are preferred when there are two outcome choices. The current study used a probit model. The decision of the i^{th} farmer to plant trees or not depends on the unobserved utility index $I_{i.}$ which is determined by explanatory variables. The probit model of the decision to practice agroforestry is derived from a latent variable model, which is specified as:

$$Yi^* = \beta 0 + \beta ij Xij + ei$$

Where Yi* is the underlying index showing the utility difference among those who are practicing agroforestry and those who do not; β0 is the constant, βij is the vector of parameters to be estimated, Xij are the explanatory variables which explains the decisions to practice agroforestry, and ei is the error term.

From the model above, the decision of the household to grow trees is derived as:

$$\mathbf{P(Yi^* = 1|x) = F(\beta 0 + \beta ij Xij)}$$

Where F is the likelihood function of the decision to practice agroforestry and it is restricted between 0 and 1. Therefore a farmer practices agroforestry if $Yi^* > 0$, and otherwise if $Yi^* \leq 0$.

4. Results and Discussions

In this section, both descriptive statistics and econometric model were used to analyze the primary data. Descriptive statistics were used to describe household characteristics and institution services of sample farmers including adopters and non-adopters of agroforestry system. Econometric model was used to identify the effect of socio-economic characteristics on the decision to plant trees on farm in study area.

4.1 Household Characteristics

Table 1 the results on socio-economic and household characteristics

Variable	Descriptive Statistic
Land ownership (% Yes)	96
Practice agroforestry (% Yes)	63
Decision to harvest trees	
Wife (%)	19
Husband (%)	38
Both Wife and Husband (%)	31
Anyone (%)	10
Others (%)	2
Source of seedlings	
On – farm nurseries	22
Bought from private nursery	6
Borrowed from farmers	17
NGO/ research institution	22
Government	33
Access to credit (% Yes)	44
Use of credit	
Purchase agricultural inputs	30
School fees	7
House construction	20
Buying food/ assets	32
Others (business and health insurance)	11
Practice dairy farming (% Yes)	73
Use trees as fodder (% Yes)	55
Gender (% Male)	56
Average distance from farm to market (Kms)	5.0
Average family size	5
Membership in development group (% Yes)	69
Access to extension service (% Yes)	40

Education level	
None (% Yes)	28
Primary level (% Yes)	58
Secondary level (% Yes)	6
University level (% Yes)	3
Vocational training (% Yes)	7

Source: Survey data 2018

Out of the 270 respondents surveyed, 56% were males, 96% of the surveyed farmers owned land obtained through family, purchase, and lease arrangements. Farmers have the right to make choice of land use, this explained the high adoption of Agroforestry in Rulindo and results showed that 63% were practicing agroforestry on their land. This confirm the findings from Kalaba et al., (2010) in southern African, where farmers appreciate agroforestry and its potential linkage to food security and household welfare indicators. However, a major challenge to the uptake of agroforestry is land ownership. Having secure land tenure, could serve as security for investment into longer term improved practices such as planting agroforestry, Otherwise farmers are likely to grow fast growing crops than trees.

The average household size was about 5 persons, which is higher than Rwanda's national mean of 4.2 persons (NISR 2012). The number of members of a household point to the availability of labor, additional working members in the household give more chance for the adoption of agroforestry and this is also confirmed by (Ghadim & Pannel, 1999). Larger household sizes make it easy for farmers to implement labor-intensive adaptation strategies (Nyangena, 2008). On the other hand, size of the household could be a limiting factor for agroforestry adoption because having bigger family size with a limited land size would affect the decision to plant trees on farm as farmers will rather prefer to grow food crops to feed the family.

Source of agroforestry inputs was considered as an important aspect and this study has shown that in Rulindo 33% of seedlings are provided by the government and development partners' support up to 22%. Meaning around 55% of tree seedlings are provided to farmers for free, access to inputs motivate farmers to grow more trees on their land because available inputs reduce investment cost needed to plant trees and explain high adoption of agroforestry system observed in Rulindo. In addition to this 22% of surveyed farmers get seedlings from their own farms, this reduces the expenses made by a household in buying seedlings, thus motivate Rulindo farmers to grow more trees**.**

Other equally important factor identified by respondents as affecting adoption of agroforestry included power in decision making to harvest trees in household. The results showed that in 38% of household surveyed, the decision to harvest the trees is made by the husband only and 19% of the decision is made by wife only. Women`s participation in decision making especially at the early stage of tree establishment and maintenance could affect agroforestry adoption in Rulindo.

Agroforestry trees are an important source of fodder for livestock, this study revealed that 73% of respondents practice dairy farming, this could explain the fact that more than 55% of farmers prefer to plant trees producing fodder to feed their livestock.

Level of education of respondents was also considered and the study revealed that more than half of the respondent's equivalent to 58% had primary level of education. A greater proportion of respondents (28%) are illiterate, this low level of education could affect the adoption of agro-forestry technologies in the district. According to fourth population and housing census, 57% of the national resident population aged three and above, had attended primary school. (NISR 2012).

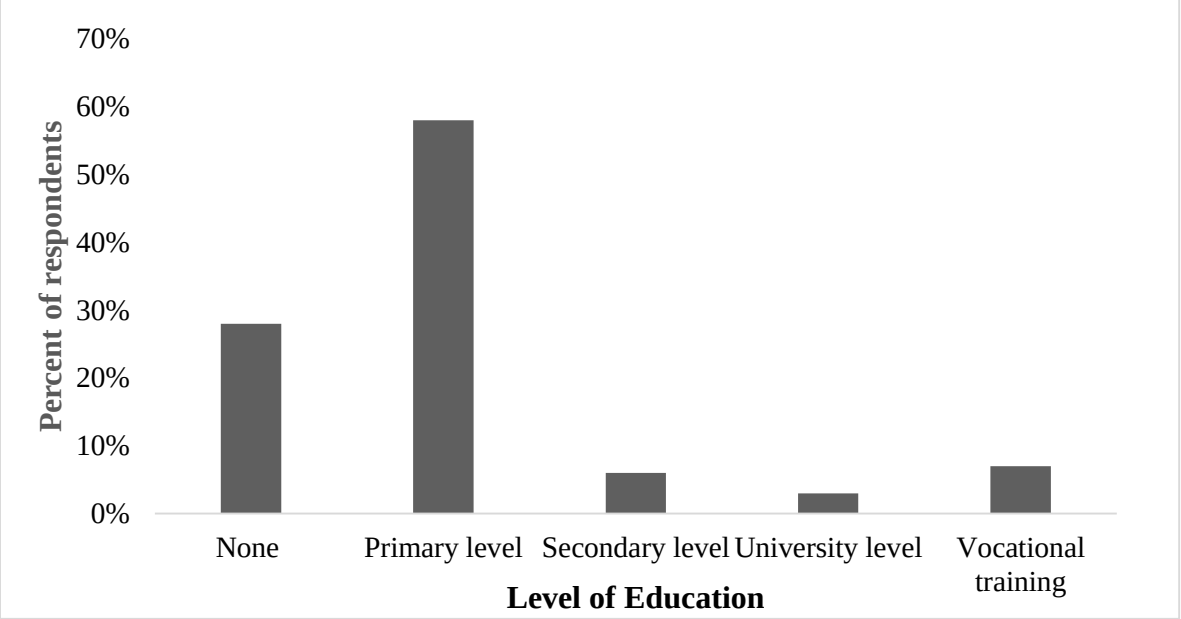

Figure 2: Distribution of farmers in terms of highest level of format education

Source: Survey data 2018

Education level could also influence decision making at household on adopting agroforestry. This confirms findings from Adesina et al., (2000) who found that educated farmer possess a good decision making ability and thus is able to take steps to plant trees on farm for conservation of natural resources and produce goods and service from agroforestry trees. Mekoya et al., (2008) also highlighted that technologies are knowledge intensive and thus necessitate high levels of education.

4.2 The effect of socio-economic characteristics on the decision to plant trees

Table 2: Estimates from a Probit model highlighting the determinants of decision to participate in agroforestry among farmers

Variables	Marginal Effects	P - Value
Average land size*	0.09	0.07
Access to credit	0.03	0.59
Crop production enough for subsistence	0.07	0.23
Practice dairy farming*	0.12	0.06
Gender of respondent ***	-0.13	0.01
Age of respondent	0.00	0.13
Size of the household***	0.05	0.00
Group Membership	0.08	0.19
Access to extension services	0.05	0.41
Occupation (Farmer as base)		
Casual workers	0.05	0.66
Public or private Servant*	-0.24	0.06
Business Man/Woman	0.07	0.61
Distance from farm to the market	-0.04	0.64

Level of education	0.03	0.68
Land tenure	0.04	0.52
Farm Location	0.09	0.13

Notes: ***, **, * significance levels at 1, 5 and 10 percent respectively.

Source: Survey Data (2018).

N=270

Prob > chi^2 = 0.0000

Pseudo R2 = 0.19

Log likelihood = -142.40487

The average land size per household of the respondents is 0.285 ha, the high rate of increase in population in district has led to fragmentation of land and shared by too many people. This study found that the Average land size had a positive and significant effect on the decision to plant trees. A one hectare increase in the size of land increased the probability of the decision to plant trees by 9%. This is because trees require a huge space for growth and maturity so that after planting cash and food crops, there is limited space for planting of trees. A study by Amsalu and Graaff (2007), found similar results, where land size was linearly related to the decision to plant trees or investment in soil conservation measures.

Gender had an inverse relationship to the decision to plant trees in Rulindo district, particularly, being male decreased the probability of the decision to plant trees by 13%. This can be attributed to the fact that men are usually interested in trees for commercial purposes while women are more inclined to tree products for subsistence use such as soil fertility improvement, firewood, stakes for bean, fruits and fodder. This study found that in Rulindo, women are more focused in growing Fruit trees for home consumption and other agroforestry trees are planted on steep land to protect the land against erosion. According (David 1992) found that intra-household decision making processes play a big role on selection of commodity to be grown on the farm.

Dairy farming had a positive and significant effect on farmer`s decision to plant trees of their farms in Rulindo. Close to three quarters (73%) of respondents practiced dairy farming in Rulindo and 55% among them have adopted agroforestry trees which provide fodder for their livestock among other benefits. Being a dairy farmer increased the likelihood of adopting agroforestry system by 12 % in Rulindo. This study confirmed findings from (Wambugu et al., 2011) that farmers use calliandra as a substitute for dairy meal or as a supplement to a basal diet including crop residues, Napier grass and natural grasses in Rwanda, Kenya, Uganda and Tanzania. A study by (Franzel et al., 2014) explained this new approach involving growing mostly exotic tree fodders along the field boundaries, where they do not compete with crops, and along contours to help to limit soil erosion.

This study revealed that being a public or private servant as the main occupation decreased the probability of planting trees on farm by 24%. This could be explained by the fact agroforestry system requires allocation of time for managing the trees including pruning and weeding to avoid competition with other crops, having an alternative source of income apart from farming, reduces the chance to adopt agroforestry system on farm. These findings contradict (Jamala et al., 2013) explaining that di-occupational farmers had acquired capital formation through other revenues of income to support their farming activities and this serves as a security for more investment in agroforestry.

Increasing family size, with land holdings held at the community means, had a strong positive effect on decision to plant trees on farm in Rulindo. Based on simulation results, a potential tension between food security within farm households and adoption of fruit-tree based agroforestry may exist. Fruits as alternative of source of food and income provide an opportunity to maximize agricultural potential and larger family provide additional labor in household to plant and take care of trees planted on farm land.

5. Conclusion

This study provided the empirical evidence on drivers of smallholder farmer`s decision to adopt agroforestry in Rulindo District. Results from the study revealed that some socio-economic factors are positively influencing farmer's decision to plant trees on their farms such as increase of size of the land, livestock husbandry and available of additional labor in household. Gender and farmers occupation had an inverse relationship.

These results of the study provided information on policy makers and other stakeholders on farmer's decision about adoption of agroforestry. The results of this study provided baseline information and will be useful in planning and improving agroforestry programs and strengthening ongoing initiatives in Rulindo District to attain sustainable agriculture, land restoration and protection, increasing rural income and ultimately poverty reduction in the country.

6. Recommendations

Based on the adoption barriers assessed in this study, Policies supporting women organization in cooperatives for agroforestry based activities should be strengthened and Government should invest in informing and sensitization equal responsibilities in decision making, emphasizing uses and benefits of agroforestry products. Proposed policies should be oriented towards promoting agroforestry systems that meet the key goals of food security, poverty reduction, gender equity and sustainable management of natural resources.

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