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Full Length Research Paper

Assessing the adoption Level of Agroforestry Species in Nyabihu District Rwanda

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Abstract
The purpose of this study was to assess the adoption level of agroforestry tree species in Mukamira sector, Nyabihu District, Western Rwanda. This study was conducted from July to August, 2012. Data was collected from 67 households randomly selected from Mukamira sector (Rukoma, Rurengeri and Rubaya cells). A structured questionnaire was used for data collection. Data was analyzed using Microsoft Office Excel and the Statistical Package for the Social Science (SPSS) where Freidman test was applied. The results showed that the agroforestry species planted on farmland were Erythrina abyssinica (100%) followed by Alnus acuminata (76.1%). Freidman test showed that Alnus acuminata is more preferred by farmers with 2.38 mean rank. Soil cover improvement was the main ecological factor influencing farmers to adopt agroforestry species with 1.57 mean rank; diversification of products was the most important economic factor influencing farmers to adopt Agroforestry species with mean rank of 2.63 and training and agricultural extension with 2.62 as mean rank as the first social factors influencing farmers to adopt agroforestry species. The lack of seedlings was the most critical constraint faced by famers in adoption of agroforestry species with 1.46 mean rank value. Agroforestry nursery establishment, training on agroforestry practices and availability of bank credit loan were the major suggestions given by respondents to resolve the mentioned constraints with respective percentages of 100, 64.2 and 17.9. This research showed many factors influencing the farmers to adopt agroforestry species.

Keywords: *Agroforestry species, ecological factors, socioeconomic factors, farmers, adoption level*

Introduction

Young (1989) defined agroforestry as a land use system in which trees or shrubs are grown in association with agricultural crops, pasture or livestock. There are both ecological and economic interactions between the trees and other components. The adoption of agroforestry practices is considerably complex because it requires establishing a new input- output mix of annuals, perennials, green manure, fodder and other components combined with new conservation techniques such as contour hedgerows, alley cropping and enriched fallows (Sanchez et al.1995). Unlike standard agriculture, there are few packaged agroforestry or farm based natural resource management practices to deliver to farmers (Sanchez et al., 1995). Tree planting in Rwanda was limited to some plants around households such as *Ficus thoningii, Euphorbia tirucallii, Erythrina abyssinica, Vernonia amygdalina, Dracaena afromontana,* etc., but the cultivation of woody perennials for timber, energy generation or other services was not part of the customs. The first forest plantations were created in 1920 and 1948 and only consisted of Eucalyptus species. Later on, other species were introduced. These were namely *Pinus sp., Callistris sp., Grevillea robusta, Cedrella sp., Cupressus sp.* Those plant species proved to be dangerous for the biological patrimony because they used to drain and acidify places that are already acid, causing the reduction or even the extermination of the underground biodiversity growth. The covered surface area was estimated at 256,300 hectares in 1998. Despite the efforts of diversifying tree species, it is estimated that 99% of trees consisted of Eucalyptus sp. However, a replacement of those trees by agroforestry species such as *Grevillea sp., Cedrella sp., Maesopsis sp., Calliandra sp., Leucena sp.* proved to be of urgent need because of the added services they bring in agroecosystem.

Factors influencing farmers' adoption of Agroforestry

For farmers, whenever they have to decide to apply a new production model or not, they always consider three aspects including feasibility, profitability and acceptability (Franzel,1999). The feasibility means that whether farmers get enough knowledge to manage new technology and cultivation techniques or not, they should have capital and necessary information to apply new techniques. Feasibility includes support of government, experience of farmers, labor, land, and capital, etc. Concerning the profitability, farmers calculate whether applying new technique is more economically effective than other techniques that they can practice or not.

Profitability is explained by crop productivity and labor cost. The acceptability appears when farmers realize that advantages being got from these systems are higher than the disadvantages. Thus, acceptability consists of many other factors. Acceptability concerns the environmental awareness, poverty amongst famers, gender issue, etc.

In Rwanda, the majority of population relies on subsistence agriculture and the national average farm size is about 0.8 ha per household (Mpyisi et al, 2003). However, high population growth rate coupled with limited land and poor access to capital has led to low investment and prevented the development of more productive and profitable agriculture. The farmers in Mukamira Sector have adopted the agroforestry species in different ways in order to improve the agricultural productivity. This study is an attempt to assess different factors influencing famers to make a choice on agroforestry tree species to be associated with the crops in Rukoma, Rurengeri and Rubaya cells of Mukamira sector. The results of this study will reveal the information on how farmers adopt agroforestry species in their farmland and their preference level. This research will also provide a useful understanding of adoption level of agroforestry species and the main factors influencing farmers to adopt them. The specific objectives of this study were the following:

1. To identify agroforestry tree species preferred and adopted by farmers;
2. To assess how ecological factors such as soil erosion control, soil cover improvement, soil fertility influence farmers to adopt agroforestry species
3. To assess how economic factors such as household income, diversification of timber, fodder and stakes influence farmers to adopt agroforestry species
4. To assess how social cultural factors such as education, agricultural extension influence farmers to adopt agroforestry species
5. To identify the constraints faced by farmers during the adoption of agroforestry species

Upon the completion of this study, the following null hypotheses should be tested and verified:

1. The farmers' preference level on different agroforestry species is not high in Mukamira sector.
2. There is no significant difference between the ecological factors influencing farmers' adoption of agroforestry species.
3. There is no significant difference between the economic factors influencing farmers' adoption of agroforestry species.
4. The social factors do not significantly influence farmers' adoption of agroforestry species
5. Lack of seedlings, lack of technical advice, lack of man power, lack of capital is the main constraints faced by farmers in the adoption of agroforestry tree species.

Material and methods

Study area description

The study area was carried out in Mukamira sector in Nyabihu district, Western province of Rwanda. Mukamira sector is subdivided into seven cells namely Rubaya, Rurengeri, Rukoma, Jaba, Rugeshi, Gasizi and Kanyove. The administrative borders of Mukamira sector are Jenda sector in Northern and Western border, Karago sector in Southern border and Kintobo sector in Eastern border. The average monthly temperature of Mukamira sector ranges between 13 and 23^{o}C throughout the year. While the average annual rainfall in Mukamira sector is between 1300 and 1600mm per year. The average monthly rainfall shows that there are two prominent rainy seasons: short rain season from October to middle December (umuhindo) and long rainy season from mid of February to June (itumba). There are also two dry seasons: short dry season from Mid of December to mid of February (Urugaryi) and long dry season from July to September (Icyi or Impeshyi). The soil of Mukamira sector is dominated by the volcanic soil and very permeable with low depth on mountains and deposited soil with high depth in swamps. This soil is generally very fertile. More than 90 % of total population of Mukamira sector is involved in agriculture. In this sector, the following crops are grown: Industrial crops (tea and pyrethrum); Vegetables (cabbages, carrots and onion); Food crops (beans, maize, wheat, peas, sorghum and Irish potatoes). Practically, the fauna is composed by reared animals like cow, goats, sheep, pigs and chicken. The flora is dominated by different trees such as *Eucalyptus sp., Cypress sp.,* and different agroforestry species such as *Alnus acuminata, Erythrna abyssinica, Sedrella serrata, Calliandra callothyrsus, Casualina equisetifolia* and *Grevillea robusta* (Mukamira sector, 2011).

Sampling procedure

A sample of n households was selected using the following formula:

$$n = \frac{z^2 \times p \times q \times N}{d^2(N-1) + z^2 \times p \times q}$$

(Kothari, 1985)

Where: n= Sample size,
N= Population size (number of households),
Z= Coefficient normal distribution,

q= Probability of failure,
d= Margin error,
p= Probability of success

Purposive sampling method was used to select Mukamira sector as a study area as it is the sector where the agroforestry species have been adopted by many farmers. It is also located not far from the ISAE institution. The cells were also selected because of the same reasons. A proportionate allocation sampling method was used to know the number of population to be interviewed in each cell. For Kothari (1985), the margin error varies between 5 % and 10 %. We are going to use the margin error of 10 %, then the confidence level of 90 %, our probability of success is p= 0.5, failure probability of q= 0.5, as $Z_{0.25}$=1.65

The total number of respondents in Mukamira sector was then calculated:

$$n = \frac{z^2 \times p \times q \times N}{d^2(N-1) + z^2 \times p \times q}$$, then

$$n = \frac{(1.65^2) \times 0.5^2 \times 3204}{(0.1^2) \times (3204 - 1) + (1.65^2) \times 0.5^2} = 66.67 \approx 67$$

67respondents were randomly selected according to the sample size from each cell calculated below: The following formula was used to calculate the total number of respondents in each cell:

$$ni = \frac{Ni \times n}{N}$$

Where:
ni= the sample size proportion to be determined;
Ni= the population proportion in the stratum;
n= the sample size;
N= the total population.

The proportion of population in cells: Rurengeri: 1229; Rubaya: 1018; Rukoma: 957; Therefore, the sample size in each cell is: Rurengeri: (1229x67): 3204= 26; Rubaya: (1018X67):3204= 21; Rukoma: (957x67):3204= 20

Data collection and analysis
Data were collected from three cells by using a structured questionnaire. Field observation, focus group discussion, formal and informal interviews were used for collecting data. Data analysis was done using Microsoft Excel and SPSS 16.0 Windows© program (Statistical Packages for Social Sciences) where Friedman test was used to determine the correlation between the factors influencing farmers' adoption of agroforestry species.

Results and discussion

Household characteristics

Identification of respondents according to the age

The following figure 1 indicates the age distribution of farmers sampled in three cells of Mukamira (Rurengeri, Rubaya and Rukoma).

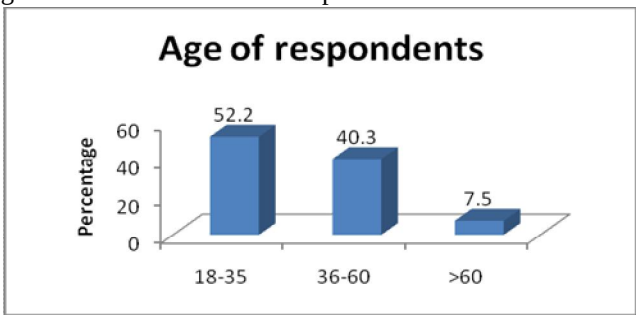

Figure 1: Age distribution of respondents

From the results of the above figure1, it can be seen that the majority of the surveyed farmers are still young where 52.2 % are in class of 18-35 age. This indicates the capacity of sector in different works demanding the physical energy for example in agricultural sector and also this is an opportunity to ensure the sustainability of agroforestry practices in future generation and the last class is composed by old class of > 61with 7.5 %.

Identification of respondents according to the Sex

The figure 2 below indicates the sex distribution of sampled farmers in three cell of Mukamira sector (Rurengeri, Rukoma and Rubaya).

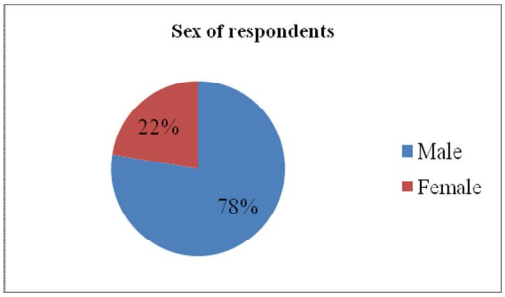

Figure 2: Sex distribution of respondents

The above figure 2 shows that among 67 respondents surveyed in Mukamira sector, it was observed that the number of male was greater (78 %) than the number of female (22 %) because I have questioned the heads of family and usually governed by males and also during my survey, most of females were on the farms cultivating The heads of family are decision makers that may affect the adoption of agroforestry practices and species.

Education level of respondents

The figure 3 below illustrates the education level of respondents

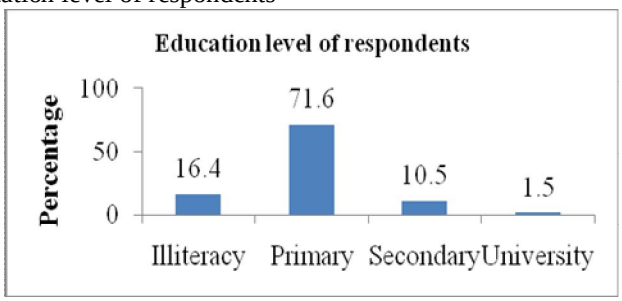

Figure 3: Education level of respondents

According to the results shown in the above figure 3, it is evident that the majority of respondents (71.6 %) attended primary level of education which facilitated them to read the journals and even books talking about Agroforestry techniques, followed by those who had secondary education level with 10.5% and few of them had university education (1.5 %). Most of farmers interviewed in Mukamira sector have achieved primary school. Most of farmers in Mukamira sector know to read and write. Therefore, they easily understand the training on agroforestry practices and their various roles on soil conservation and their livelihood improvement. Consequently, farmers can easily adopt agroforestry tree species.

The household size

The following figure 4 indicates the household size of interviewees.

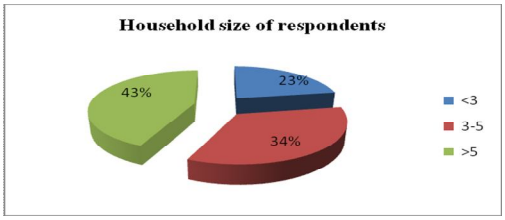

Figure 4: Household size of respondents

The results of the figure 4 show that the majority of interviewees were in the class of above 5 people with 43% interviewees followed by 34% of interviewees who have the family size in class of 3-5 people and finally 23% of interviewees have the size of household below 3 people. This means, the labor availability is high for adopting agroforestry species.

The marital status

The figure 5 below shows the marital status of respondents

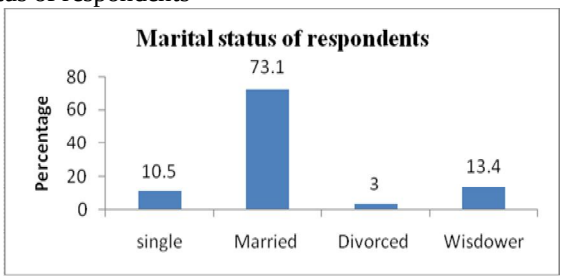

Figure 5: Marital status of respondents

The figure 5 shows that the majority of respondents are married (73.1%) and widowers come in the second place with 13.4% of interviewees and finally single and divorced with 10.5% and 3% respectively. This means that most of households in Mukamira sector are composed of men and women who jointly take decision on the adoption of agroforestry species.

Household income

a) Source of income

The crop production, livestock, regular employment, commerce are considered as the most economic activities for the farmers in Mukamira sector. These activities help them improve their welfare and achieve sustainable agriculture in this sector. The figure 6 below shows different activities that generate income in the household.

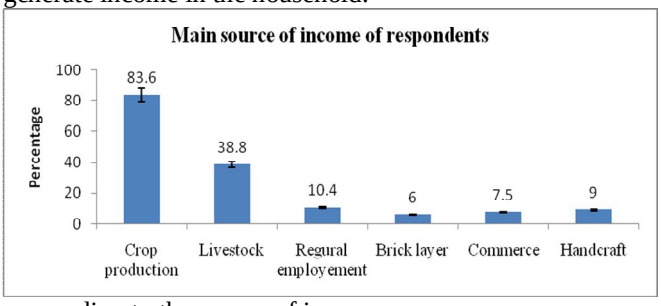

Figure 6: Distribution of respondents according to the source of income

The crop production is the main activity in Mukamira sector which generates income where 83.6% of respondents gained income from this activity followed by livestock activity with 38.8% of respondents because of different programs such as Girinka and Ubudehe in this region. The agroforestry practice is promoted in this sector in order to make the agriculture and livestock more productive.

b) Annual income earned by farmers

The figure 7 below shows the estimation of income obtained by respondents per year.

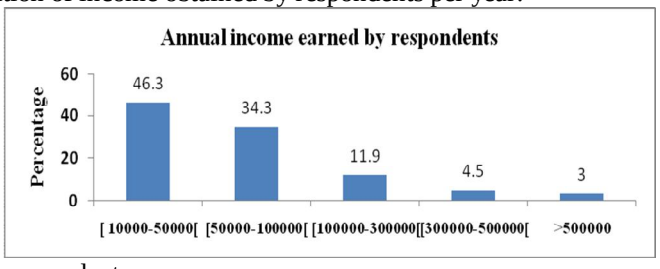

Figure 7: Annual income earned by respondents

As illustrated in the above figure 7, a greater number 46.3% of respondents earned annual income between the interval of [10000-50000[frws per year, followed by 34.3% of respondents earning income situated in interval of [50000-100000[frws per year. This shows the financial capacity of respondents to adopt agroforestry species easily.

Agroforestry species and their location in farmland

Agroforestry species planted in farms

The following figure 8 indicates different agroforestry species planted on farmland

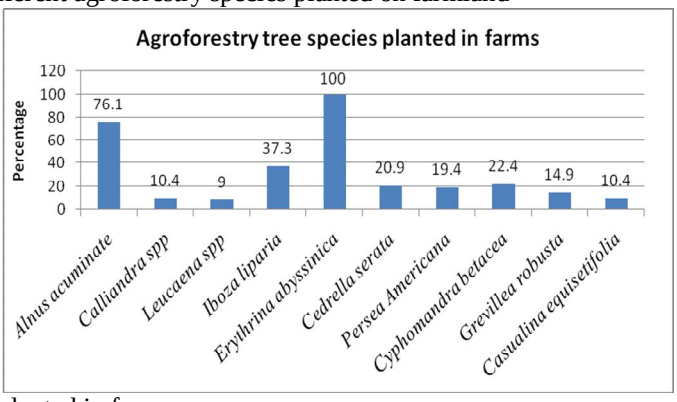

Figure 8: The agroforestry species planted in farms

The above figure 8 shows different agroforestry species planted in the farms of interviewees. *Erythrina abyssinica* is an indigenous species which occupy the first place with 100% of respondents in Mukamira sector due to its use by farmers such as farm boundaries, terraces stabilization, homestead fencing, etc. Due to the local Non Governmental Organizations (NGOs) and local government interventions encouraging farmers to plant agroforestry species in that region, A*lnus acuminata* occupies the second place with 76.1%. According to the adaptability and seedling production factors, fruit and fodder trees have lower percentage where *Persea Americana* has 19.9%; *Cyphomandra betacea* with 22.4%, C*alliandra sp.* has 10.4% and *Leanaena sp.* 9%.

Distribution of agroforestry species in the surveyed farmland

The figure 9 below shows different locations where the agroforestry species are planted in farmland

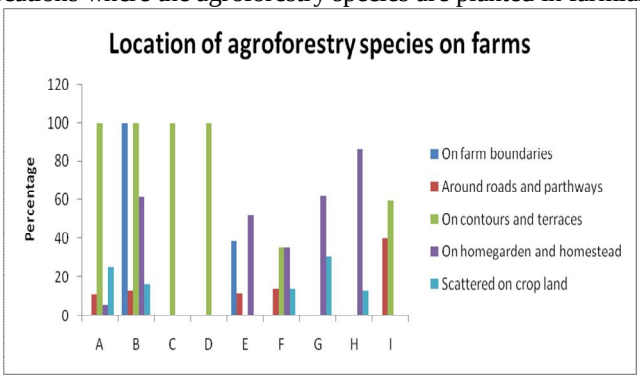

Figure 9: Distribution of agroforestry species in the surveyed farmlands

a) *Alnus acuminate, b) Erythrina abyssinica, c) Calliandra sp., d) Leucaena sp., e) Iboza riparia, f) Cedrella serrata, g) Persea Americana, h) Cyphomandra betacea, i) Grevillea robusta.*

According to the results presented in figure 9, it can be seen that *Alnus acuminata, Erythrina abyssinica, Calliandra sp.* and *Leucaena sp.* are the agroforestry species most used in contours and terrace stabilization (100% of respondents). The *Erythrina abyssinica* is an agroforestry species most used in farmland delimitation in Mukamira sector where 100% of respondents have this species in farmland boundaries in order to help farmers avoid the conflict of boundaries.

Agroforestry species preferred by farmers in Mukamira sector

The figure 10 below indicates the preference level of agroforestry species classified in four categories. The classification is done according to the farmers 'preference of agroforestry species such as 1) High, 2) Middle, 3) Low and 4) Not preferred.

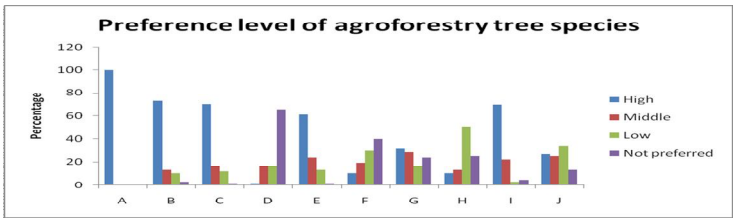

Figure 10: Level of preference of agroforestry species

A. *Alnus acuminata*
B. *Cyphomandra betacea*
C. *Calliandra sp.*
D. *Iboza riparia*
E. *Grevillea robusta*
F. *Erythrina abyssinica*
G. *Cedrella serrata*
H. *Persea americana*
I. *Leucaena leucocephala*
J. *Casualina equisetifolia*

The above figure10 shows the farmers' preference levels of agroforestry species due to different outcomes, roles and needs they expect to get from those agroforestry species. *Alnus acuminata* is highly preferred at 100% because of its adaptability and its different uses in this sector. *Cyphomandra betacea* as a fruit tree is the most preferred by farmers in this region with 73.1%. *Cyphomandra betacea* is appreciated because it provides food and money if sold.

Factors influencing farmers to adopt agroforestry species

Land size

The following figure 11 shows the land size of interviewers

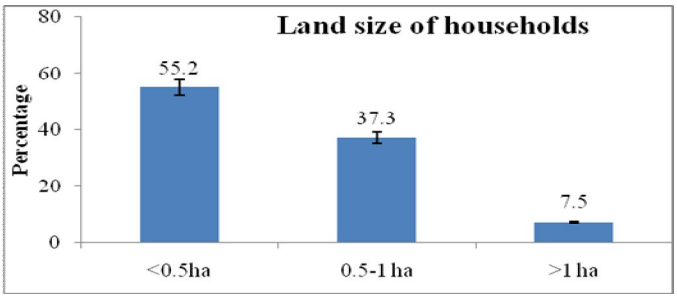

Figure 11: The land size of farmers

The results from the above figure11 show that the majority of respondents have a problem of land shortage where the 55.2% of respondents have the land size under 0.5ha. Therefore, the agroforestry species might be used to reduce the problems caused by land shortage such as lack of fuelwood, stakes etc. Due to the lack of land for growing forest trees, the agroforestry can improve the soil fertility and then the agricultural productivity of that small land increase.

The location of farmland

The following figure 12 shows the farmland location according to the slope of land

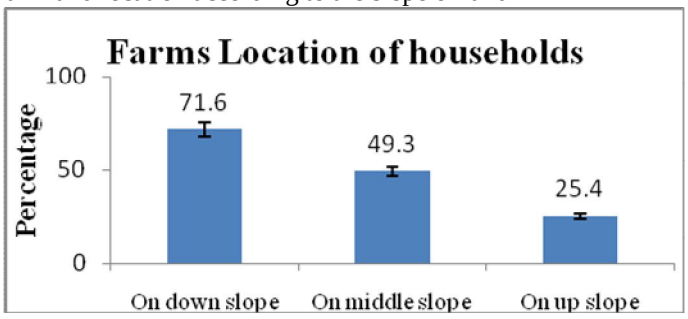

Figure 12: Farmland location

From this figure 12, it has been shown that the majority of respondents have the farmland located in down slope areas with 71.6%. Farmland located in middle (moderate) slope areas with 49.3% and finally 25.4% of respondents have farmlands located in high slope areas. As the slope is one of the factors that can cause the soil erosion, the agroforestry plant species are applied as a method to resolve the problem of soil erosion.

The farmland use management

The use of farmland can influence the adoption of agroforestry species.The figure 13 shows different uses of farmland.

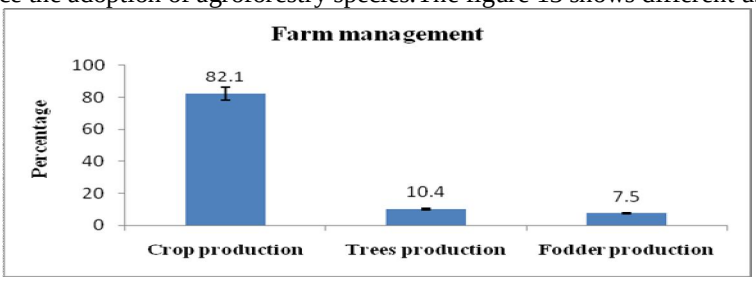

Figure 13: The farmland management

The figure 13 shows that the crop production is the most activity done by farmers in Mukamira sector with 82.1% of respondents followed by tree production with 10.4% of respondents. The results show that the majority of farmers in this sector depend on crop production and the soil has been cultivated for many seasons without changing the crops. This led to the problem of soil infertility and soil erosion. By planting agroforestry trees, those issues can be resolved.

Ecological factors influencing the adoption of agroforestry species

Table 1: Statistical test of Ecological factors influencing farmers' adoption of agroforestry species by using Freidman test

Ecological factor	Mean Rank	Test statistics
Soil erosion reduction	2.25	N= 67
Soil cover improvement	1.57	Chi-Square=
Increasing soil fertility	3.66	161.112
Improving soil structure	3.70	Df= 4
Changing climatic conditions	3.81	Asymp. Sig.= 0.000

The most influencing factors are: soil cover improvement with 1.57 mean rank followed by soil erosion reduction, increasing soil fertility, improving soil structure and then changing climatic conditions with mean rank of 2.25, 3.66, 3.70 and 3.81 respectively. With Friedman statistical test with p-value of 0.00 at significance level 0.05, there is a statistical significance difference as p-value is less than 0.05. Therefore, there is a significant difference between ecological factors influencing farmers to adopt agroforestry species in Mukamira sector.

Economic factors influencing farmers' adoption of agroforestry species

There are different economic factors influencing farmers' adoption of AF species in farmland as shown in table 5.

Table 2: Statistical test of economic factors influencing farmers' adoption of AF species by using Friedman test

Economic factors	Mean Rank	Test statistics
Agricultural income	3.37	N= 67
Energy provision	3.04	Chi-Square= 13.631
Diversification of agroforestry products	2.63	Df= 4 Asymp. Sig.= 0.009
Overall family income	2.89	
Sustainable agriculture	3.07	

This table 2 shows that the first economic factor influencing farmers' adoption of AF species is the diversification of products such as timber, fodder. Stakes, wood for cooking and constructing houses with the mean rank of 2.63. The last factor is the agricultural income with 3.37 mean rank. As the p-value of 0.009 at significance level 0.05 is less than 0.05, there is an overall statistical significant difference between the economic factors influencing farmers to adopt agroforestry species in Mukamira sector.

Social factors influencing farmers' adoption of agroforestry species

The table 3 below shows the social factors influencing farmers' adoption of agroforestry species in farmlands in Mukamira sector.

Table 3: Statistical test of social factors influencing farmers' adoption of AF species by using Friedman test

Social factors	Mean Rank	Test statistics
Better health conditions	2.77	N= 67
Family size	3.33	Chi-Square= 15.106
Successful households	3.22	Df= 4
Training and agricultural extension	2.62	Asymp. Sig.= 0.004
Strong family tie	3.07	

The table 3 presents the social factors influencing farmers to adopt agroforestry species. It is indicated that education of farmers (training) and agricultural extension is the most important factor influencing farmers to adopt agroforestry species with 2.62 mean rank followed by better health conditions, strong family tie, successful household and family size with 2.77,3.03, 3.22 and 3.33 respectively. Considering the p-value of 0.004 at significance level 0.05, there is a statistical significant difference (p-value< 0.05).

The input of Agroforestry species

Reception of agroforestry seedlings

The figure 14 below indicates the information about the reception of agroforestry seedlings.

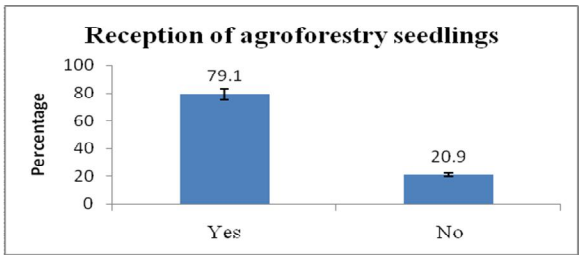

Figure 14: Agroforestry seedlings

The figure 14 shows that farmers get seedlings from elsewhere whereas 20.9 % of respondents have not received agroforestry seedlings nor fruit seedlings. This has a negative impact on the adoption of agroforesty species in Mukamira sector because the farmers do not get seedlings easily.

Source of agroforestry seedlings

The figure 15 below shows different sources of agroforestry seedlings

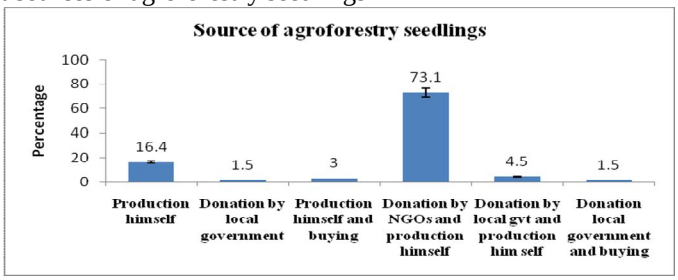

Figure 15: Sources of agroforestry seedlings

The above figure 15 shows that the major sources of agroforestry seedlings are the NGOs with 73.1%. The NGOs occupy the first place in giving agroforestry seedlings because the government of Rwanda prioritises the private sector in agroforestry nursery establishment in order to promote the private sector in agriculture.

Location of agroforestry nurseries

The figure 16 below shows the location of agroforestry nurseries according to the farmland location.

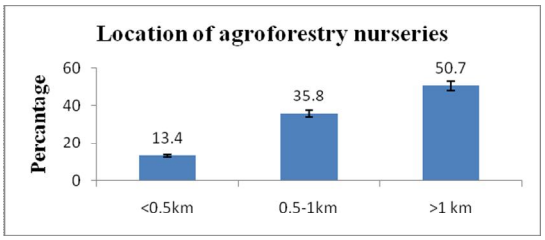

Figure 16: Location of agroforestry nurseries

The figure 16 shows that the distance from nursery to the farmland is very long (50.7% of respondents): Farmland located at more than one km from the nurseries and few farmlands are located near the nurseries site. This negatively impacted on agroforestry species adoption in this region.

Constraints in growing agroforestry species in farmland

The table 4 below shows different constraints in growing agroforestry species in farmland

Table 4: Constraints faced by farmers in growing agroforestry species in farmlands

Constraints in growing agroforestry species	Mean Rank	Test statistics
Lack of seedlings	1.46	N= 67
Lack of technical assistance	2.89	Chi-Square= 88.345
Lack of man power	3.01	Df= 3
Lack of capital	2.65	Asymp. Sig.=0.000

The lack of seedlings is viewed as the most critical constraint faced by famers in the adoption of agroforestry species with 1.46 mean rank followed by the lack of capital with mean rank of 2.65. The p-value of 0.00 at significance level 0.05 shows that there is a statistical significant difference (p-value<0.05) amongst those factors. Those constraints have negative impact on agroforestry species adoption and practices in study area.

The suggestions to the mentioned constraints

The figure 17 below illustrates the suggestions to the mentioned constraints.

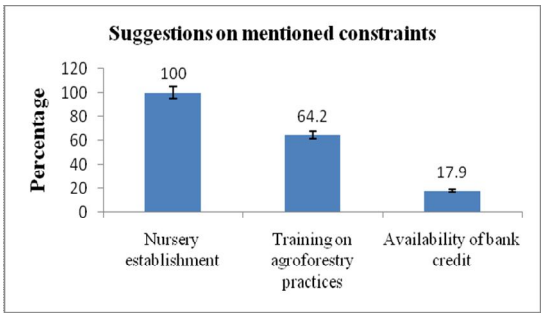

Figure 17: Suggestion to the constraints mentioned

The above figure 17 shows that 100% of respondents suggested the nurseries establishment for seedling production; others suggested that they need the training on agroforestry practices (64.2% of respondents) and 17.9% of respondents want bank loan for establishing their own nurseries.

Conclusion

This study aimed at evaluating the adoption level of agroforestry species in Rukoma, Rurengeri and Rubaya cells of Mukamira sector, Northern Province of Rwanda. This study was done from July to August 2012. The results showed that the farmers of Mukamira sector have adopted agroforestry species in their farmlands. Plant species such as *Alnus acuminata*, *Cyphomandra betacea* and *Calliandra sp.* are the agroforestry species highly preferred by farmers due to their various roles such as fuelwood provision, stakes for climbing beans, fodder for cattle and fruits to humans. The main ecological factors influencing farmers' decision in the adoption of AF species are soil cover improvement, soil erosion reduction, soil fertility increase, soil structure improvement and climatic change conditions. The main economic factors influencing farmers' decision in the adoption of AF species are diversification of agroforestry products followed by overall income increase, energy provision, sustainable agriculture and agricultural income. The main social

factors influencing farmers' adoption of AF species are training and agricultural extension as most important factor followed by better health conditions, strong family tie, successful households and family size. Farmers also lack the agroforestry seedlings.

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