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Original Article

AGROFORESTRY TECHNOLOGIES ADOPTED BY SMALLHOLDER FARMERS IN SOUTHERN PROVINCE OF RWANDA

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ABSTRACT

Agroforestry is an agricultural system that deliberately integrates trees, crops and animals on the same land and under the same management. Agroforestry practices have the ability to counter the increasing food insecurity and offers several outputs (e.g. enhanced crop production, money and job opportunities) to smallholder farmers hence the improvement of rural living standards. This paper focuses on the agroforestry practices adopted by smallholder farmers, challenge faced and the benefits derived from the agroforestry practices. This study was carried out in four districts in the Southern Province of Rwanda. A descriptive survey design was used in this study. The study adopted a stratified random sampling technique for questionnaire distribution. Descriptive methods of analysis were used to identify the different agroforestry technologies adopted by smallholder farmers in Rwanda. This study illustrated the different agroforestry practices adopted by farmers. The results revealed that most farmers in the Southern Province adopted boundary planting agroforestry followed by homegardens, alley cropping and scattered trees on farm. Most adopters (68%) of agroforestry planted trees around their farms. The farmers maintained that these trees are retained to provide various uses (e.g. fuel wood, staking material, constructional materials, grazing, climate regulation, soil erosion, control of wed and pest, reduction of crop failure, improving soil fertility, nutrient recycling and nitrogen fixation). Input and productivity were the common challenges faced by the farmers who adopted agroforestry practices. Most of the respondents were able to access the necessary information on the importance of agroforestry, attained knowledge for planting trees (especially in spacing and management skills) and knowledge about various species of trees and management skills. The government of Rwanda and other stakeholders should promote tree farming in the area so as to prevent deforestation and land degradation in search of firewood and timber from the community and government forests.

INTRODUCTION

Agroforestry has become a maintainable land management practice observing into land degradation and deterioration of soil abundance (Buttoud, 2010). There are three primary agroforestry practices based on the agroforestry components including: agrosilvicultural (crops and trees, home gardens, etc.); silvopastoral (trees and livestock as in pastures) and agrosilvopastoral (crops, trees and livestock as in zero grazing). Agroforestry systems can be carried out in different farm sizes ranging from small plots to large tracts of lands. On small plots, cereal crops are often combined with nitrogen fixing trees to enrich the soil. On large tracts of land, trees may be planted in woodlots, boundaries, and landscape scale trees and other vegetation can be cultivated (Sileshi and Mafongoya, 2006). Properly managed agroforestry plots have demonstrated that trees add value that surpass any loss in crop production process. Nevertheless, these results are not assured, therefore, consideration on the type of agro-forestry system used and species selected is key (UNEP, 2015). Agroforestry gives resources and wages from carbon, wood vitality, progressed soil richness and improvement of climate conditions; it gives environment services and diminishes human impacts on common woodlands. Agroforestry can be the most successful way to diminish deforestation in Rwanda hence could bring solutions to meet both environment and development objectives (Rahman, 2012).

Agroforestry has been identified as an important solution to counter the needs of the society as well as sustainable development models due to its benefits not only to the society, economy and to the ecosystem (Bargali *et al*., 2009; Vien, Quang, & Thanh, 2005). Farmers ought to take the advantages of agroforestry technologies that provide solutions to problems such as soil efficiency, product alteration, and economic problems (Franzel and Scherr, 2002). Most of these benefits correspond to other benefits from related adaptation but collectively contribute to worldwide endeavors to control greenhouse gas concentrations in the atmosphere (Mbow *et al*., 2014). This can be basically based on the increment of soil natural matter and organic nitrogen fixation by leguminous plants through tapping water and anticipation of nutrient filtering (Pouliot *et al.*, 2012). Trees offer assistance to recover nutrient, preserve soil humidity (Duguma and Hager, 2011).

There are a number of effective agroforestry innovations such as but not limited to quick establishments of trees for fuel wood, distinctive natural product, trees to supply food and income, and trees that can provide plant restoration (Molua, 2005). The interest of examining agroforestry in a changing climate comes from the potential of agroforestry practices to create resources for smallholder's farmers and potential to empower them to improve agroecosystem in different qualities and adaptability. Subsequently, agroforestry is regularly missing from discussions and efforts for assuring food security under climate variation (Beddington *et al.*, 2012). Numerous agroforestry practices have been noted to provide benefits for farmers development, buffer against climate changeability, offer assistance for farmers adjust to climate change and contribute to climate change moderation (Thorlakson *et al.*, 2012; Hoang *et al*., 2011). Many studies have revealed that agroforestry can moderate or invert land deterioration, sequester carbon and secure livings through the arrangement of environmental and financial benefits (Adedire, 2004; Adekunle, 2005; Owolabi, 2010; Oke, 2008). Besides the improvement of soil richness, trees grown by farmers can also give environment facilities and capacities as well as associated product and services incentivizes farmers to plant or protect them (Skole *et al.*, 2013; Buttoud, 2013).

In Rwanda, agroforestry schemes are plasticized by smallholder farmers to attain different targets such as to create wood items and services. Within the country, agroforestry has been in practice for a long time and it offers alternatives for expanding rural efficiency by nutrient reusing, decreasing soil degradation, progressing soil richness and creating wood and non-wood items from trees and woodlots on ranches (ISAR and ICRAF, 2001; Ndayambaje et al., 2011). Currently, Rwandan agroforestry backgrounds are dominated by a wide array of shrubs species and exotic trees that are appropriate for distinctive land use management and are profoundly acknowledged by Rwandese farmers for their benefits (Mukuralinda *et al*., 2016). The planting of chosen tree species in spatial and

worldly combination with rural crops can be practiced to fulfill profitable capacities of the tree species. Therefore, agroforestry in Rwanda is devoted in meeting the criteria of the tree-based ecosystem approaches (TBEAs) serving landscape multi-objectives (Iiyama *et al.*, 2018). In Rwanda, woodland farms and agroforestry are the most sources of fuel wood hence agroforestry systems are incredible sources of energy to many smallholder farmers.

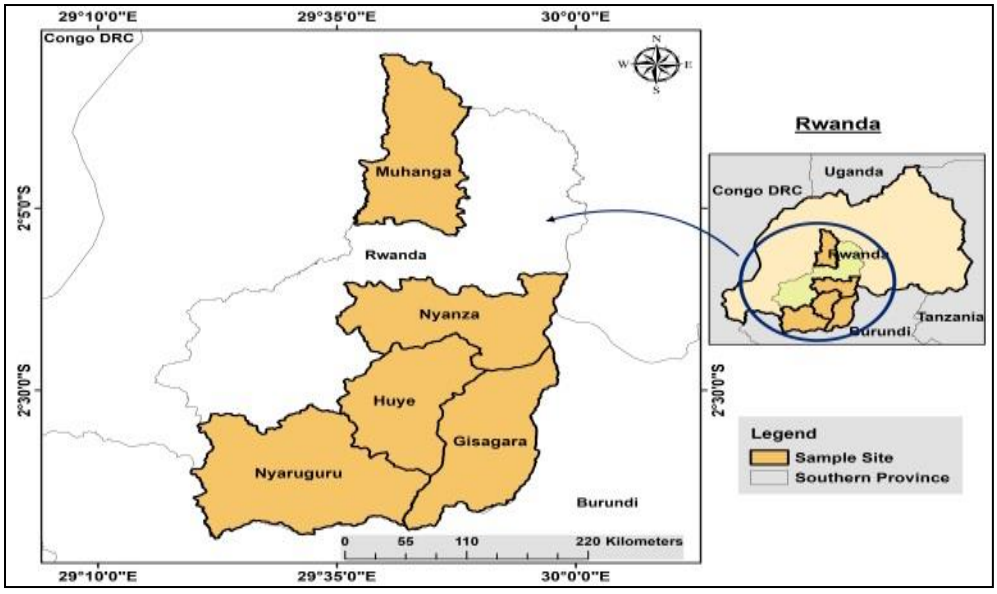
Rwanda agroforestry is controlled by independently possessed trees planted as woodlots, lines (farm boundary and contour lines) and distributed trees on farmlands. Eucalyptus woodlots are among the most commonly adopted agroforestry systems in Rwanda as it is projected that at a countrywide level about 36-40% of farm owners plant them on their land (Ndayambaje *et al.*, 2013). Many socio-economic studies in agroforestry have focused on perception and adoption in agroforestry practices (Mahmoud et al., 2018; Adedayo & Oluronke, 2014; and Nouman et al., 2007). Other major agroforestry studies have addressed its importance on soil fertility renovation and weed control (Nair, 2006; Motis, 2007; Bayala et al., 2014; Ordonez et al., 2014). However, there is limited literature on the adoption of appropriate controlling practices and incorporation of those practices into rural livelihood structures (Liyama et al., 2014; Namirembe et al., 2014). There is little investigation on the adoption of agroforestry practice in specific (Jera & Ajayi, 2008) and few articles have studied the adoption of agroforestry outside visible features (Calle et al., 2009; Frey et al., 2012; Hayes, 2012). Therefore, the objective of this study was to identify the agroforestry practices adopted by the farmers, its benefit and challenges met by the farmers adopting agroforestry in the Southern Province of Rwanda.

MATERIAL AND METHODS

Study Area

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 increases soil erosion. The rainfall pattern is bimodal; the long rains are between March and May, short rain in October up to December. The daily average temperature ranges from 28.5 °C to 32 °C. The main economic activity in Southern Province is agriculture. Consequently, the province has given priority to the growing of tea, coffee, wheat, passion, Irish potatoes, processing of honey and livestock keeping. Same farmers practice agriculture together with trees while others don't practice such kind of agriculture.

Figure 1: A map of Southern Province showing study area location



RESEARCH DESIGN

This study was conducted through descriptive survey design which is used for gathering information from respondents through interview and questionnaires (Orodho, 2003). This study was carried out in four (4) districts in Southern Province of Rwanda. Both quantitative and qualitative methods were used to enable the researcher to draw valid and dependable conclusions and recommendations about the effect of agroforestry on farmers' livelihood. The study location was chosen because the southern area is one of the regions in Rwanda with fruitful stories of agroforestry practices boosting nourishment, production and raise household income. The target population for this study consists of farmer households which comprise 5,290, 1,247 agroforestry adopter households and 4,043 households of non-adopters of agroforestry from those districts located in Southern Province of Rwanda as shown in distribution *Table 1*.

Table 1: Distribution of Target Population

District	Adopters Household	Non-Adopters Household
Nyanza	209	1041
Muhanga	230	1200
Huye	428	672
Ruhango	380	1130
Total	**1247**	**4043**

Source: Researcher 2019

The sample size of this study was computed using Yamane (Kasunic 2005) simplified formula with a 90% confidence level and the maximum variance (p = 0.1).

$n = \frac{N}{(1+Ne^2)}$ Where: **n** is the sample size; **N** is the population size (209); e is the level of precision (0.1).

By using the sample size of adopters for Nyanza District and also the total sample size was 290 for adopters and 360 for non-adopters. The study employed a stratified random sampling technique. With this technique, the analysis was done on the elements with strata, during stratified sampling and a random sample used for each stratum. Therefore, random sampling was taken to select 290 samples of adopters and 360 of non-adopters in four districts of Southern Province.

The researcher adopted primary data collected using questionnaires. The data was obtained from the farmers and agricultures offices in each district through the questionnaire.

RESULTS AND DISCUSSION

Demographic Characteristics of Respondents

According to the study, most of the smallholder farmers were mainly non adopters of agroforestry. The study found that majority of the farmers was aged 54 years. The study found that most respondents had obtained primary level education as their highest education level. It found that most smallholder farmers have 6 members as their household size. It was discovered that most respondents owned between 14 acres of land and were more likely to adopt agroforestry

Agroforestry Practices adopted by the Farmers

There are various types of agroforestry practices in the Southern Province of Rwanda. The following types of agroforestry practices were adopted by the smallholder farmers in Southern Province (*Table 2*).

Table 2: Agroforestry practices adopted by the farmers

Agroforestry practices	Number of farmers(n=290)	Percentage
Alley cropping	34	11
Home garden	43	14
Boundary planting	191	68
Scattered trees on farm	22	7
Total	**290**	**100**

Out of the 290 agroforestry adopters, 68% of the respondents had boundary planting agroforestry

followed by 14% to homegarden, 11% to alley cropping and 7% to scattered trees on farm. Most adopters of agroforestry farming in Southern Province of Rwanda planted the trees around their farms.

Benefit from Agroforestry

The farmers maintained that these trees are retained to provide various uses such as fuel wood (18%), staking material (22%), constructional materials (7%), grazing(5%), climate regulation (7%), soil erosion (14%), control of weed and pest (6%), reduction of crop failure (6%), improving soil fertility (7%), nutrient recycling (4%) as well as nitrogen fixation (5%). The responses from farmers on benefit from agroforestry are illustrated in *Table* 3.

Table 3: Benefit from agroforestry

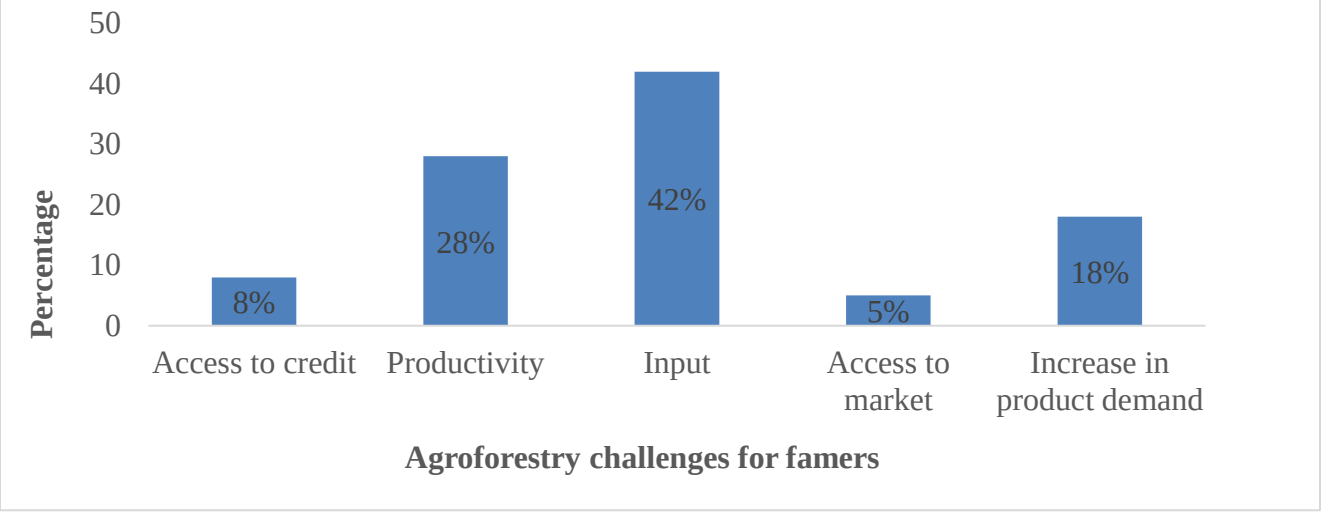
Benefit from agroforestry	Number of farmers(n-290)	Percentages
Fuelwood	52	18
Staking material	64	22
Construction material	21	7
Grazing	15	5
Climate regulation	20	7
Soil erosion	41	14
Control wed and pest	17	6
Reduction of crop failure	17	6
Improving soil fertility	19	7
Nutrient recycling	13	4
Nitrogen fixation	11	4
Total	**290**	**100**

The study uncovered that the respondents either plant trees for extra benefit like firewood, staking materials, constructional materials, soil improvement, control wed and pest, reduction of crop failure and nutrient recycling (*Table 3*). This is in agreement with Adewusi (2006) who stated that farmers plant or retain trees on their farm land, both for food, income, soil improvement, environmental improvement and for shadow during the bitter weather period.

Agroforestry Challenges for Farmers

The result in *Figure 2* shows the challenges of farmers who adopted agroforestry this result indicates 42% to input, 28% to productivity, 18% increase in product demand, 8% access to credit and 5% access to market. Therefore, input and productivity are the most challenges faced by the farmers who adopted agroforestry practices.

Figure 2: Agroforestry Challenges for Farmers



CONCLUSION

This study illustrated that most of the smallholder farmers who had adopted agroforestry in the Southern Province of Rwanda planted the trees around their farm driving to an increase in demand for food and forest products. Finally, the study revealed that the main use of trees they had planted was for fuel and stake therefore they are likely to adopt agroforestry to use the trees later for fuel and stake. Most of the respondents were able to access the necessary information on the importance of agroforestry, attained knowledge for planting trees especially in spacing and management skills and knowledge about various species of trees and management skills. For recommendation, the government of Rwanda and other stakeholders should promote tree farming in the area so as to prevent deforestation and land degradation in search of firewood and timber from the community and government forests. The government should give incentives to encourage people to plant trees for own consumption and at the same time to restore the degraded environment.

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