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Impact of EBA activities on stallholder farmers' land restoration and their socio-economic development, a case study of trees planted by LDCF II in Ngororero District, Western Province - Rwanda

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ABSTRACT
This paper assessed the impact of EbA Activities on smallholder farmers' land restoration and their socio-economic development: A case study of trees planted by LDCF II in Ngororero District, Western Provence-Rwanda. The study was guided by three objectives: (i) assessment of the impact of EbA activities on soil physical properties, (ii) assessment of the impact of different EbA activities on reduction of soil acidity parameters (H and Al) and increase plant nutrients (iii) evaluation of socio-economic and environment benefits gained by farmer after intervention of EbA activities by LDCF. The findings of this study showed that EbA intervention had positive impact including: soil erosion was reduced (98.7%), soil fertility and productivities was increased (97.4%), water runoff was minimized (96.1%), soil nutrients content was increased (92.2%), the soil conserve water for long period (82.2%), increase of earth worms in the soil (81.3%), change the soil color (76.4%) and reduced cracking (72.6%). Implementation of EbA showed positive effects where local community said that after EbA intervention there is no case of malnutrition in our cell 96.5%, agricultural production increased 94.8%, we have more than one meal per day 86.1% and no drop out student due to school fees 86.1%. On the other hand, this study showed that EbA activities increased soil fertility element such N, P, K, Ca, and Mg while reducing soil exchangeable parameters. This study also concluded that EbA activities have a significant impact in the study area. It validates two hypotheses said (i) EbA activities in the study area affect positively soil physical properties and (ii) EbA activities in the study area increase soil plant nutrients. And recommend to use of EbA approach to help people to resist the impacts of climate change which leading degradation and poor functioning ecosystem. This study also recommends to evaluate the time that EbA activities takes to have a significant impact, this will help institutions, governments and NGOs to integrate local community in implementation of EbA on large scale. Based on finding of this study and field observation, I recommend REMA to expand EbA activities all over the country to protect and maintain the benefits and services from healthy ecosystem.

Keywords: Smallholder farmers, land restoration, Ecosystem based adaptation (EbA) activities, soil acidity parameters, socio-economic development and LCDF project.

I. INTRODUCTION

This paper aims at assessing the impact of EbA Activities on smallholder farmers' land restoration and their socio-economic development: A case study of trees planted by LDCF II in Ngororero District, Western Provence-Rwanda. Different previous studies on land restoration, like Udawatta et al., (2017) showed that Land degradation defined as a long-term loss or reduction of ecosystem services and function, caused by disturbances from which the system cannot recover unaided.

Also, Aldeen et al., (2013) showed that degradation of environment like soil erosion, reduction of fertility, overexploitation of soil and ground water, reduction of forested area and scarcity of resource are serious issues and the one way of handle this issues is to adopt agroforestry as systems to attain a diversified and sustainable production system. It has high potential to deliver different products to the farmers and generate local income. For Saturday, (2018), restoration of degraded land is very crucial for sustainability of agriculture and environment. Nowadays land is under high pressure caused by over rising population thus resulting in growing demand for food, shelter and fiber. Agricultural land is being deteriorated due to different anthropogenic and natural factors. Agroforestry species reduce the intensity of splash erosion and run off through decrease of raindrops impacts on the soil. Those species also regulate soil temperature due to its shade and then may results in reduction of water evaporation.

On Ecosystem based adaptation (EbA), USAID, (2019) report showed that EbA is an approach based on nature where ecosystem services and biodiversity are used or integrated to help local communities to withstand different effects of climate change. This ecosystem-based adaptation approach included different activities like protection, sustainable management and restoration of ecosystem to provide both products and services of an ecosystem that help local community to withstand variability and change of climate.

Swiderska et al., (2018), highlighted principles for any approach or activity to be qualified as EBA, it might address all of the follow three elements (i) help local community to adapt to effects of climate change; (ii) Active utilization of biodiversity and ecosystem services, (iii) In the context of an overall adaptation approach.

For UNEP, (2021), EbA contributes to the conservation of ecosystem and biodiversity and climate change adaptation to provide both social and economic benefit. EbA have guidelines which define why addressing the problem of climate change risks via EbA provides the achievement of very wide development goals. By putting local community (people) in the center, EbA integrate community based and fully participatory methods to the local level and then go up to the high level like provincial or national. This is for guiding the activity of planning and policy development to increase adaptation effects.

On the impact of agroforestry as EbA approach on land restoration, Mulyono et al., (2019) showed that Agroforestry as main EbA approach has a considerable potential as a major alternative land use management for maintaining and conserving fertility of soil. Woody plants and other vegetation located in agroforestry system have ability to improve soil properties underneath them. Agroforestry contributes in different processes which resulting in soil health such as increase of nutrients into the soil, minimize losses of nutrients from soil, affect physical properties of soil, affect soil chemical properties and affect soil biology.

II. MATERIALS AND METHODS

For the methodological details, the research was conducted in Ngororero District (District, N. (2019) and for sampling, the researcher had two parts; the first part focused on survey for assessing the socio-economic and environmental impacts of EbA intervention through implementation of LDCF on the study area while second part was focused on soil analysis for assessing the impact of EbA activities on land restoration. For the collection of primary data was conducted in sampled households, which were selected randomly from the study area. The sampling method that I was used to study population was randomly sampling, the households that was selected, were ones from beneficiaries of LDCF projects. For sample size determination, 230 respondents were calculated, and for data collection, after preparing questionnaire, I visiting selected farmers and interviewed them in order to get needed data to be used in assessment of environmental and socio-economic benefits. Then for data analysis, after data collection and data was analyzed using Microsoft Excel, SPSS (statistical package for social sciences).

III. RESULTS

4.1. Awareness and Participation in EbA Interventions

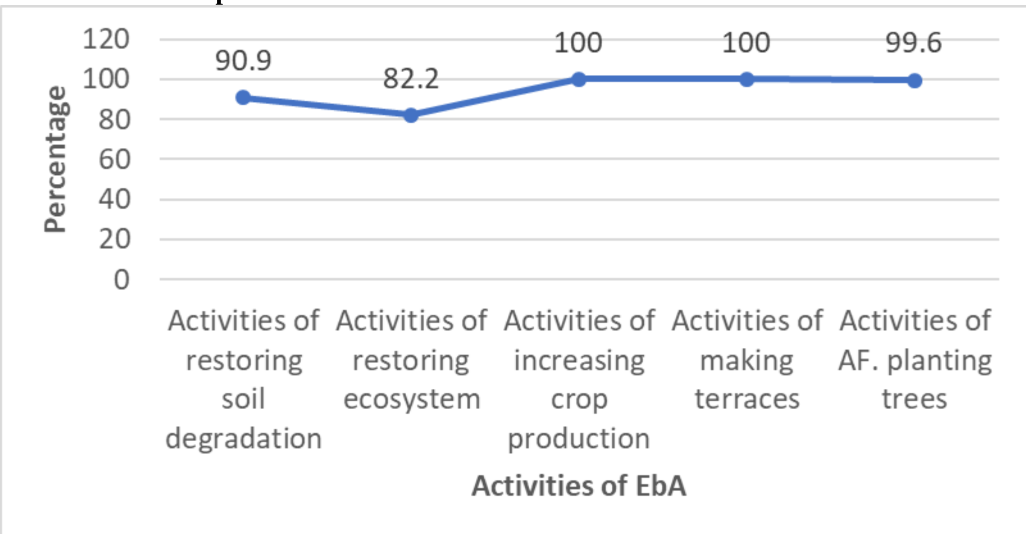

Figure 1: **Implementation of EbA approach by LCDF II**

4.2. Impact of EbA activities on Socio-economic of small farmers

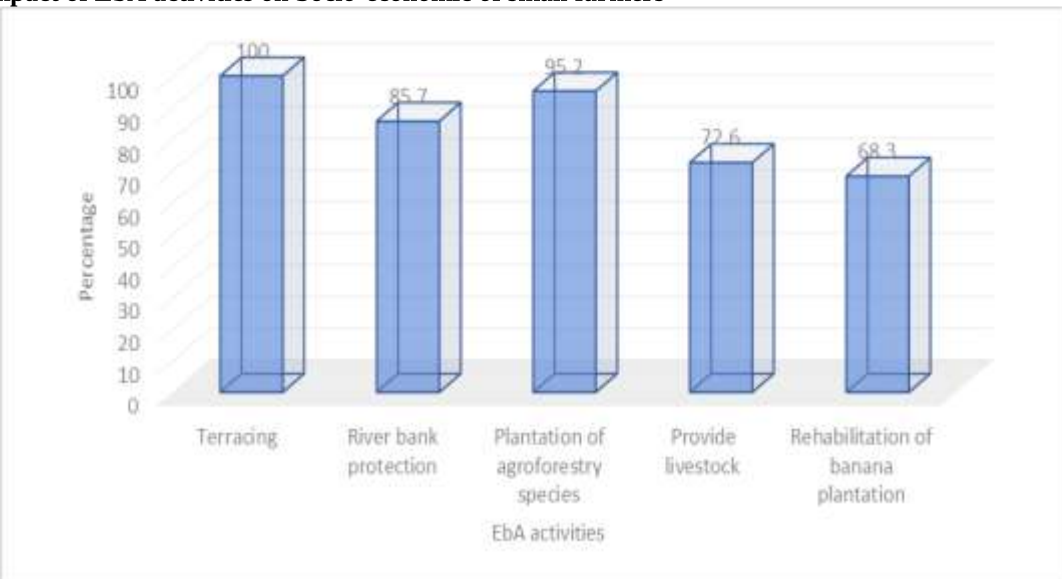

Figure 2: **Activities of EbA as implemented by LCDF II**

4.3. Impact of EbA approach on capacity building

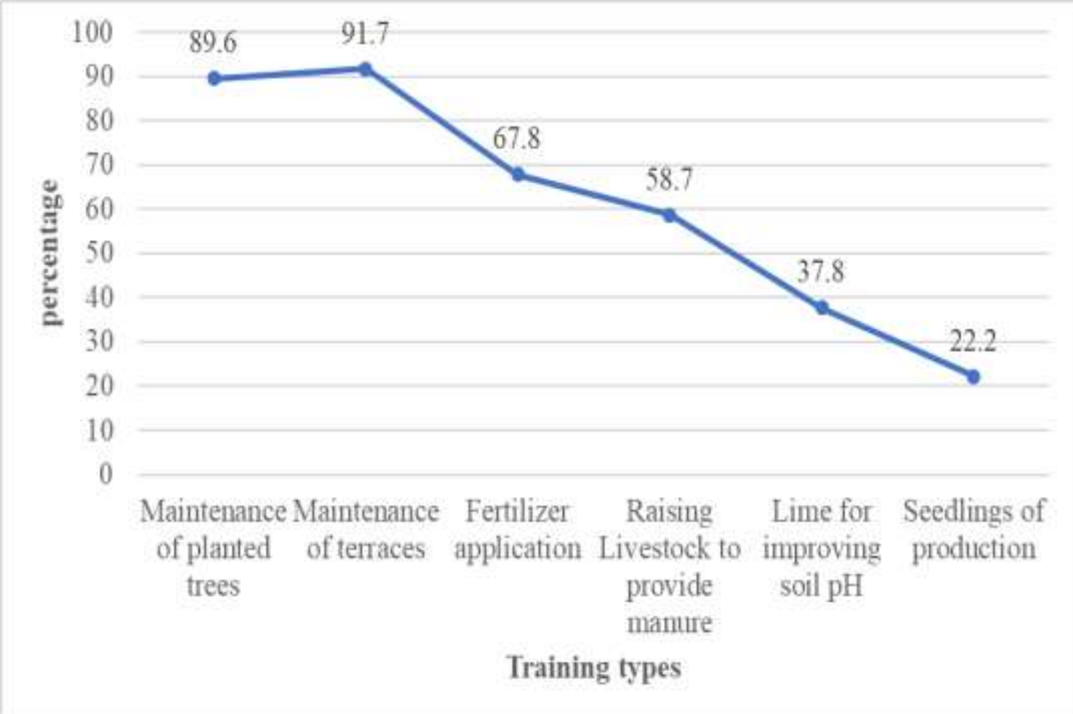

Figure 3: **Training received by Respondents due to implementation of EbA**

4.4. Impact of EbA on land restoration

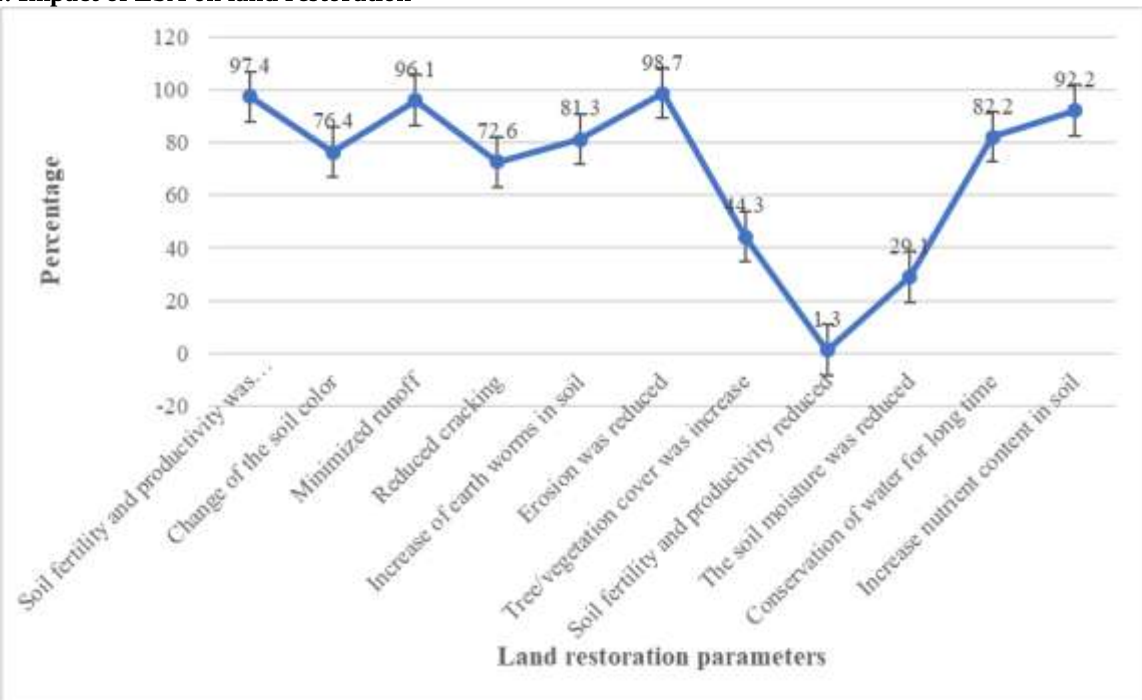

Figure 4: **Land restoration activities implemented by LCDF II**

4.5. Effects of EbA activities on Agricultural system

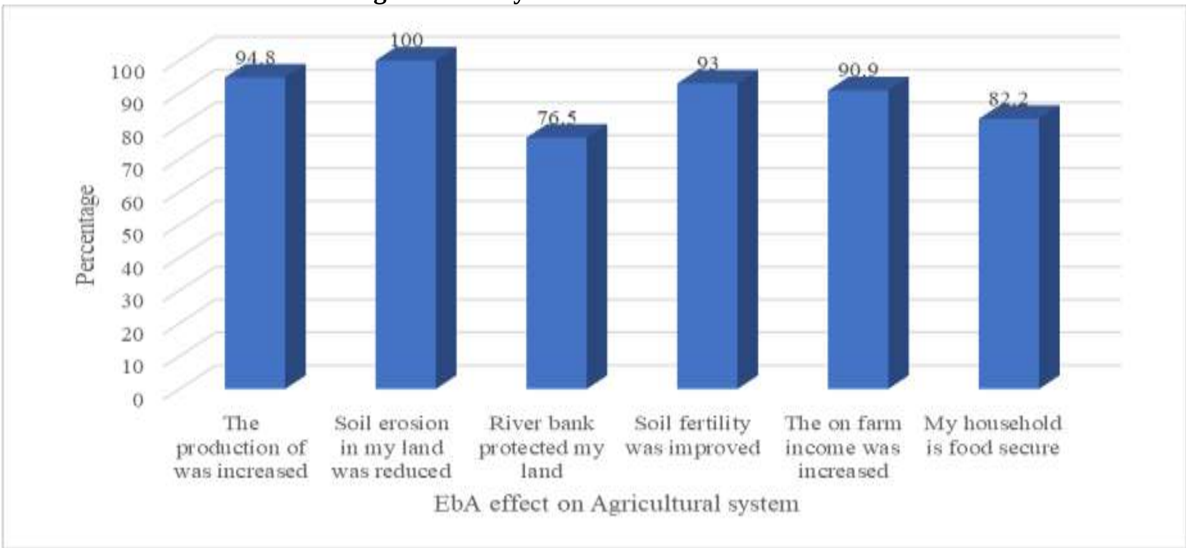

Figure 5: **Effects of EbA activities on agricultural system**

4.6. Impacts of EbA on crop Yield

Table 1: **Yield obtained before and after EbA**

Statistics				
	Yield of Corn before EbA	**Yield of Corn after EbA**	**Yield of Beans before EbA**	**Yield of beans after EbA**
N	230	230	230	230
Mean	30.93	40.03	41.44	47.70
Median	32.00	41.00	42.00	48.00
Mode	35	38[a]	45	47[a]
Sum	7113	9206	9531	10972
a. Multiple modes exist. The smallest value is shown				

4.7. Effect of EbA on food Security

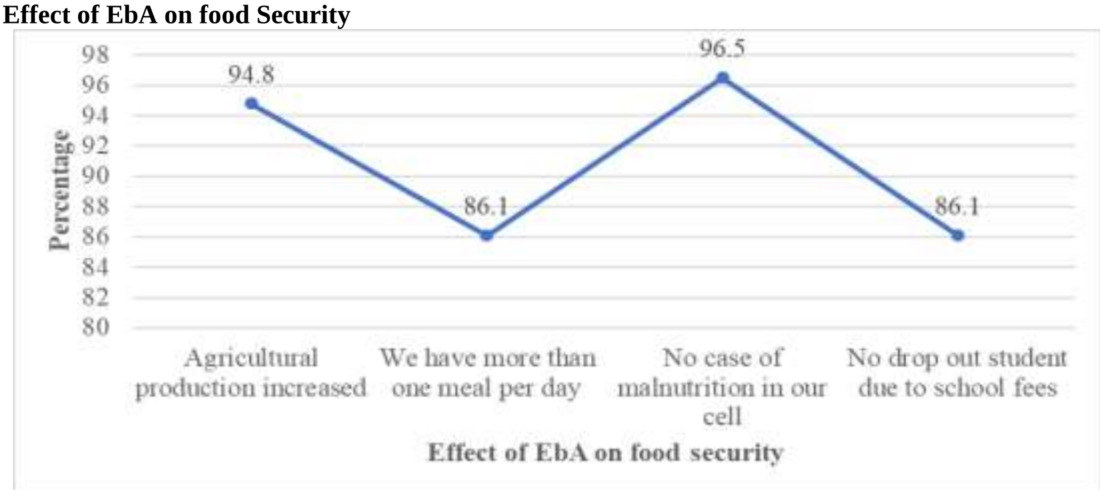

Figure 6: **Effect of EbA on food security**

Table 2: **Results from T-test of parameter to evaluate the significance of difference**

	Paired Differences			Paired Differences			Paired Differences		
	Mean	Std. Deviation	Sig. (2-tailed)	Mean	Std. Deviation	Sig. (2-tailed)	Mean	Std. Deviation	Sig. (2-tailed)
pH (Treatment - Control)	0.253	0.166	0.027	0.357	0.098	0.000	0.403	0.290	0.019
TN (Treatment-Control)	0.038	0.022	0.017	0.096	0.086	0.041	0.050	0.045	0.042
Av.P (Treatment - Control)	0.926	0.578	0.023	2.040	1.871	0.044	1.022	1.224	0.096
OC (Treatment-Control)	0.532	0.419	0.047	0.667	0.431	0.013	0.435	0.261	0.010
OM (Treatment - Control)	0.892	0.744	0.055	1.145	0.740	0.013	0.750	0.458	0.010
Ca (Treatment - Control)	3.200	1.783	0.016	1.167	0.871	0.022	3.300	2.382	0.019
Mg (Treatment - Control)	1.360	1.322	0.083	2.933	1.836	0.011	3.367	2.289	0.015
Al3+(Treatment - Control)	-0.608	0.407	0.029	-0.290	0.258	0.040	-0.320	0.113	0.001
H+ (Treatment - Control)	-0.124	0.110	0.065	-0.143	0.098	0.016	-0.187	0.165	0.040
K+(Treatment - Control)	81.000	65.898	0.051	146.667	101.423	0.017	222.500	233.597	0.067
WAS (Treatment - Control)	21.122	9.736	0.008	14.773	12.281	0.032	10.235	10.722	0.067

Table 1: **Results from T-test of parameter to evaluate the significance of difference**

Table 3: **Correlation between tested parameters**

Correlations											
	pH	% TN	Av.P (ppm)	% OC	% OM	Ca (Cmol/kg)	Mg (Cmol/kg)	Al3+ (meq/100g)	H+ (meq/100g)	K+(ppm)	WAS
pHH2O	1										
% TN	.248	1									
Av.P (ppm)	.298	.464**	1								
% OC	.048	.262	.003	1							
% OM	.037	.253	.003	.999**	1						
Ca (Cmol/kg)	.208	-.068	.025	.388*	.385*	1					
Mg (Cmol/kg)	.154	-.102	.206	.535**	.538**	.743**	1				
Al3+ (meq/100g)	-.481**	-.300	-.072	-.590**	-.579**	-.441**	-.286	1			

H+ (meq/100g)	-.327	.028	-.229	-.429*	-.434*	-.508**	-.632**	.309	1		
K+(ppm)	.261	.303	.536**	.026	.023	.168	.288	-.117	-.254	1	
WAS	.455**	.330	.462**	.262	.261	.240	.205	-.500**	-.518**	.320	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

IV. DISCUSSION AND CONCLUSIONS

In light of the pre-determined objectives of the study, the author interprets data and draw conclusions. The results in figure 1, showed the awareness and Participation in EbA Interventions (implementation of EbA approach by LCDF II. All respondents 100% in the study area confirmed that the know EbA approach as it was implemented by the LCDF project in the study area. After confirming this, respondents highlight different activities conducted by LCDF project. All respondents 100% said that EbA had the purpose of increasing crop yield and making terraces. On the other hand, 99.6% of respondents said that LCDF project had activities of planting agroforestry species in created area. Other respondents said that the activities of EbA were restoration of degradation soil and restoration of whole ecosystem with percentage of 90.9 and 82.2 respectively. The findings of this is the line with the report prepared by REMA said that the implementation of EbA by LCDF projects, planted trees, made terraces, providing cows, fertilizers and regenerated the forest for the purpose of restoring land which will resulting in improvement of livelihood of people, and reduction of poverty in different part of country particularly Ngororero Districts (REMA, 2019a).

The results in figure 2, showed the impact of EbA activities on Socio-economic of small farmers especially the activities of EbA as implemented by LCDF II. According to the results, implementation of EbA approach in the study area was done through different activities as highlighted by respondents in the figure 4, those activities include creation of radical terraces (100%), planting agroforestry species in the created terraces (95.2%), establishment of river bank protection (85.7%), provide livestock (72.6%) and rehabilitation of banana plantation 68.3%. The respondents said what they were remember. The mentioned activities were also confirmed by report done by (REMA, 2019a) that its project called LCDF II restored Nyiramuhondi watershed through construction of radical terraces on 100 ha, rehabilitation of 5 ha Gihe hill forest; river bank protection on 10 ha.

The results from figure 3, showed the impact of EbA approach on capacity building especially the training received by Respondents due to implementation of EbA. the results showed that the training of provided were different including maintenance of terraces (91.7%), maintenance of planted trees (89.6%), fertilizer application (67.8%), raising livestock to provide manure (58.7%), lime for improving soil pH (37.8%) and seedlings of production (22.2%). The findings of this study is in the line with other study that highlighted that awareness-raising activities regarding restoration, protection, and management of ecosystems, ecosystem processes and biodiversity or for the implementation of specific agricultural practices or new crop varieties to help people adapt to climate change (Donatti et al., 2020).

The results in figure 4 about the impact of EbA on land restoration particularly land restoration activities implemented by LCDF II, showed that respondents highlighted different parameters showing that land was restored. Those parameters include: soil erosion was reduced (98.7%), soil fertility and productivities were increased (97.4%), water runoff was minimized (96.1%), soil nutrients content was increased (92.2%), the soil conserve water for long period (82.2%), increase of earth worms in the soil (81.3%), change the soil color (76.4%) and reduced cracking (72.6%). The findings of this study is in the line with other study that highlighted that agroforestry as EbA approach play an important role in soil erosion control, mulch, reduction water logging and enrich soil and as catch crop (Mugure & Oino, 2013).

The results in figure 5 about the Effects of EbA activities on Agricultural system showed activities of EbA, after intervention of EbA, the soil erosion was reduced at rate 100%, the production of was increased 94.8%, soil fertility was improved 93%, the on-farm income was increased 90.9%, my household is food secure 82.2% and 76.5 %. The findings of this study have similarities with the study said that healthy ecosystems also provide a wide range of life-sustaining co-benefits, from clean water for drinking, fertile soils for agriculture and habitat for fish (USAID, 2019).

The results in figure 6 showed the effect of EbA on food security. According to results, after implementation of EbA, no case of malnutrition in our cell 96.5%, agricultural production increased 94.8%, we have more than one meal per day 86.1% and no drop out student due to school fees 86.1%. EbA activities affect production of crops and livestock resulting in improvement livelihood of people. The findings of this research has similarities with study that highlighted that EbA activities strengthen food security through planting shade trees to improve soil fertility and support pollinators, restoring and managing watersheds to maintain water supply for irrigation and intercropping to improve resistance to pest outbreaks (USAID, 2019).

The results in table 2 showed results from T-test of parameter to evaluate the significance of difference. According to results, the amount of all basic cations studied (Potassium, Calcium and Magnesium) were increased under restored area and decreased away from restored. During this study I analyzed the impacts of EbA intervention on basic cations. The findings proved that EbA has positive impact on increase of exchangeable basic cations (K^+, Ca^{2+} and Mg^{2+}). After soil laboratory analysis, t-test was conducted with SPSS to compare the means of treatments samples and control samples. The mean differences value of samples from uphill, middle-hill and downhill of calcium were 3.200 ±1.783%, 1.167±0.871% and 3.300±2.382 % with p-value of 0.016, 0.022 and 0.019 respectively, Magnesium mean differences of samples from uphill, middle-hill and downhill were 1.360±1.322%, 2.933±1.836% and 3.367±2.289% with p-value of 0.083, 0.011 and 0.015 respectively. Organic matter contains around 58% of organic carbon and then remain portion occupied by other nutrients such nitrogen, phosphorus, potassium etc. One of the benefits of growing trees on agricultural farms is an increase of soil organic carbon which is good indicator of fertile soil (Ndlovu et al., 2013)

The results in table 3, showed the correlation between tested parameters. According to the results, this correlation was found to be very highly positive correlation with p- value of 0.999 and statistically significant at 0.01 significant level. Organic carbon is also positively correlated with calcium and magnesium. Even though the correlation between both calcium and magnesium correlated positively with organic carbon, their p-value are different. Because, correlation of organic carbon and calcium found to be low positive correlation and statistically significant at 0.05 level with p-value of 0.388 whereas correlation between organic carbon and magnesium found to be moderate positive correlation with p-value of 0.535 and statistically significant at 0.01 level. This correlation means that organic carbon increase as organic matter, calcium and magnesium increase. On the other hand, aluminum found to be low negative correlated with pH and Calcium with p-value of =0.481, -0.441 and statistically significant at 0.01 level. This means that as aluminum increases soil pH and Calcium decrease. Soil acidity in the study areas, was found to be the result of increase of hydrogen.

The future studies the results encourage include: (i) to segment Mango Telecom's customer based on demographic, psychographic, and behavioral factors to tailor marketing strategies and offerings to different customer segments effectively, (ii) to track changes in customer engagement metrics over time in response to different marketing initiatives, promotional campaigns, and external factors, providing insights into the long-term effectiveness and sustainability of customer engagement strategies.

In conclusion, Mango Telecom Rwanda can significantly enhance customer engagement by leveraging a combination of effective online platforms, targeted advertising campaigns, strategic promotional offers, and influencer collaborations. By implementing the recommendations provided and continuing to adapt to evolving customer needs and market trends, Mango Telecom can foster stronger connections with its customers and drive sustainable business growth in the dynamic telecommunications industry landscape.

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ADDITIONAL MATERIALS

List of Tables

List of Figures