Assessing the contribution of agroforestry species in the conservation of Volcanoes National Park (VNP) in Rwanda

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Abstract: The purpose of this study was to assess the contribution of Agroforestry species in the conservation of Volcanoes National Park (VNP) where illegal activities such as wood and water collection, beekeeping and illegal hunting were observed. In order to overcome these issues, the strategies for conserving VNP should consider the introduction of agroforestry practices around that protected area. This study aimed at providing the information on role of agroforestry species in supporting the conservation of VNP. This study was conducted in June and July 2011 in Gataraga Sector of Musanze district in Rwanda. Data were collected by using a structured questionnaire containing open and closed-ended questions. The formal and informal interviews were conducted with 108 households 'heads randomly selected. The data were analyzed using Statistical Package for Social Sciences (SPSS) version 16. The results showed that agroforestry practices provided the services to farmers such as homestead, farm boundary and multipurpose trees on farmlands (in their spatial structural arrangements). Agroforestry species such as *Alnus acuminata, Grevillea robusta, Persea Americana*, *Cedrela serrata*, *Erythrina abyssinica*, *Polyscias fulva*, *Ricinus communis and Senecio manii* were adopted by the majority of respondents. The major constraints of existing agroforestry species include small land holdings, lack of seedling for planting and lack of technical assistance. Firewood is the most important benefit gained from the agroforestry species. The respondents perceived positively the future potential role of agroforestry in VNP conservation because Agroforestry practices could help reduce the dependency of local communities on VNP resources**.** As agroforestry practice plays a significant role in VNP conservation, by improving the livelihood of local communities, more attention should be paid to its incorporation in protected area policy.

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1. Introduction

Agroforestry is a symbiosis of tree growing, crop production and livestock (Bandyopadhyay, 2001). It is also a land use system in which trees or shrubs are grown in association with agricultural crops, pastures or livestock (Baumer,1987). These definitions imply that in agroforestry system: 1) there are two or more species of plants and animals of which one is woody perennial; 2) there should be a biological and economic interactions within the components; 3) the cycle of agroforestry system is always more than one year (Mesele, 2002). An agroforestry system consists of one or more agroforestry practices that are practiced extensively in a given area and the system is usually described according to its biological composition and arrangement, the level of technical management or the socioeconomic features. An agroforestry practice denotes a specific land management operation on a farm or other management unit and consists of arrangements of agroforestry components in space and/ or time (Gholz, 1987). Agroforestry plays a significant role in reducing the pressure that human being exerts on protected forest area in search of forest resources by providing the required products and services being obtained from natural forest. The introduction and development of agroforestry practices into buffer zones around protected forest areas has been suggested as a practical option which may not only reduce the pressure on forest resources but which can also improve the livelihood conditions of local communities (Van Orsdol, 1987). Illegal activities have been noticed around VNP such as keeping beehives, water and wood collection, illegal hunting and medicinal plant collection. To overcome this issue, the strategies for conserving VNP included the introduction and development of agroforestry practices around that area. Therefore, the present study mainly aims at providing the information on the current situation on the roles of agroforestry species in the conservation of Volcanoes National Park in Rwanda. The specific objectives to achieve are as follows : (i) To determine the existing agroforestry practices around the VNP ; (ii) To assess the perception of local communities on the benefits obtained from agroforestry practices in that area ; (iii) To assess the challenges of existing agroforestry

species in the study area ; (iv) To generate information on the development and use of agroforestry practices in the conservation of VNP. To achieve the stated objectives, the study will answer the following research questions : (1) At which extent the agroforestry practices are done around VNP? (2) What are the benefits that the local communities obtain from these agroforestry practices?(3)What are the challenges related to the existing agroforestry practices around VNP? (4) How do the local communities perceive the development and contributions of agroforestry practices in the conservation of VNP ?

2. Material and methods

Study area description

The study area is Gataraga sector situated in Musanze district, Northern Province, Rwanda. About 92% of its land is used for agriculture. The total population of Gataraga sector is 17,247 inhabitants with a density of 505 inhabitants per square kilometer. The climate is characterized by four seasons well established as follows: Short rain season covering the period between September and December; short dry season starting around mid-December and lasting in February; long rain season covering the period ranging from March to June and long dry season starting from June and ending in September. The annual average temperature ranges from 15ºC to 21ºC with an annual rainfall of 1400 mm. The soil type is volcanic with an average pH of about 5.9. Gataraga sector is also located at 2200 m a.s.l.

Methods

Data were collected by using a structured survey questionnaire containing open and closed-ended questions. The formal and informal interviews were conducted with 108 households 'heads randomly selected at the sector level. Pretesting method was used with 25 randomly selected respondents. The data were analyzed using Statistical Package for Social Sciences (SPSS) version 16 where Friedman test one way ANOVA and logistic regression analysis were applied. Cluster and purposive sampling methods were used at the cell level and a proportionate allocation sampling method was used in order to know the sample size in each cell. Two selected cells were Rungo and Mudakama with 65 and 43 respondents respectively.

3. Results and discussion

Table 1: Agroforestry species found in farmers' plots around VNP

AF Species	Mean Rank	Chi square	Asymptotic significance
Alnus acuminata	2.67	499.871	0.000
Polyscias fulva	5.59		
Ricinus communis	6.84		
Persea americana	6.65		
Cedrella serrata	6.61		
Grevillea robusta	3.83		
Erythrina abyssinica	2.67		
Senecio manii	6.65		

The table1 above showed that the most abundant species introduced by farmers in the study area is *Alnus acuminata*. This exotic species plays a significant role in soil conservation around VNP. The probable reasons for the acceptability of *Alnus acuminata* by farmers include coppicing and fast growing abilities, fodder production and the use of stems for bean stakes. Other exotic tree species include *Grevillea robusta, Persea Americana* and *Cedrela serrata*. The farmers are also aware of the importance of indigenous species in soil conservation and soil fertility improvement. The commonest indigenous plant species are *Erythrina abyssinica, Polyscias fulva*, *Ricinus communis* and *Senecio manii*. Shade service (for humans and livestock), conduciveness for beehives placing, ability to increase soil fertility, fodder provision, wood for construction, firewood, fast decomposability, having lower branch volume (to minimize the intensity of shade) and palatable leaves by animals are the main services provided by the agroforestry trees that influenced the farmers in the study area to incorporate them in their farmland. The Friedman test showed that those species have a significant difference between them because the p-value (0.0) is less than alpha (α) equal to 0.05.

Table 2: Factors affecting existing Agroforestry species in farmland

Factors	B coefficient	Standard error	Significance
Illiteracy	-1.348	00.883	0.05**
Primary education	1.253	0.735	0.003*
Single	-0.294	0.585	0.617
Married	0.345	0.367	0.266
Lack of seedlings	-0.686	0.709	0.336
Access to technical assistance	0.440	0.527	0.004*
Prunning	-0.421	0.436	0.0336**
Source of income	-0.069	0.071	0.033**

Shortage of land	-0.432	0.512	0.0337**
Benefits obtained from VNP	0.090	0.185	0.627
Benefits obtained from AF species	0.034	0.105	0.748

**** (p-value at 10%); *(p-value at 5%)**

The table 2 indicates that illiterate farmers, being single, shortage of land, lack of seedling, pruning and source of income are the respective factors having negative impact on the existing AF species in farmland around VNP while primary education, access to technical assistance on AF practices, the benefits obtained from VNP and the benefits obtained from AF species have the positive impact on the existing AF species. Concerning illiteracy, the non participation in school makes the number of AF species reduced. This means that the farmers who attended schools have more AF species than those who did not go to school. Being single and the marital status situation amongst farmers negatively influenced the adoption of agroforestry species. Married farmers adopt quickly the agroforestry system than single people because of high level of needs in tree products and services such as wood, timber and fruits. In addition, both husband and wife gain better advice from each other for better agricultural production improvement through the adoption of agroforestry species. The lack of seedlings for planting decreases the AF species. Paying less attention on AF management practices especially pruning practice led the farmers to get less AF production. The shortage of land among farmers constitutes a barrier to agroforestry practices because farmers tend to use the small sized land for crop production instead of planting AF trees. Moreover, the lack of sufficient household income led to the non adoption of AF species. The increase of access to technical assistance for farmers and the benefits obtained from VNP led to a high number of AF species grown. Furthermore, illiteracy, primary education, shortage of land, pruning practice, access to technical assistance and source of income have significant impact on existing AF species in Gataraga Sector. Therefore, the farmers have to put more effort for planting more AF species.

Table 3: Benefits gained from AF species

Benefits	Mean Rank	Chi square	Asymptotic significance
Timber	4.59	330.726	0.000
Fodder	3.62		
Stakes	2.26		
Fruits	4.31		
Medicinal plants	4.48		
Fire wood	1.73		

The table 3 showed that the farmers gave greater importance on the firewood than timber, fodder, stakes, fruits and medicinal plants. This means that farmers consider the firewood as their basic need because of lacking the opportunity to collect wood from VNP. Friedman test showed that the benefits obtained by farmers from AF species have a significant difference on the farmers' livelihood because p-value (0.0) is less than alpha(α) equal to 0.05. Similarly, farmers in South East Langano in Ethiopia maintained trees and shrubs in their farmland for different socio-economic purposes including medicinal products, provision of shade and shelter, fodder, fuel wood and alike (Biruk, 2006). In Indonesia, the Agroforestry systems provide significant economic benefits to people. For example, smallholders grow stands of trees as components of their diverse farming systems and help to make the country the world second largest producer of natural rubber and about three-quarters produced by smallholders (Nyhus & Tilson, 2004).

Table 4: Farmer's response to external factors that contributed to VNP vegetation cover

Factors	B coefficient	Standard error	Significance
1.Benefits obtained from VNP	0.007	0.016	0.682
2.Benefits obtained from AF species	0.013	0.025	0.612

The table 4 shows that both benefits obtained from VNP and benefits obtained from AF species have positive impact on VNP vegetation cover change. 83.3% of respondents indicated that the VNP vegetation cover was highly increasing compared to the situation of ten years ago. Another study conducted by Shekhar (2001) in India showed that harvesting of fuel wood and timber has profound effects on biodiversity in forest ecosystem. This may often lead to the change in species composition and vegetation structure. The same author also noted that uncontrolled grazing by domestic livestock can remove the biomass from natural ecosystems, causing direct impact on forest regeneration process.

5: AF species as an alternative solution to farmers' needs

AF species	Mean Rank	Chi square	Asymptotic significance
Alnus acuminata	2.11	251.091	0.000
Calliandra callothyrsus	2.57		
Sinarundinaria alpina	3.63		
Grevillea robusta	2.34		
Other flowering plant species	4.35		

The table 5 shows that the majority of respondents indicated *Alnus acuminata* as the major AF species which can be an alternative solution to their needs because It can provide wood for cooking or constructing houses. *Grevillea robusta*, *Calliandra callothyrsus, Sinarundinaria alpina* and flowering plants follow respectively. Friedman test revealed that those AF species have significant difference between them because p-value (0.0) is less than alpha(α) equal to 0.05.

Table 6: Factors affecting the reasons for not destroying VNP

Factors	B coefficient	Standard error	Significance
1.Benefits obtained from VNP	0.049	0.041	0.238
2.Benefits obtained from AF species	0.151	0.071	0.0362
3.Fear of conservationists	0.044	0.032	0.003

The table 6 above indicates that three factors such as the benefits gained by farmers from VNP, the benefits obtained from AF species and the fear of government and non government agencies in charge of VNP conservation have a positive relationship with the effective VNP conservation. This is due to the fact that farmers in the study area get the benefits from VNP conservation incetives such as road construction and rehabilitation, dispensaries construction and financial and technical support to farmers' associations and cooperatives. The farmers also get the goods and services from AF species such as firewood, wood for construction, fruits, fodder and bean stakes. In Budongo forest in Uganda, another study done by Kasolo & Temu (2008) got the same results. It was highlighted that the importance of careful selection of AF tree species and appropriate niches in farmlands around forest ecosystem were the major conservation strategies for threatened forest resources.

4. Conclusion

An assessment of the roles of agroforestry species in the conservation of VNP in Rwanda was conducted in Rungo and Mudakama cells of Gataraga Sector in Musanze district, in June and July 2011. Data were collected by using a survey questionnaire and data analysis was done by using SPSS software 16th version. 108 respondents indicated that farmers have adopted Agroforestry species in their farmland. The results showed that agroforestry practices such as homestead, farm boundary and multipurpose trees on farm lands (in their spatial structural arrangements) were observed. Agroforestry species such as *Alnus acuminata, Grevillea robusta, Persea Americana*, *Cedrela serrata*, *Erythrina abyssinica*, *Polyscias fulva*, *Ricinus communis and Senecio manii* were adopted by the majority of respondents. The major constraints of existing agroforestry species include small land holdings, lack of seedling for planting and lack of technical assistance. Firewood is the most important benefit gained from the agroforestry species. The dependency on VNP resources includes wood collection for cooking and building houses. The respondents perceived positively the future potential role of agroforestry in VNP conservation because Agroforestry practices could help reduce the dependency of local communities on VNP resources.

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