Impact Assessment of Agroforestry Practices on Community Socio-Economic Livelihoods in Rwanda

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Abstract— Agroforestry is the source of energy for cooking, materials for construction, domestic utensils and other products and services including fruits, medicine, livestock, feeding and fencing. This study aimed to assess the impact of agroforestry practices on community's socio-economic livelihoods in Karongi district, western Rwanda. The authors interviewed 45 Agroforestry Practioners (AFP) and 45 Non-Agroforestry Practioners (NAFP) from 8 cells randomly selected between July and September 2019.The data were analyzed by using the Statistical Package for Social Sciences (SPSS), version 20. The result, as asserted by 100 % of AFP, the Grevillea robustae was the frequently planted specie on contours and terraces due to its contribution on improving soil fertility and protecting the soil against erosion. The inheritance of land is the main mode of getting lands as mentioned by 69% and 62% of AFP and NAFP, respectively. In addition, it was noted that the number of reared goat, cattle and poultry is higher for the AFP than that of NAFP. Furthermore, the AFP' mean yearly income and its uses (food security, agriculture and household building) is significantly higher ($p<0.05$) compared to that of NAFP. Thus, in Karongi District, the agroforestry significantly enhances its practioner's livelihoods. This study can serve as guide to other similar areas in adopting the agroforestry.

Keywords— Agroforestry; Local Community; Livelihood; Karongi district; Rwanda.

I. INTRODUCTION

Cropland agroforestry system provides enough food, timber, fodder, fruit, fuel wood, construction materials, raw materials and other products for forest-based small-scale enterprises and other cottage industries. Trees in crop fields work as insurance in case of sudden crop failure or to support crops against environmental hazards and also to provide extra income from trees. Moreover, if there is a failure in one crop, the other crops would supplement the deficit. Therefore, cropland agroforestry is largely evolved with sustainability concerns, resiliency and diversity (Maduka 2007; Chakraborty et al. 2015; Islam et al. 2012). There is a range of practices that can be used for agroforestry, some of which have been employed for thousands of years. Such methods include alley cropping (planting single rows of trees and growing crops in the alley ways in between), silvopasture (combining trees with pasture or livestock grazing areas), forest farming (the cultivation of shade-tolerant crops under the protection of a managed forest), and others (TURGUT 2019; Enete and Amusa 2010).

Integrating trees in agricultural systems can certainly be complex and might be difficult to implement in various situations, and there is no one model that works for every region, but the benefits are significant. Overall, incorporating trees introduces more species in usually one or few species systems. And this in turn, has been shown to increase the crop productivity, improve nutrient cycling, create and change microclimate (Ospina 2017; TURGUT 2019). Some countries have heeded the call and are employing agroforestry technology as a strategy to rehabilitate degraded forestlands, avoiding "slash and-burn" farming, reducing soil erosion, improving soil quality, enhancing vegetation cover, and improving the living standards of forest-dependent communities (Bugayong 2003; Glover et al. 2013). Agroforestry can help to improve the livelihoods of the rural poor by producing food (e.g. fruit, nuts, edible leaves, sap and honey), fodder, timber, wood fuel, fibers and medicines. The adoption of agroforestry can save time in the harvesting of fodder and wood fuel, a particularly important benefit for women (Hillbrand 2017). According to the study conducted in Orlando, Florida, USA, trees also provide farmers with supplementary socio-economic benefits (fruit for food, firewood, medicines, forages, etc.) (El-Lakany 2004b; El-Lakany 2004a).

The Rwandan 3rd Integrated Household Living Conditions Survey (EICV3) reported that in Karongi district, 77.7% of households own less than 0.99 ha of land, among them 36.7% own less than 0.2 ha, and only 22.3% own more than 1 ha (Nahayo et al. 2016; Nabahungu and Visser 2011). A higher proportion of farmers cultivating larger areas would create an enabling environment for agriculture production increase. The proportion of households cultivating the smallest areas, i.e. below 0.3 ha land, represents 37.4% in Karongi District. This is slightly lower than the average national level (46%). The mean size of land cultivated per household in Karongi District is 0.5 ha, which is slightly higher than the national average (0.59ha) (Karongi 2018).Sometimes, it is argued that small farms in terms of land size are more productive than large farms and it is further recommended that agricultural development strategies need to be based on the backing of small rather than

large farms. In addition to this, the small farm biased agricultural development strategy simultaneously can help to overcome both growth and income distribution objectives (H.Freeman 2005; Ellis 2008).

The conversion of forestlands to agricultural lands in the region is rapidly increasing, which is reducing forest cover. However, in Rwanda, the adoption of agroforestry techniques to avoid rampant deforestation has not been simple in the country due to the existing challenges such as low literacy rate, insufficient credit facilities, absence of farm inputs, and other sociocultural issues (MINAGRI 2006). In such circumstances, traditional land use patterns should be converted into sustainable land use, which will permit maintenance of productivity combined with conservation of the resources. Agroforestry; a land based production system that is directly related to food security, employment, income opportunities and environmental issues plays a vital role in rural socio-economic development as well as poverty reduction (Maduka 2007; Chakraborty et al. 2015; Islam et al. 2012). Karongi District faces the problem of soil degradation, including soil infertility, soil erosion, deforestation, shortage of farmlands, land sliding. These are associated with other environmental concerns mainly in agriculture, urbanisation, infrastructure development and energy (Karongi 2018).Hence, agroforestry practices would be the best land-use system for sustainable livelihood in Karongi District to cope with the above challenges.

Therefore, it is good to analyze the extent to which agroforestry practices contribute to the advancement of social and economic livelihood of the local community. Hence, this study is conducted in Karongi Districtin order to assess the socio-economic impact of agroforestry practices on farmers' livelihood. The results derived from the current study will serve as guide to decision makers on how agroforestry practices contribute to rural community socio-economic livelihoods improvement.

II. MATERIALS AND METHODS

2.1 Description of the study area

This study was conducted in Karongi District, one of seven districts of the Western Province of Rwanda. For this study, the authors randomly considered eight cells namely: Kibilizi, Gitwa, Gisanze, Nyarugenge, Ruragwe, Gacaca, Bubazi and Mataba. The Karongi District stretches over an area of 993 Km^2 with an altitude varying between 1,470 to 2,200 meters. The District is mountainous and part of the Congo Nil Ridge (Watershed) which falls in both Kivu and Upper Nyabarongo Sub catchment(Karongi 2018).Due to its relief and topography, soil erosion and landslides are frequent in most areas of the district. The Karongi District has two dry seasons covering the period from December to January and from June to mid-September. The annual average temperature varies between 16^{o}C and 21^{o}C. The district is also characterized by two rainy seasons. The long rainy season starts from mid-September to late December, and the short rainy season begins from February to June with an annual rainfall ranging from 1,100 to 1,500 mm (DDP 2013).

According to the 4th Rwanda Population and Housing Census (EICV4), Karongi District has 331,808 inhabitants (156, 073 males, 175,735 females). The district counts 73,326 households; the population density is 334 inhabitants per square km (Nagel et al. 2015). The settlement in Karongi District is scattered at 53.6% compared to 50.8% at national level. The district counts only 2% of urban areas, not well developed while the remaining is rural and suffers from limited basic infrastructures(Nagel et al. 2015).

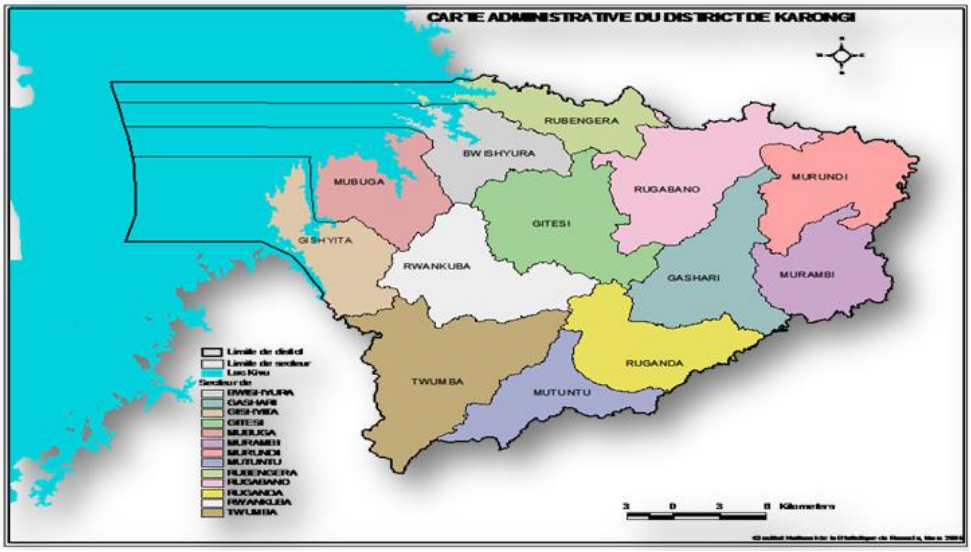

FIGURE 1: Administrative Map of Karongi district Source: Karongi, 2018

2.2 Methodology

For this study, a total of ninety (90) households were randomly selected from eight (8) villages in Karongi district. During the selection of 90 households, the authors made sure that half of the households (45) are Agroforestry Practioners (AFP) and the other half (45) is Non Agroforestry Practioners (NAFP).The authors considered that fact that it could not be possible to attain all the farmers, and then selected a representative sample among others. This study adopted purposive sampling procedure where a sample has been taken within a population of 8,802 households by using the formula of Dagnel, 2006.

$$n = \frac{Z^2 \times P \times q \times N}{d^n (N-1) + Z^2 \times P \times q \times N} \quad (1)$$

Where n is the sample size, Z is the coefficient of normal distribution, P is the probability of failure, d is the margin error and p is the probability of success and N is the total number of population (Universe size $<10^6$ individuals).

The margin error varies between 5 % and 10 %. By using the margin error of 10 %, the confidence level of 90 %, the probability of success (p = 0.5), failure probability (q = 0.5) and the coefficient of normal distribution (z = 1.65 in student table). Thus, the total households on these selected cells are 90 calculated by using the above formula.

$$n = \frac{(1.65)2*(0.5)*(0.5)*(8802)}{(0.1)2*(8802-1)+(1.65)2*(0.5)*(0.5)} = 89.8 = 90 \quad (2)$$

TABLE 1
NUMBER OF INTERVIEWED HOUSEHOLDS BY CELL

District	Cell	Total number of households	Selected sample of households
KARONGI	Kibilizi	1573	16
	Gacaca	1287	13
	Gitwa	1154	12
	Nyarugenge	1019	10
	Bubazi	939	10
	Ruragwe	1094	11
	Mataba	874	9
	Gisanze	862	9
Total		8802	90

Source: Karongi district Statistics, 2019

2.3 Data Collection and Analysis

This study targeted both the households in Karongi District that practice agroforestry practices (AFP) and those without agroforestry practices (NAFP) in their farmland. An intensive household survey was carried out by using the questionnaire between July and September 2019. The authors described the respondents by age, education level and sex. Thereafter, the study investigated on the types of trees used in agroforestry practices and the associated benefits to farmers practicing agroforestry compared to non-practioners of agroforestry. The Statistical Package for Social Sciences (SPSS) and Microsoft Excel were used to analyze primary data. Some data were checked randomly against original completed questionnaires to detect entry errors. Accordingly, the detected errors were corrected for analysis.

The Descriptive statistical analysis including frequency distribution, percentage, cross tabulation, mean and standard deviation (SD) were used for data analysis to summarize the farmers' socio-economic characteristics and farm specific characteristics. Furthermore, the Tables Pearson Chi-Square Test was used to analyze the relationship between dependent variables (Livestock asset, Physical asset, income and expenditure**,** use of generated income and health insurance) and independent variables (Agroforestry practices). In order to identify the variations, sample means were compared by performing independent t-test.

III. RESULTS AND DISCUSSION

3.1 Household characteristics

The following section described the respondents, both AFPA and NAFP by their age, sex and education level.

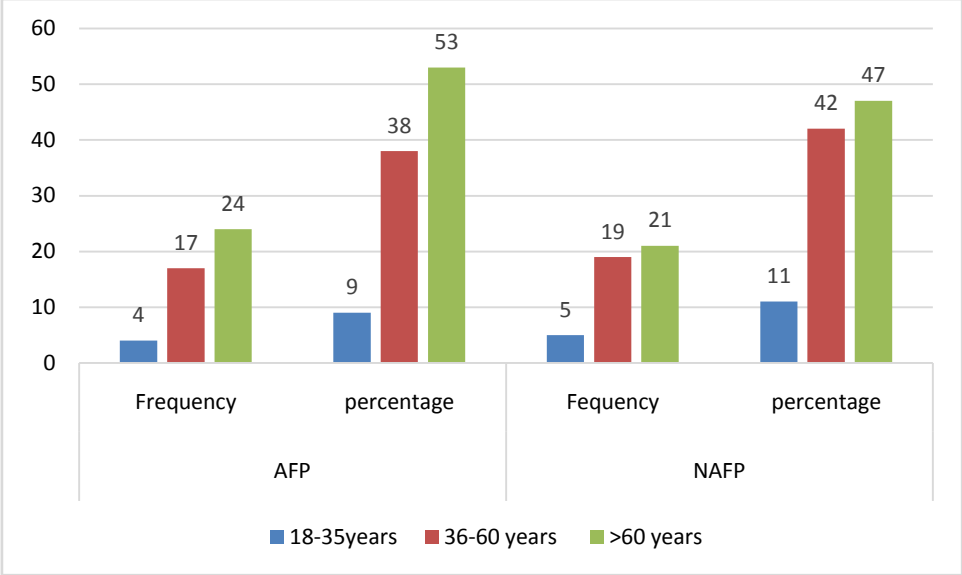

FIGURE 2: Age of respondents

From the results in the above Figure 2, it was noted that the majority of the surveyed farmers (53% of AFP and 47% of NAFP) are aged over 60 years old. A small proportion of respondents were composed by young people with4% and 11% of AFP and NAFP farmers, respectively. This indicates that the information on agroforestry practices and their social-economic benefits among the surveyed farmers was obtained from experienced people, as the majority of them (53 and 47 percent for the AFP and NAFP, respectively) are aged above 60 years. The study conducted in the Eastern Agro-Ecological Zone of Uganda, showed that farmers practicing agroforestry were above 42 years than non- agroforestry practioners and the difference was significant (Basamba et al. 2016).Also, the study conducted in China showed that the age of households implied a positive effect on farm yield (Ma and Abdulai 2016; Kumar et al. 2018). Likewise, the studies conducted in Ethiopia and Turkey, on the determinants of agricultural productivity and rural household income found out that farmers' age had a positive impact on their land productivity (Urgessa 2015; Gül and Ar 2019).

The findings of this study (Fig.2) showed the similarity with the study conducted in Busogo Sector of Musanze District of Rwanda which indicated that the high percentage (40.3 %) of the surveyed population was over 60 years old (Ndayambaje 2013). Accordingly, the study of Maduka (2007) reported that the high percentage (48%) of surveyed population was between 18-39 years old in Semi-Arid areas of Misungwi District, Mwanza, Tanzania. This indicates that age and experiences of an individual play an important role in application of indigenous knowledge and innovations(Makawia 2003; Akpınar et al. 2019).

TABLE 2
DESCRIPTION OF HOUSEHOLDS BY SEX

Sex	AFP		NAFP	
	Frequency	Percentage	Frequency	Percentage
Male	34	76	36	80
Female	11	24	9	20
Total	45	100	45	100

Source: Primary data, 2019.

From the results in Table 2, the number of NAFP (80%) and AFP (76%) male was higher than that of the female NAFP and NAFP which recorded 20 percent for both cases, respectively. This was likely due to the fact that the study surveyed the heads of households who are mainly male in Karongi district. These heads of families are decision makers that may affect the adoption of agroforestry practices (Ndayambaje 2013).Similarly, this was reported in Busia District, Uganda that there were more male than female farmers adopting (82.7%) compared to those who (79.1%) do not adopt agroforestry (Basamba et al. 2016).

In Karongi district, the level of education among AF farmers is generally high. About 73 percent of respondents of AFP and 67% of NAFP have formal education (primary level) while 6% of NAFP and 5% of AFP are illiterate (Table 3). The level of education is found to be significantly higher for AF farms than for NAF farms (Table 3).

TABLE 3
RESPONDENTS CLASSIFICATION BASED ON THEIR EDUCATION LEVEL

Level	AFP		NAFP	
	Frequency	Percentage	Frequency	Percentage
Primary	33	73	30	67
Secondary	5	11	3	7
Artisan School	4	9	9	20
Illiterate	2	5	3	6
University	1	2	0	0
Total	45	100	45	100

Source: Primary data, 2019.

The results of this study (Table 3) showed that Illiteracy is estimated at 5% among the AFP and 6% of NAFP. The results indicated that 20 percent of AFP and 9 percent of NAFP have studied in artisan school. This percentage is the results of the Craft production centers established across the district to provide the working facilities which most craftsmen and women cannot afford on their own. As the main part of farmers (73% of AFP and 67% of NAFP) interviewed has achieved primary school, this basic education can facilitate the delivery training to farmers and adoption of agroforestry practices which enhance their land use system and household welfare. The findings of this study (Table 3) are in congruency with report of Ndayambaje (2013) which revealed that the majority of agroforestry practitioners reached primary level of education (40.3%) in Busogo Sector of Musanze District of Rwanda. According to Basamba et al (2016), education was largely limited to primary level for both categories of agroforestry farmers. Similarly, such statement was reported (Sood and Mitchell 2009), that educated farmers are considered to be innovative or opinion leaders and willing to take more risks than illiterate farmers.

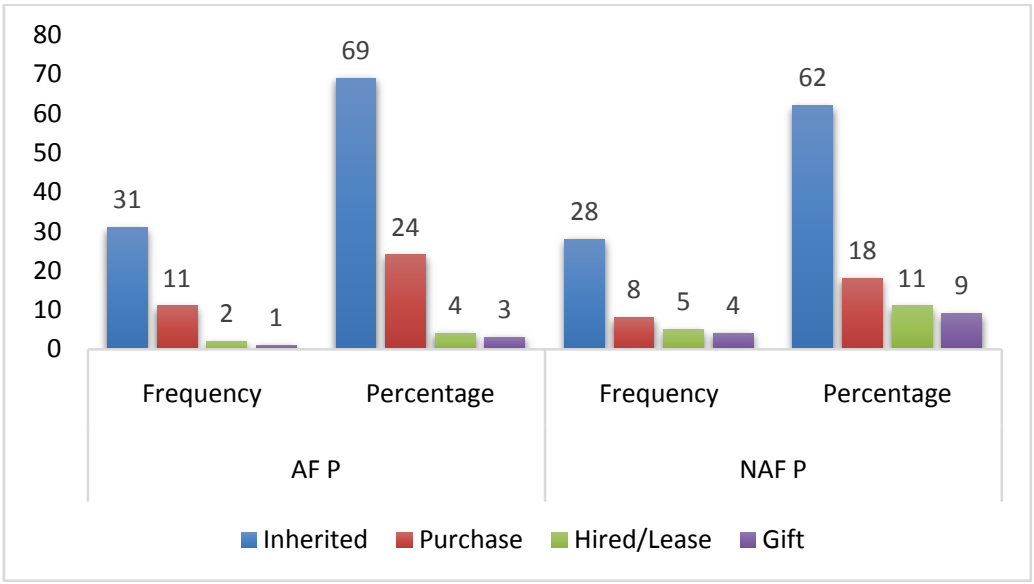

FIGURE 3: Respondent's classification according to land tenure.

The results in Figure 3 showed that in Karongi district, the land inheritance is the main mode used to get lands among farmers, as asserted by 69 % of AFP and 62% of NAFP. This is followed by land purchasing highlighted by 24% of AFP and 18%of NAFP, whereas the gift is the least mode of gaining land among people in Karongi district as mentioned by 9 % of NAFP and 3% of AFP. The findings of this study (Fig.3) agree with the results of Ndayambaje (2013) where land inheritance was ranked as the main mode (59.7%) in Musanze District of Rwanda. In addition, the study of Maduka (2007) reported that the major mode of land acquisition was mostly through inheritance (96.0%)in Semi-Arid areas of Misungwi District, in Mwanza, Tanzania. This kind of land acquisition motivates more farmers to extend agroforestry practice to their own lands.

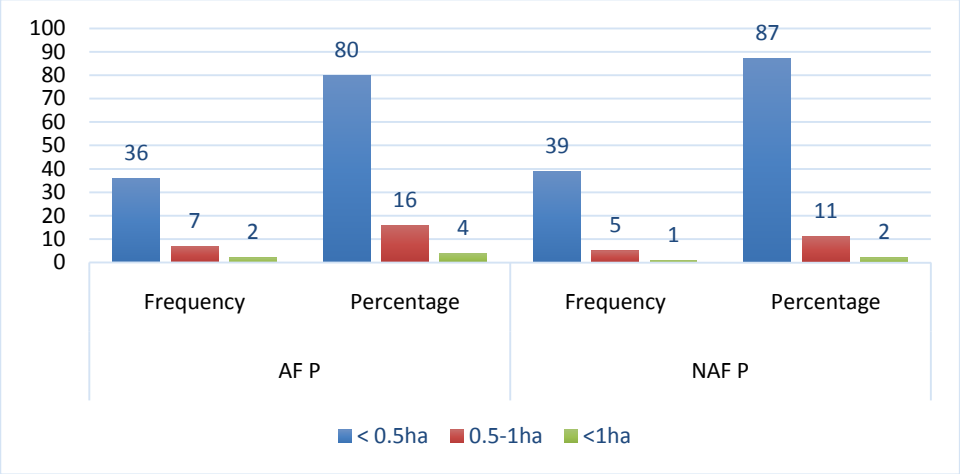

FIGURE 4: Farm size of respondents.

This study found that 80% of AFP farmers and 87% of NAFP have land size inferior than 0.5ha while 16% of AFP and 11% of NAFP have land ranging between 0.5 to 1ha (Fig. 4). According to the report of the Karongi District Development Plan (DDP, 2013), the mean size of land cultivated per household is 0.5 ha, which is slightly higher than the national average (0.59ha). The EICV3 reported that in Karongi district, 77.7% of households own less than 0.99 ha of land, among them 36.7% own less than 0.2 ha, and only 22.3% own more than 1 ha. Similar results were reported in Legho Mulo, in Kilimanjaro region where the landholding is 0.58 ha (Maduka 2007; Kessy 1992). However, due to these land shortages, farmers have adopted contour and terrace practices which have been providing better results due to favorable climatic condition.

3.2 Agroforestry Practices

TABLE 4
TYPES OF TREES GROWN BY FARMERS

Species	Frequency	%	Mean Rank
Callianda Calothyrsus	33	73	6.37
Persea Americana	44	98	4.62
Dracaena Afromantana	42	93	4.69
Euphorbia Tirucarri	40	89	5.75
Cajanus Cajan	17	38	7.06
Psidium Guajava	38	84	4.85
Persea Americana	44	98	4.62
Ricinus Comminus	36	80	5.05
Mangifera Indica	36	80	5.35
Leucana Diversifolia	33	73	5.70
Grevillea Robusta	45	100	4.60
Alnus Acuminata	35	78	5.35
Morus Alba	23	51	7.02
Ficus Thonningii	32	71	6.87
Markhamia Luthea	31	69	6.45
Eurthryna Abssynica	30	67	6.98
Carica Papaya	15	33	7.10
Test Statistics[a]			
N			**45**
Chi-Square			**111.335**
Df			**8**
Asymp. Sig.			**0.002**

a. Friedman Test; **b.** Ranks are in ascending order; **c.** 2 groups are generated; **d.** Consecutive ranks with ties sharing the same value

The Table 4 above indicated the trees planted by households in Karongi district as agroforestry practices. The results showed that the *Grevillea Robusta* (100%) is planted by all surveyed farmers in Karongi district with the Chi-squared value p-value = 0.002. In addition, the results in Table 4 indicated that the Grevilea Robusta was the agroforestry specie adopted by many farmers with high ranking of 4.60 while the lowest observed specie with lower ranking of 7.10 was the *Carica Papaya* (Table 4).

Also by using the Friedman Test, the study (Table 4) showed the p-value of 0.002 which means that there is no statistically significant difference in the number of farmers who adopted agroforestry species. The agroforestry practices used by farmers influence the choice of agroforestry species and their adoption. The Table5 below showed the agroforestry practices which are planted within the selected households in Karongi district.

TABLE 5
TYPES OF AGROFORESTRY PRACTICES IN KARONGI DISTRICT

Agroforestry practice	Frequency	%	Mean Rank
Alley Cropping	42	93	3.13
Live fences	19	42	5.91
Trees on farm boundary	41	91	3.09
On contours and Terraces	44	98	2.82
Around road and pathways	29	64	3.34
Homegarden	25	56	3.86
Test statistics[a]			
N			45
Chi-Square			62.5756***
Df			5
Asymp. Sig.			**0.025**

a. Friedman Test
b. *** imply statistical significance at 0.001

As indicated in Table 5, the most important agroforestry practice adopted by the farmers in Karongi district is trees planted on contours and terraces (98%) with the Chi-squared value p-value = 0.025. The findings of this study are similar to the study conducted in Musebeya sector, Nyamagabe District in the southern province of Rwanda. The study reported that the predominant agroforestry practices included alley cropping, woodlots, and boundary planting (Kiyani et al. 2017). In the above Table 5, the ranking highlighted the contours and terraces as the largely adopted agroforestry practice (rank of 2.82) compared to the live fences which ranked 5.91. Also by using the Friedman Test, the p-value of 0.025 was obtained, which means that the current agroforestry practices in Karongi district have a significant difference among farmers.

3.3 Agroforestry socio-economic benefits among household

3.3.1 Livestock ownership

Although the sale of crops and non-farm income are considered as main source of income for most households, farmers also get income from the sale of livestock. Most households rear different kinds of livestock including chicken, cattle, goat, sheep and pig. The livestock rearing is mainly practiced for two major reasons: income and food.

TABLE 6
TYPES OF REARED LIVESTOCK IN KARONGI DISTRICT

Livestock Assets	AFP			NAFP			Significance P value
	Mean	SD	%	Mean	SD	%	
Cattle	1.18	1.09	73	0.49	0.87	27	0.001**
Goat	1.31	1.04	78	0.69	0.79	51	0.001**
Poultry	1.64	1.46	80	0.76	1.21	33	0.002**
Pigs	0.29	0.51	27	0.20	0.40	20	0.359
Rabbit	0.64	1.19	31	0.33	0.65	20	0.144
Sheep	0.38	0.75	24	0.13	0.40	11	0.056*

Source: Primary data, 2019.

The results of this study in Table 6 indicated an average poultry of 2 for AFP and 1 for NAFP. For the goat, cattle and poultry rearing, it was found that the number of livestock is significantly higher for AFP than for NAFP (Table 6). Thus, there is statistically significant difference between livestock numbers among the two categories of households. This was confirmed by the study of Chakraborty et al (2013) where cropland agroforestry (CAF) farmers have 3 cattle per household, whereas non-cropland agroforestry (NCAF) farmers have 2 cattle per household on an average.

3.3.2 Physical assets ownership

Physical asset is a source of coping with shocks in the rural livelihoods. It is also a good indicator of life standard. People having more physical assets likely enjoy more social status than others (Chakraborty et. al.2013).

TABLE 7
PHYSICAL ASSETS OWNERSHIP

Physical asset	AFP			NAFP			Significance P value
	Mean	SD	Percentage	Mean	SD	Percentage	
Radio	0.69	0.47	69	0.73	0.50	53	0.646
Mobile Phone	0.80	0.40	80	0.62	0.49	62	0.063*
Bi-cycle	0.64	0.48	64	0.47	0.50	47	0.091*
Motor cycle	0.36	0.48	36	0.31	0.47	31	0.659
Television	0.51	0.51	51	0.38	0.49	38	0.207

Source: Primary data, 2019.

The results of this study in table 7 revealed that80 percent AFP have mobile phone compared to 62 percent of NAFP, and the possession of television is high for the agroforestry Practioners (51%) compared to the non-agroforestry Practioners (38%). The results indicated that the possession of the considered physical assets among the AFP is higher than that of NAFP. There are significant differences ($p<0.10$) in cases of bi-cycle and mobile phone ownership at 10 percent level of significance between the two categories of households (Table 7). The results of this study are similar to the study of Chakraborty et al. (2013) on the possession of television among CAF and NCAF, which indicated 55 and against 38 percent, for AFP and NAFP, respectively.

3.3.3 Main income sources

TABLE 8
INCOME SOURCES AMONG HEADS OF HOUSEHOLDS

Principal occupation	AFP		NAFP	
	Frequency	Percentage	Frequency	Percentage
Farmers	36	80	34	76
Handcrafts	4	9	7	16
Traders	3	7	2	4
Other groups	2	4	2	4
Total	45	100	45	100

According to the results in Table 8, the majority of AFP respondents (80 %) and 76% of NAFP grow crops, followed by handcrafts (16 % for NAFP) and 9% for AFP, along with trading occupied by 7 %and 4% of AFP and NAFP, respectively.

3.3.4 Health insurance

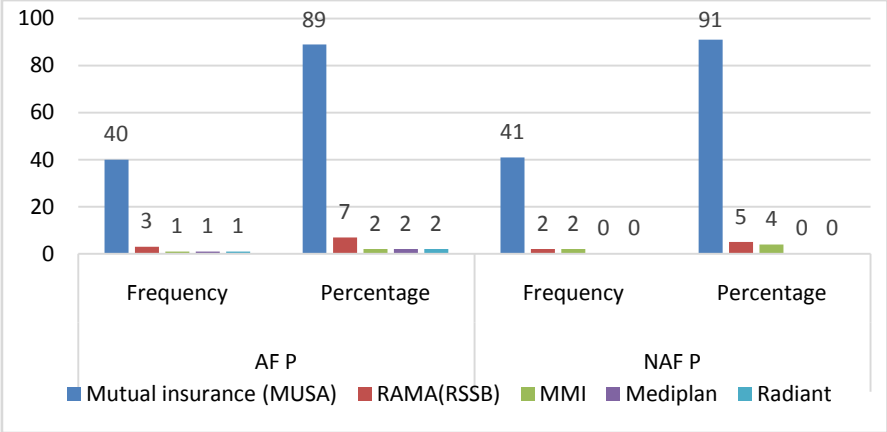

FIGURE 5: Possession of health insurance among respondents

The results in Fig.5 showed that 89 percent of AFP and 91% of NAFP use the Community Health Insurance, known as Mutuelle de Sante (MUSA) for health care whereas 7 percent of the AFP and 5% of NAFP employ the RAMA (Figure 5).

3.3.5 Income and expenditure among farmers

TABLE 9
AGROFORESTRY PRODUCTS HARVESTED

Product	Frequency	Percentage
Fruits	45	100
Stakes	34	80
Firewood	7	16
Building (poles &timber)	23	51
Biomass (green manure)	23	51
Fodder	3	7
Charcoal	2	4

Source: Primary data, 2019.

According to the results in Table 9, the agroforestry trees planted by respondents in Karongi district are mainly for fruits (100%), stakes (80%), building and green manure (51%).

TABLE 10
CASH INCOME (in million Rwfs) AND EXPENDITURE BY AFP AND NAFP

Indicators	AFP				NAFP				Significance P Value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Annual Income	0.49	0.25	0.08	1.1	0.37	0.20	0.07	1	0.016**
Annual Expenditure	0.40	0.20	0.06	0.83	0.35	0.18	0.07	0.87	0.362

AFP: Agroforestry Practioners and NAFP: No-Agroforestry Practioners
Source: Primary data, 2019

The result in Table 10 showed that the mean income of AF households is 0.49 million and 0.40 million for NAF households in Karongi district. This expresses that the AF households' mean yearly income is higher than that of NAF households. The results in Table 10 indicated that the difference between mean income between the AF and NAF farmers is significantly different at 5 percent level of significance whereas the average expenditure values are not significantly different (P0.362) between The AF and NAF groups. The results of this study (Table10) are similar to the report of Chakraborty et al.,(2015)which indicated that the mean income of cropland agroforestry farmers (CAF) was Tk. 0.19 million and Tk. 0.13 million for cropland agroforestry farmers (NCAF) in Jessore District of Bangladesh. According to the study conducted in Nyamagabe District of Rwanda on the adoption of agroforestry, the practice has contributed to the increase of famers' income where the mean annual income of AFP was higher than that of NAFP at 278,000 Rwfs (about US$331) and 249,000 Rwfs (about US$297), respectively (Kiyani et al. 2017).

In addition, the report from the survey in Mwanga district of Tanzania indicated that AF participants in average had extra income than non-AF participants of almost US$ 617.5 annually (Charles et al. 2013). This expresses that agroforestry is one way to attain higher income and expenditure that leads to improving the socio-economic conditions and livelihood of farmers. Additionally, for this study (Table 9), the interviewed farmers reported increasing incomes through sales of local fuel wood and testified that that agroforestry helps to improve their social economic livelihoods in general. In Karongi district, the difference in incomes between AFP and NAFP can be attributed to factors like type of agroforestry practices adopted, number and type of trees species established and sold, and land ownership. Furthermore, the extra income obtained by AFP compared to NAFP can result from the levels and readiness of farmers in testing different interventions when delivered to them, like purchase of physical assets, keeping livestock, health insurance and improving well-being status of household as compared to non-AF practitioners.

TABLE 11
USE OF GENERATED INCOME BY HOUSEHOLDS

Indicators	AFP				NAFP				Significance P Value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Energy	0.014	0.011	0	0.04	0.020	0.018	0	0.01	0.083*
Buying Food	0.163	0.12	0.01	0.46	0.109	0.09	0.009	0.419	0.023**
Paying School fees	0.115	0.079	0.02	0.32	0.113	0.085	0.007	0.3	0.895
Clothing	0.05	0.021	0.01	0.12	0.054	0.03	0.01	0.12	0.462
Medical insurance	0.025	0.006	0.015	0.04	0.024	0.118	0.015	0.65	0.460
Further investment	0.034	0.029	0	0.17	0.029	0.022	0	0.1	0.304
Agricultural inputs	0.154	0.112	0.015	0.409	0.109	0.094	0.015	0.419	0.047**
Building	0.201	0.15	0.015	0.07	0.108	0.095	0.008	0.419	0.001**

Source: Primary data, 2019.

From the independent t-test of the weighted mean of AF and NAF households, it is found that there is a clear difference between two categories of farmers. The use of income for the AF farmers for the food security, agricultural inputs and buildings is significantly higher ($p<0.05$) than that of NAF farmers (Table 11). The results of this study as shown in Table 11, agreed with previous report of Maduka (2013) that the income from agroforestry maintains the basic household needs, provides food security and fuel wood, and contributes to healthcare, housing and sanitation conditions, and meeting educational expenses.

It is reported by Ospina (2017) that in some place without agroforestry practices, some women and child would walk over 5 kilometers to collect firewood from state forests. Very often women who must travel so far for basic resources are at risk of assault during their journeys and have less time to devote to other household activities. The findings of this study in Fig. 6showed that the adoption of agroforestry in Karongi District significantly reduced the amount (2000 Rwfs) of fuel wood purchased and the time that households used to spend while collecting wood.

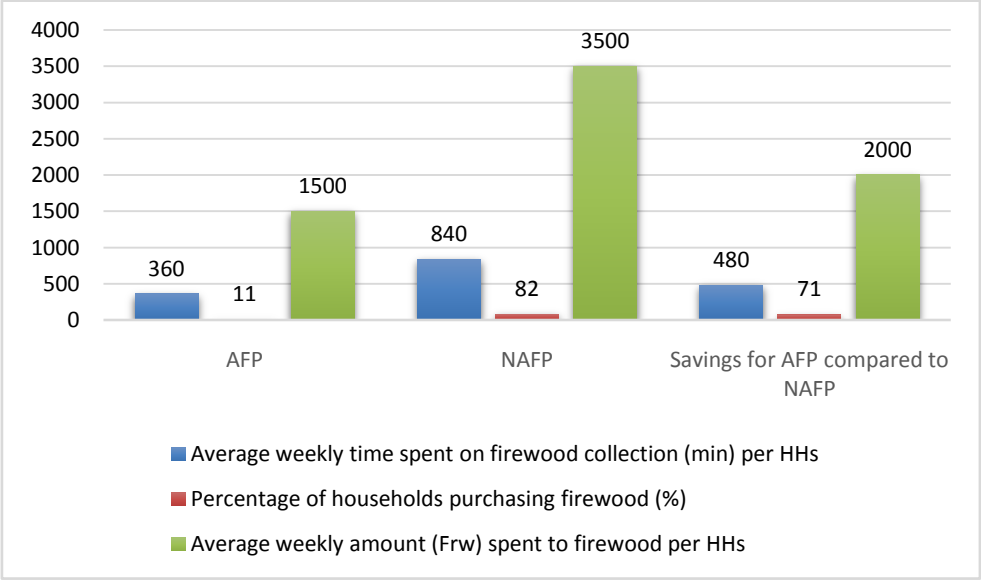

FIGURE 6: Amount and time spent by households on purchasing and collection of fuel wood

According to the results of this study (Fig.6),the respondents asserted that practicing the agroforestry has reduced the time spent on collecting firewood. This enabled AFP to save an average weekly time of 480min.In addition, the results in Fig. 6showed that households spend the average weekly amount of 1,500Rwf for AF and 3,500Rwf for NAF for purchasing fuelwood. This expresses that the agroforestry practices decreased the weekly amount spent up to 2,000Rwf for AFP compared to NAFP.

IV. CONCLUSION

Agroforestry has great potential to improve social and economic conditions in developing countries. Its ability to improve soil quality and mitigate climate change through carbon sequestration should also make it an appealing agricultural method in countries with more significant economic resources or large farm systems. This study surveyed 90 heads of households in Karongi district and compared the agroforestry socioeconomic benefits between agroforestry practioners (AFP) and non-agroforestry practioners (NAFP). The authors used a questionnaire to collect data from the selected respondents. The results indicated that agroforestry practice has a significant impact on farmers' livelihoods. It was noted that the AFP can save an average weekly time of 480min on fuel wood collection and a weekly amount of 2,000 Frw compared to the NAFP. Moreover, the findings indicated that the income of farmers who have adopted agroforestry practices is increasing since its introduction in the district. The findings of this study can serve as guidance to policy makers to design the necessary support measures to expand agroforestry practices toward increasing farmers 'livelihoods. This will ultimately improve rural communities' living standards, forest cover, and mitigate climate change as well.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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