



Received: 15 April, 2020

Accepted: 06 June, 2020

Published: 08 June, 2020

*Corresponding author: Mukundente Liliane, Rwanda Southern Province, P.O. BOX 05 Nyanza, Rwanda, E-mail: mukundelilly@gmail.com

Keywords: Agroforestry; Socio economic factors; Institutional factor; Binary regression model; Smallholders

<https://www.peertechz.com>



Research Article

Socio-economic and institutional factors affecting smallholders farmers to adopt agroforestry practices in southern province of Rwanda

Mukundente Liliane^{1*}, Ndunda Ezekiel² and G Gathuru²

¹Rwanda Southern Province, P.O. BOX 05 Nyanza, Rwanda

²Environmental science and Education Department, Kenyatta University, P.O. BOX 43844-00100, Nairobi, Kenya

Abstract

This paper is mainly focused on identifying the socio economic and institutional factors influencing agroforestry adoption in Southern Province. Field survey was conducted during July to September, 2019 using structured questionnaire. This study was carried out in four districts in southern province of Rwanda. The number of respondents involved in the study was 650 farmers. A descriptive survey design was used in this study. For the selection of the sample, the study adopted a stratified random sampling technique and simple random technique. Binary logit regression model has been used to determine the factors affecting farmers adopting agroforestry. Finally, Binary regression analysis showed no significant association between the adoption of agroforestry practices and respondent's age, gender, marital status, farming experience or income range of the respondents. On the other hand, there is a positive significant association between the adoption of agroforestry practices and household size is 0.00 p-value as well as the farm size of the respondents. It is expected that farmers with larger household size are more likely to adopt agroforestry practices than farmers with smaller household size and also shows that most of the farmers who were more likely to adopt agroforestry had a bigger land acreage for planting more trees.

Introduction

Agroforestry is one of the most noticeable land-use systems across agro-ecological zones and landscapes in the world. With increased threats of climate change and food shortages and, concern in Agroforestry gathers its ability to meet different adaptation needs on-farm in other to achieve many roles in Agriculture Forestry and Land Use associated mitigation pathways [1]. Income from carbon, wood energy, assets, improved soil fertility; ecosystem services and enhancement of local climate conditions are all provided by agroforestry; in other to reduce human effects on natural forests [2]. Maximum of these effects have immediate local adaptation benefits when leading to global achievement to control concentrations of greenhouse gasses in atmosphere. [3]. Agroforestry has ability to recover soil fertility primarily by increasing soil organic

matter and fixing leguminous trees with biological nitrogen. Farm trees also promote closer nutrient cycling than monocultivation systems and enrich the soil with nutrients and organic matter while enhancing proper soil structural relations [4]. Therefore, trees help to recover nutrients, maintain soil moisture and increase organic soil quality by tapping water and preventing nutrient leaching [5,6]. There are benefits of outstanding agroforestry technologies, such as fast growing fuel wood trees, native fruit trees that provide additional nutrition and revenue, trees that can supply medicinal plant products and trees that improve the soil [7]. The interest of researching agroforestry in a changing climate stems from the benefits of agroforestry to produce farmers' assets, mixed with opportunities to mitigate change of climate and advantage to promote sustainable production that improves quality of the diversity and resilience of agro-ecosystems. [8].



Agroforestry in India adds to the Indian Agricultural Research Council's target of growing forest cover from the current 23% of the land size to 33% [9]. The Greening India Task Force Report on Living Security and Sustainable Development suggests that 18 million hectares of rain-fed land and 10 million hectares of irrigated land should be managed under agroforestry systems [9]. The International Panel on Climate Change (IPCC) Third Assessment Report on Climate Change [10] has recognized the Agroforestry's ability to tackle multiple issues and provide a variety of scientific, environmental and socio-economic benefits. Estimates of the carbon sequestration potential of agroforestry systems range from 0.7–1.6 Gt to 6.3 Gt [11]. Secondary environmental benefits comprise land tenure stability, increased farm income, food availability, biodiversity restoration and maintenance, conservation and maintenance of above and below-ground carbon storage capacity, and watershed hydrology and soil protection [12].

Plantings such as poplars (*Populus*) and eucalyptus (*Eucalyptus*) are well maintained and successful activity in India. On many farm properties in South Asia, quickly growing poplars are now many components of woodlots and shelter belts. Food-producing trees cultivated in systems of agroforestry will increase the economic security and the nutritional of poor people living in tropical countries [13]. Many Sub-Saharan African smallholder farmers practice agroforestry. Such systems influenced despite lasting for long times attempts to introduce annual crop monoculture production, which in Africa was far less successful than elsewhere [14]. Agroforestry has been shown to give farmers a number of advantages. In many cases, for example, it can enhance soil fertility and boost farm household resilience by providing home consumption or additional products for sale [15]. The concept that farm trees provide livelihood advantage is not recent, and many farmers have adopted diversity-based approaches to adapting agriculture to change of climate [16].

In view of persistent food shortages, predicted change of climate and increasing prices of agricultural contributions dependent on fossil fuel, agroforestry has newly experienced a surge in interest from development communities and research as a cost-effective means of improving food safety at the same time contributing to mitigation and adaptation of climate change. Consequently, agroforestry is often absent from guidelines to ensure food safety in the context of climate variability [17], although many activities have been presented to provide advantages for rural development, buffer against climate fluctuations, help farmers to adapt and mitigate climate change [18]. Several studies have shown that agroforestry practices can delay or reverse soil degradation, sequester carbon from secure livelihoods and atmosphere by providing environmental and economic benefits [9,19,20]. Besides that soil fertility, farmers run trees can also provide functions in addition to the products and ecosystem services that inspired farmers to conserve or plant trees [21,22].

Agroforestry systems and forest plantations in Rwanda are the main sources of fuelwood used by many people. Nevertheless, agroforestry can be an efficient strategy for

helping smallholder farmers adapt to change of climate. Agroforestry provides many benefits over other farming systems in assisting farmers to cope with the changes expected. Agroforestry helps to diversify production into a wider range of forestry and agricultural products, thus avoiding the increased climate variability predicted to result from climate change [9,23].

Agroforestry can also increase agricultural output products in wet and dry seasons by increasing soil porosity and using deep-rooted trees during drought periods and increasing soil aeration and evapotranspiration levels during wet season and also reducing runoff [24]. Agroforestry also offers farmers with a means to diversify their farms by building materials, making firewood, fruits, and other tree products. Rwanda does not have enough forest resources to meet the increasing demand for woody bioenergy and timber products [25]. Agroforestry may play a positive role in improving this challenge by giving farmers access to multifunctional trees that can yield not only firewood or coal, but also timber and other wood products [25,26]. Eventually, by increasing water filtration and reducing soil erosion, agroforestry can increase water quantity and quality [9,23].

The main objective of this study was to determine the socio-economic and institutional factors influencing adoption of agroforestry practices in Southern Province of Rwanda.

Materials and methods

Site description

The study was conducted in Southern Province of Rwanda is located at 2°19'60.0"S latitude and 29°40'00.0"E longitude.

The topography of southern province is generally hilly with deep water valley and this contributes to the regular flush flood that damage property and cause loss of life during rainy seasons and also provides soil erosion. The rainfall pattern is bimodal determines seasonality.

The long rain is between March and May, short rain in October up to December. The monthly means of daily temperature maxima range from 28.5 °C to 32°C [27].

Agriculture is the main economic activity in southern province. Consequently the province has given priority to the growing of tea, coffee, wheat, Passion, Irish potatoes, processing of honey and livestock keeping. Some farmers' practices agriculture together with trees and others don't practice such kind of agriculture Figure 1.

Sampling design

The descriptive survey design used in this research to gather information by interviewing or administering a questionnaire to a sample of individuals [28]. This research was carried out in four (4) districts in southern province of Rwanda. This study used both quantitative and qualitative methods to allow the researcher to draw valid and reliable conclusions and recommendations regarding the effect of agroforestry on the livelihood of farmers.

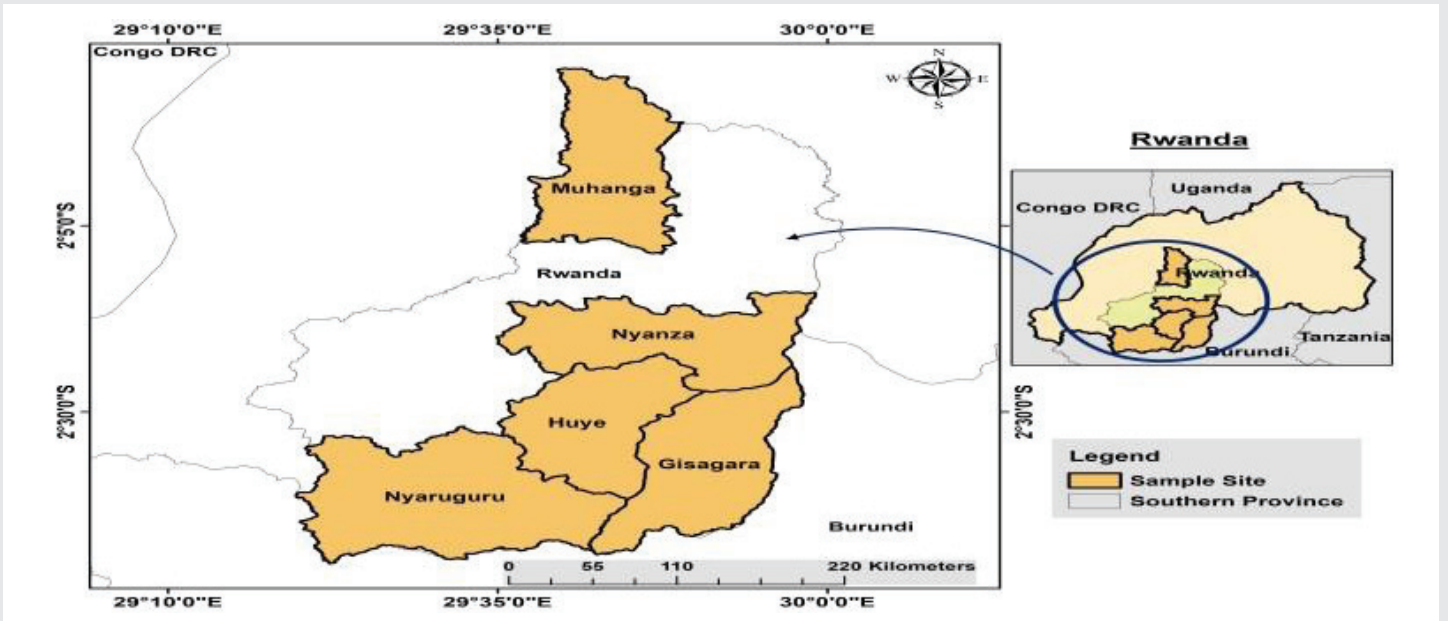


Figure 1: A map of Southern province showing study area location.

Target population

The location of this study was chosen because the southern region is one of the areas in Rwanda with fruitful agroforestry stories to boost food production and increase household income. The destination population for this study comprise farmers which comprise of 6925, 1247 agroforestry adopters household and 4043 household of non-adopters of agroforestry will be the respondents from those districts located in southern provinces of Rwanda as shown in distribution Table 1

Sample size

To determine the sample from this study, simplified formula Yamane (cited in Kasunic 2005) was used to calculate sample sizes. This basic formula assumes a confidence level of 90 per cent and the maximum variance (p = 0.1).

The formula is

$$n = \frac{N}{1 + N \cdot e^2} \tag{1}$$

Where:

n is the sample size.

N is the population size (209)

e is the level of precision (0.1)

$$n = \frac{209}{1 + 209(0.1)^2} = 68$$

Sample size of adopters for Nyanza District (Table 2)

Sampling and data collection procedure

The study employed a stratified random sampling technique. In this technique, the analysis was done on element

Table 1: Distribution table for householder population.

No	District	Adopters household	Non-adopters household
		Population	Population
1	Nyanza	209	1041
2	Muhanga	230	1200
3	Huye	428	672
4	Gisagara	380	1130
	TOTAL	1247	4043

Table 2: Sample size.

No	District	Adopters	Non adopters
1	Nyanza	60	91
2	Muhanga	70	90
3	Huye	81	87
4	Gisagara	79	92
	TOTAL	290	360

with strata, during stratified sampling, a random sample was used for each strata. Therefore, random sampling was taken to select 290 samples of adopters and 360 of non-adopters in four districts of southern province. Purposive sampling was employed to identify the key informants from the relevant agriculture office for each district.

In data collection the researcher used interview and questionnaires. The study used questionnaires which were self-administered as principal research instrument. This study also utilized interview schedule as instrument to collect data from some respondents.

In collecting data, the researcher adopted primary and secondary data and the type of data expected to collect both qualitative and quantitative data. Primary data was obtained from the farmers and agricultures offices in each district through the questionnaire with structured questions and interview schedule with face to face and open ended interview.



Secondary data was obtained from the relevant authorities that deal with agriculture in each district and also other data were gathered from books, journals and the previous farmers' livelihood record from agricultures office of each district.

Data analysis

In this study binary logit regression model has been used to determine the factors affecting farmers adopting agroforestry. Binary logistic regression model is statistical technique used to calculate the relationship between dependent variable and independent variables which accommodates two variables (binary).

The binary logit regression estimates the possibility that a feature is present, or otherwise given the values of extraneous variables. If probability of adopting agroforestry practices is given by Y, then that for not adopting is given by 1-Y. The

ratio referred to as the odds ratio can be expressed as $\frac{y}{1-y}$. Taking the natural logarithm of the odds ratio gives the log of odds ratio, which can be estimated by the logit method. In the logit model, the log of the odd ratio is a linear function of the explanatory variables:

$$\log \frac{y}{1-y} = \alpha + \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n \tag{2}$$

Where, β = coefficients to be estimated, X =explanatory variables, α = error term.

Following from the above, a farmer's choice to adopt agroforestry practices is given as a function of socio-demographic factors, agro-based characteristics and stated preferences for on-farm trees.

Decision to adopt agroforestry practices (Y) (Yes=1); (No =0). The adoption decision (dependent function) within the model framework is represented as follows:

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n \tag{3}$$

Where Y_i lies between 0 and 1 which is the predicted likelihood of adopting agroforestry practices adopting agroforestry practices is given as $\beta_1, \beta_2, \dots, \beta_n$ for a unit increase in the independent variables and X (1, 2, ..., n) are the independent socio-economic variables and β is the constant (error term) in the estimated model equation as indicated in equation1.

The final model of the decision to adopt agroforestry can therefore be estimated by equation below:

$$Y_i = \beta + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} \tag{4}$$

Y_i – the dependent variable (decision to adopt agroforestry practices)

X_1 – gender of respondents

X_2 – total annually income

X_3 – education

X_4 – respondents 'age

X_5 – household size

X_6 – farm size

X_7 – farming experience

X_8 –Access to credit service

X_9 – Access to market

X_{10} – Access to extension services

Results and discussions

Demographic characteristics of the respondents

This section presents an overview of the socio-economic characteristics of the sample of farmers participating in the survey as well as the variables used in the analysis and how they are defined (Table 3). The demographic features provide the information about respondents' age, household size, farm size, farming experience as continuous data and employment, agroforestry practices, marital status, gender, education level as categorical data.

The results in Table 3 indicated that the Mean age of respondents was 45.88 years, the maximum age of the farmers was 70 years and minimum age of the farmers was 23years old. This indicated that the respondents were adult and enthusiastic, and were able to participate actively in agricultural activities. In addition, the younger age groups in the Rwandan community were students attending secondary and tertiary institutions. Table 3 also indicated that the Mean household size of the respondents was 5.44 house members with minimum of 1 person in the house and maximum of 11 people in the house. The result shows that the Mean farming experience of respondents in this survey was 21.45 years with minimum of 1 year and maximum of 39 years' experience in farming.

The results demonstrated that Mean of farm size of the respondents was 22.67 acres with the minimum of 5 acres and maximum of 44 acres farming activities. The annual farm income from farming activities had mean of 127003.1Rwfs the minimum income was 50000Rwfs and maximum income was 750000Rwfs per year. The consumption expenditure of the farmers was 50000Rwfs as minimum money and maximum

Table 3: Descriptive statistics for continuous socioeconomic characteristics.

Variables	Mean	Std. Dev.	Min	Max
Age	45.88	10.56	23	70
Household size	5.44	2.66	1	11
Farming experience	21.45	9.27	1	39
Farm size	22.67	10.68	5	44
Annual farm income	127003.1	48538.2	50000	750000
Consumption expenditure	115003.1	47438.2	50000	750000
Farm under agroforestry	12.01	6.37	1	20



of 750000Rwfs with the Mean consumption expenditure of 115003.1Rwfs. The results indicated that the mean of farm size under agroforestry was 12.01 acres with the minimum of 1 acre and maximum of 20 acres farming trees and crops on the same land unit.

Table 4 indicates that out of the 100% respondents, 47.38% were males while 52.62% were females. This result indicated that the female farmers dominated relatively in the study.

Result for marital statuses shows that approximately 90.62% of the respondents were married and 9.38 were single. This shows that the majority of smallholder farmers were married in this study. This means that married people dominate agricultural production in which they employ family members as labor force.

The results of this survey demonstrated that 75.08 % were not employed and 24.92% were employed. This result shows that most smallholders' farmers do not have another occupation apart from farming activities.

In this study 44.62% of farmers practices agroforestry while 55.38% of the farmers do not practice agroforestry. This indicated that the non-adopters 'farmers dominated this study. The result illustrated that 54% of respondents in the survey had primary education, 27.08% had secondary education and 18.92% of respondents had no formal education. This result indicated that most smallholders' farmers have had primary education. This means that farmers without education need some form of informal education to improve their skills and ability to adopt new technologies, which will have a significant impact on their livelihood.

Socio-economic and institutional factors that influences the farmers to adopt agroforestry

Table 5 shows the estimated m The marginal effects for binary variables measure odel which provides the coefficient, the T-test and P-value of 95 percent confidence interval. Tenth logit models based on socio-demographic features and institutional factors have been estimated to predict the probability of adopting agroforestry practices. Overall, two of the tenth independent variables included in the model had significant effects at 95 % confidence interval in explaining the decision to adopt agroforestry practices. The results of the estimated model

Table 4: Descriptive statistics for categorical socioeconomic characteristics.

Variables	Attribute	Percentage
Gender	Male	47.38
	Female	52.62
Marital status	Single	9.38
	Married	90.62
Employed	Yes	24.92
	No	75.08
Agroforestry Adaptation	Adopters	44.62
	Non-adopters	55.38
Level of Education	No education	18.92
	Primary	54
	Secondary	27.08

Table 5: Logistic regression of the dependent variable on the independent variables.

Adoption of Agroforestry	Coefficient	SE	T-test	P-Value
Demographic characteristics				
Gender	1.50	0.48	1.24	0.21
Age (years)	1.01	0.03	0.15	0.88
Educational level	0.37	0.09	1.72	0.09
Household Size (persons)	1.40	0.41	5.05	0.00**
Farm Size (acres)	1.10	0.02	5.41	0.00**
Farming Experience (years)	1.01	0.04	0.16	0.87
Annual farmer income	1.00	0.00	1.57	0.12
Institutional factors				
Access to extension services	2.06	0.87	1.72	0.08
Access to credit	1.19	0.49	0.43	0.67
Access to Market	0.48	0.20	-1.73	0.08
Constant	0.00	0.00	-4.33	0.00**

showed the Pseudo r² as 0.3042. This indicates an improvement or 30.42 percentage change in the log likelihood between the null model and the full estimated model. The estimated log likelihood ratio was -134.51 and the chi-square test which indicates the difference in the degrees of freedom is given as 0.000, suggesting that our model as a whole fit significantly better than an empty model.

Marginal effect for the binary variables

Marginal effects inform us how a dependent variable (outcome) changes if a specific independent variable changes. The marginal effects for binary variables measure discrete change (Table 6).

Socio-economic characteristics and agroforestry adoption

Gender had a negative sign of predicting the adoption of agroforestry practices. Controlling for all other variables, women are more likely to adopt agroforestry practices by a factor of 1.500 than men. This effect is not statistically significant. With a unit increase in a farmers' age, the coefficient of adopting agroforestry is decreased by a factor of 1.005 controlling for all other variables. Less educated farmers were 63.2 % less likely to adopt agroforestry compared to farmers with formal education holding all other variables constant.

Several authors have had similar findings. For example, Mathews, et al. [28,29], in their study of agroforestry adoption in Wellington County, Ontario reported no correlation of age and gender with the adoption of agroforestry. Place, et al. [29,30], also showed no influence of education on adoption of agroforestry practices in Kenya.

Annual farmer income, education level, farming experience and age of farmers negatively affected the adoption of agroforestry practices at 5% level of significance. For a unit increase in annual farmer income, the coefficient of adopting agroforestry practices decreased by a factor of 1.00 controlling for all other variables.

**Table 6:** Marginal effect of the dependent variable on independent variables.

Adoption of Agroforestry	dy/dx	SE	T-test	P-Value
Demographic characteristics				
Gender	.03	.48	0.58	0.21
Age (years)	.02	.05	1.93	0.88
Educational level	.07	.06	1.12	0.09
Household Size (persons)	.07	.01	6.15	0.00
Farm Size (acres)	.02	.002	9.26	0.00
Farming Experience (years)	.01	.01	-2.15	0.03
Annual farmer income	1.02	.03	1.57	0.12
Institutional factors				
Access to extension services	.17	.06	2.84	0.005
Access to credit	.02	.07	0.35	0.73
Employment	-.07	.09	-0.85	0.40

Years of farming experience indicated a somewhat positive influence on farmers' adoption decision but this was not statistically significant. With an increase in years of farming experience, the odds of adoption increased by a factor of 1.006, controlling for all other variables.

Farm size and household size and of farmers positively influenced the adoption of agroforestry practices at 95% confidence interval.

Household labor measured by total household size positively influenced adoption of agroforestry at a statistically significant P-value of 0.000. For a unit increase in total household size, the coefficient of adopting agroforestry practices is increased by a factor of 1.400 controlling for all other variables. This is in agreement with Ayuya, et al. [31], who concurs with the findings of this study by indicating that household size is significantly related to adoption of agroforestry technology. Large household size positively influences adoption of labor-demanding agricultural technologies since they have the ability to relax the labor limitations necessary in the course of introduction of new technologies. It is expected that farmers with larger household size are further likely to adopt agroforestry practices than farmers with smaller household size.

An increase in farm size positively influenced adoption of agroforestry at a statistically significant P-value of 0.000. This shows that most of the farmers who were more likely to adopt agroforestry had a bigger acreage of land for planting more trees. From the findings, respondents' farm size is related to adoption rate of agroforestry; those with larger farm sizes are more likely to adopt agroforestry than those with small farm size. This is in agreement with several studies such as the study by Orisakwe and Agomuo [32], who examined the socioeconomic factors of respondents practicing agroforestry and revealed that, farm size of the respondents had a positive relationship to levels of agroforestry adoption. He reported that an increase in respondents' farm size leads to an increase in adoption of agroforestry. A similar study by Kabwe, et al. [33], reported a significant association between adoption of agroforestry and farm size. According to Geremew [34], an increase of farm size by one hectare, increases the possibility of adopting agroforestry.

Institutional factors and agroforestry adoption

Access to credit, access to market and access to extension services of farmers negatively influenced the adoption of agroforestry practices at 5% level of significance. For a unit increase in access to credit, the coefficient of adopting agroforestry practices decreased by a factor of 1.190 controlling for all other variables.

Access to market indicated a somewhat positive influence on farmers' adoption decision but this was not statistically significant. By increasing access to market, the coefficient of adoption increased by a factor of 0.482, controlling for all other variables.

For farmers with access to extension service, the coefficient of adoption increased by a factor of 2.059 compared to those with no access to extension service. Results from this study showed access to extension service on tree planting positively associated with adoption of agroforestry but its effect in predicting the decision to adopt agroforestry is statistically not significant.

Conclusion and recommendation

The study sought to determine the socio-economic factors influencing smallholder farmers' decision to adopt agroforestry practices in Southern province of Rwanda. Socioeconomic factors and farmers value for trees expressed by their enthusiasm to plant trees on farms influenced the decision to adopt agroforestry. The key factors which had statistically significant influence on farmers' decision to adopt agroforestry practices were total household size and total farm size. The study also concluded that the size of farm had an influence on their decision to plant/not to plant trees. It further concluded that household size affect tree planting options among most smallholder farmers in many ways that include enough sources of labor and management.

The relevant government agencies should be encouraged the farmers in the areas to practice agroforestry so that they can benefit from crop yield of the crops and additional income from the sales of the tree products.

Acknowledgements

European Union under Intra-African Academic Mobility through academy project financed this study. Thanks to the staffs of all districts and Southern province of Rwanda for their assistance with data collection and also we thank smallholders farmers who agreed to spend their time to answer to the questionnaires.

References

1. World Agroforestry Center (2010) Annual report 2009–2010: Going evergreen for a Climate-SMART Agriculture. [Link: https://bit.ly/3f21IMm](https://bit.ly/3f21IMm)
2. Neumann PD, Krogman NT, Krahn HJ, Thomas BR (2007) My grandfather would roll over in his grave: family farming and tree plantations on farmland. *Rural Sociol* 72: 111-135. [Link: https://bit.ly/2ziklXX](https://bit.ly/2ziklXX)



3. Mbow C, Smith P, Skole D, Duguma L, Bustamante M (2014) Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability* 6: 8–14. [Link: https://bit.ly/2XF19Z6](https://bit.ly/2XF19Z6)
4. Lehmann J, Peter I, Steglich C, Gebauer G, Huwe B, et al. (1998) Below-ground interactions in dryland agroforestry. *Forest Ecology and Management* 111: 157-169. [Link: https://bit.ly/2BKVX7p](https://bit.ly/2BKVX7p)
5. Pouliot M, Bayala J, Ræbild A (2012) Testing the shade tolerance of selected crops under *Parkia biglobosa* (Jacq.) Benth. in an agroforestry parkland in Burkina Faso, West Africa. *Agroforestry Systems* 85: 477–488. [Link: https://bit.ly/3f5P1QF](https://bit.ly/3f5P1QF)
6. Duguma LA, Hager H (2011) Farmers' Assessment of the Social and Ecological Values of Land Uses in Central Highland Ethiopia. *Environ Manage* 47: 969–982. [Link: https://bit.ly/37c0fAi](https://bit.ly/37c0fAi)
7. Molua EL (2005) The economics of tropical agroforestry systems: the case of agroforestry farms in Cameroon. *Forest Policy and Economics* 7: 199–211. [Link: https://bit.ly/3f5OWfP](https://bit.ly/3f5OWfP)
8. Chedzoy BJ, Smallidge PJ (2011b) Silvopasturing in the Northeast an introduction to opportunities and strategies for integrating livestock in private woodlands. Cornell Cooperative Extension New York. [Link: https://bit.ly/3cJUZVw](https://bit.ly/3cJUZVw)
9. Jose S (2009) Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems* 76: 1-10. [Link: https://bit.ly/2UmFoF7](https://bit.ly/2UmFoF7)
10. McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (2001) *Climate change Impacts, adaptation and vulnerability*. Cambridge, UK: Cambridge University Press 967.
11. Brown S, Sathaye J, Cannell M, Kauppi P (1996) Management of forests for mitigation of greenhouse gas emissions. In *Climate Change: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*. Cambridge, UK and New York, USA: Cambridge University Press; RT Watson, MC Zinyowera, & RH Moss Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. [Link: https://bit.ly/2MAjELs](https://bit.ly/2MAjELs)
12. Van Ardenne-van der Hoeven A, Benn H, Malloch Brown M, Chino T, et al. (2003) *Poverty and climate change: Reducing the vulnerability of the poor through Adaptation*. Paris: Organisation for Economic Co-operation and Development. [Link: https://bit.ly/3cGKRqj](https://bit.ly/3cGKRqj)
13. World Bank (2006) *Unlocking opportunities for forest-dependent people in India*. New Delhi, India: The World Bank Agriculture and Rural Development Sector Unit, South.
14. Djurfeldt G, Hiolmen H, Jirstrom M, Larsson R (2005) *The African Food Crisis*. CABI Publishing. [Link: https://bit.ly/2YqvdrP](https://bit.ly/2YqvdrP)
15. Thangataa PH, Hildebrand PE (2012) Carbon stock and sequestration potential of agroforestry systems in smallholder agroecosystems of sub-Saharan Africa: mechanisms for 'reducing emissions from deforestation and forest degradation' (REDD+). *Agric Ecosyst Environ* 158: 172-183. [Link: https://bit.ly/2XFUVSw](https://bit.ly/2XFUVSw)
16. Nguyen Q, Hoang MH, O'born I, Noordwijk MV (2013) Multipurpose agroforestry as a climate change resiliency option for farmers: an example of local adaptation in Vietnam. *Climatic Change* 117: 241-257. [Link: https://bit.ly/3dJvFAn](https://bit.ly/3dJvFAn)
17. Beddington JR, Asaduzzaman M, Clark ME, Bremauntz AF, Guillou MD, et al. (2012) What next for agriculture after Durban? *Science* 335: 289- 290. [Link: https://bit.ly/2XGtMyk](https://bit.ly/2XGtMyk)
18. Thorlakson T, Neufeldt H (2012) Reducing subsistence farmers' vulnerability to climate change: evaluating the potential contributions of agroforestry in western Kenya. *Agricultural Food Security* 1: 1-13. [Link: https://bit.ly/2MBC4qj](https://bit.ly/2MBC4qj)
19. Garrity D, Akinnifesi F, Ajayi O, Weldesemayat S, Mowo J, et al. (2010) Evergreen agriculture: a robust approach to sustainable food security in Africa. *Food Sec* 2: 197–214. [Link: https://bit.ly/2YeurG0](https://bit.ly/2YeurG0)
20. Roose E, Ndayizigye F (1997) Agroforestry, water and soil fertility management to fight erosion in Tropical mountains of Rwanda. *Soil Technol* 11: 109–119. [Link: https://bit.ly/3f1Z3IL](https://bit.ly/3f1Z3IL)
21. Skole DJ, Samek JH, Chomentowski W, Smalligan M (2013) Forests, carbon, and the global environment: new directions in research. In *Land Use and the Carbon Cycle Advances in Integrated Science, Management, and Policy*. Edited by Brown DG, Robinson DT, French NHF, Reed BC. USA: Cambridge University Press 505-522.
22. Torquebiau EF (2009) A renewed perspective on agroforestry concepts and classification. *Comptes Rendus Academie des Sciences Paris, Sciences de la vie/Life Sciences* 323: 1009- 1017.
23. Stainback GA, Masozera M (2010) Payment for ecosystem services and poverty reduction in Rwanda. *J Sustain Dev Africa* 12: 122–139. [Link: https://bit.ly/2AQhnPO](https://bit.ly/2AQhnPO)
24. Verchot LV, Van Noordwijk M, Kandji S, Tomich T, Ong C, et al. (2007) Climate change: linking adaptation and mitigation through agroforestry. Mitigation and adaptation strategies for global change 12: 901-918. [Link: https://bit.ly/30nEhZF](https://bit.ly/30nEhZF)
25. Rutunga V, Janssen BH, Mantel S, Janssens M (2007) Soil use and management strategy for raising food and cash output in Rwanda. *J Food Agric Environ* 5: 434–441. [Link: https://bit.ly/37lIf6N](https://bit.ly/37lIf6N)
26. Ndayambaje JD, Mohren GMJ (2011) Fuelwood demand and supply in Rwanda and the role of agroforestry. *Agroforestry Systems* 83: 303–320. [Link: https://bit.ly/2XEQCH4](https://bit.ly/2XEQCH4)
27. Orodho AJ (2003) *Essentials of Educational and Social Science Research Method*. Nairobi: Masola Publishers. [Link: https://bit.ly/2APQzic](https://bit.ly/2APQzic)
28. Mathews S, Pease SM, Gordon AM, Williams PA (1993) Landowner perceptions and the adoption of agroforestry practices in Southern Ontario, Canada. *Journal Agroforestry systems* 21: 159-168. [Link: https://bit.ly/2MAHQ6R](https://bit.ly/2MAHQ6R)
29. Place F, Franzel S, Oordin Q, Jama B (2003) Improved fallows in Kenya: history, farmer practice and impacts. Conference Paper No. 13 presented at the In: WENT, IFPRI, NEPAD, CTA conference "Successes in African Agriculture" Pretoria, 1-3.
30. Ayuya OI, Waluse SK, Gido OE (2012) Multinomial Logit Analysis of Small-Scale Farmers' Choice of Organic Soil Management Practices in Bungoma County, Kenya. *Current Research Journal of Social Sciences* 4: 314-322. [Link: https://bit.ly/3h7Y9px](https://bit.ly/3h7Y9px)
31. Orisakwe L, Agomuo F O (2011) Adoption of Improved Agroforestry Technologies among Contact Farmers in Imo State, Nigeria" *Asian Journal of Agriculture and Rural Development* 2: 1-9. [Link: https://bit.ly/30lInTj](https://bit.ly/30lInTj)
32. Kabwe G, Bigsby H, Cullen R (2009) Factors influencing adoption of agroforestry among smallholder farmers in Zambia. Paper presented at the 2009 NZARES Conference Tahuna Conference Centre – Nelson, New Zealand. [Link: https://bit.ly/2XLzgsn](https://bit.ly/2XLzgsn)
33. Geremew WK (2016) Agroforestry and land productivity: Evidence from rural Ethiopia. *Kassie, Cogent Food & Agriculture* 2: 1259140. [Link: https://bit.ly/2XLs53d](https://bit.ly/2XLs53d)
34. Ministry of Agriculture and Animal Resources (2009) Strategic plan for the transformation of agriculture in Rwanda—Phase II (PSTA II): Final report. Ministry of Agriculture and Animal Resources, Republic of Rwanda. [Link: https://bit.ly/30AHAWX](https://bit.ly/30AHAWX)

Copyright: © 2020 Liliane M, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.