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The Role of Indigenous Knowledge Systems on Soil and Water Conservation in Musanze and Nyabihu Districts, North-Western of Rwanda

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Abstract

Indigenous knowledge (IK) is a knowledge generated at local level and is unique in a local culture and society. Recognizing its importance can facilitate the cost-effectiveness of development interventions of a country through participatory collaboration. The overall objective of this study was to investigate the role played by indigenous knowledge systems (IKS) on soil and water conservation in Busogo and Mukamira sectors of Musanze and Nyabihu districts respectively in North-Western Rwanda. The area is much affected by soil erosion and the local population has generated local soil and water conservation technologies to deal with the problem. Data collection involved several methods including review of literature, focus group discussion, direct observation and a household survey on 236 households selected randomly. Binary logistic regression analysis and descriptive statistics analysis was used to describe the indigenous soil and water conservation systems used by the farmers. The binary logical regression results show that the coefficient estimate for gender (ß =-0.492) and education level of the farmers (ß =-0.028) have a negative influence on the application of IKS for soil and water conservation. The age of the farmers (ß =0.004), the occupation of the households (ß = 0.964), the land ownership (ß = 0.19) and size of the farm (ß = 0.315) possess a productive impact on the application of IKS for soil and water conservation. Indigenous soil and water conservation practices used in the study areas are crop rotation (83.9%), Intercropping (57.6%), mixed cropping (38.1%), cultivation on ridges/rows (76.7%), using stone bunds (67.4%), traditional dams/water retention ditches (66.5%), traditional cut-off drains (43.2%), Farm yard manure (67.8%), compost (66.5%), crop residues (36%) and green manure (8.5%). The findings from this study reveal the relevance of IKS in soil and water conservation in the study area. Therefore, there is need for researchers, experts and policy makers to recognize the role of IKS in soil and water conservation and promote integration rather than replacing indigenous technologies with new ones imposed to farmers.

Keywords

IKS, Indigenous Technologies, Adoption, Soil and Water Conservation, Agroforestry

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1. Introduction

The indigenous knowledge is the knowledge generated by local communities through empirical learning without the implication of scientific research which is contrary to modern knowledge generated by university researchers and research institutions [1]. Indigenous knowledge (IK) is a knowledge generated at local level and is unique in a local culture and society. This knowledge is mostly relevant for decision making at local level in agriculture and soil and water conservation, medicine and health care, food dietetics and any other activities planned at local level. This kind of knowledge are disseminated through generation to generations by working with other participatory methods [2].

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Recognizing its importance can facilitate the cost-effectiveness of development interventions of a country through participatory collaboration [3], [4]. However, the role of local indigenous knowledge has not been adequately acknowledged and integrated by many researchers and policy makers in developing countries [5-7].

Due to topography and soil characteristics, soil erosion and flooding events are common in many parts of Rwanda which experience high annual rainfall. In order to overcome soil erosion and flooding problems, the local people has developed many indigenous soil and water conservation practices which are used to reduce impact of soil erosion and flooding on agricultural production systems. [8] found out that local farmers have developed indigenous strategies to cope with extreme events of soil erosion in order to sustain and increase agricultural production. It is believed that the integration of local knowledge in the improvement of agricultural systems could not only strengthen soil and water conservation but could also increase agricultural production and thus enhance local people’s livelihoods.

However, the role of indigenous soil and water conservation technologies has been so far often ignored during policy formulation and provision of extension services. This research aimed at evaluating the role of indigenous knowledge systems in soil and water conservation and its potential for wider use by the future generation. Due to time and financial constraints, this study was limited only to Mukamira and Busogo Sectors respectively in Nyabihu and Musanze districts, North-Western Rwanda. The study area is known to be highly affected by flooding and soil erosion due to high annual rainfall coupled with mountainous topographic and volcanic soil characteristics. [9] reported that the total households land affected by soil erosion and flooding in wet season of 2012 was about 101.94 hectares in Mukamira and Busogo sectors.

2. Materials and Methods

2.1. Study Area

This research was conducted in Mukamira and Busogo Sectors respectively in Nyabihu and Musanze districts, North-Western Rwanda. The two sectors are located on the foot and ridge of volcano Karisimbi. The geographical relief of Mukamira and Busogo sectors is characterized by 90% mountains with a slope of more than 55% which expose the areas on high risk of erosion and flooding. The precipitations are around 1400 mm per year. The soils of Mukamira and Busogo sectors are mainly volcanic soils and few laterite, sandy and clay soils. Volcanic soils are very fertile and the sectors are among the most productive areas particularly for Irish potatoes.

2.2. Methodology for Data Collection

Household survey using semi-structured questionnaires, direct observation and group focus discussion were used to collect the primary data. Relevant publications on the subject matter were used to get the information on the secondary data.

Open and close ended questions were administered to 236 selected households. In each village, the households were selected through systematic random sampling method using their list from the village administration and the random sampling software of the smart phone. The target respondents were the heads of households. The major parts of the questions were grouped into three categories which are: (1) identification and socio-economic of the respondents, (2) questions related to the agroforestry practices (3) questions on indigenous soil and water conservation measures.

The total sample population (236 households) was determined by using the following formula:

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

In addition to household survey, focus group discussions were held with the selected farmers in the study area. In each village, the group discussion was done with five oldest selected farmers and the leader of the village. The discussion was over questions related to the causes and acceleration of soil erosion, type of modern and indigenous soil and water conservation measures used in the areas and the suitability and cost effectiveness of each methods.

Moreover, direct observation was used to confirm the types of modern and indigenous systems used by farmers for soil and water conservation and their integration in the farmland. Observations also focused on agricultural production of farmers, natural and socio-economic conditions in the study area, level and form of soil erosions and land degradation and agroforestry situations. The purpose of direct observation was also to have a full understanding about the integration of indigenous knowledge techniques and its effectiveness on soil and water conservation.

In order to ensure adequate data analysis, district and government reports, previous studies and publications relating to the indigenous soil and water conservation measures were used in order to compare with primary data.

2.3. Data Processing and Analysis

The collected data, both primary and secondary have been analysed and discussed sing both qualitative and quantitative methods. Binary logistic regression analysis and descriptive statistics analysis was used to describe the indigenous soil and water conservation systems used by the farmers. Descriptive statistics consisting of mainly frequencies and percentages were computed by using SPSS, ver. 20. Descriptive statistics results were presented through tabulation and graphs. The binary logistic regression model was used to explain the relationships between different variables and factors affecting and/or influencing the use of indigenous knowledge systems for soil and water conservation.

3. Results and Discussion

3.1. Indigenous Soil and Water Conservation Practices in the Study Area

The compiled results from the group discussion, questionnaires and field observation on indigenous soil and water conservation measures used by the farmers were summarized and presented in Table 1. The results show that the Mixed Cropping (83.9%) followed by intercropping (57.6% and Crop rotation (38.1%) are the biological soil and water conservation measures used by the farmers (Table 1). The cultivation on ridges (76.1%), stone bund/barrier (67.4%), Traditional dams/water Retention ditches (66.5%) are the most mechanical indigenous soil and water conservation measures used by the farmers (table 1). Fresh farm yard manure (67.8%) and compost 66.5% are the most indigenous soil fertilization used by the farmers (table 1).

Table 1. Indigenous soil and water conservation systems used by the farmers.

Indigenous Soil and water conservation Practices	MUKAMIRA Frequency	MUKAMIRA Percentage	BUSOGO Frequency	BUSOGO Percentage	TOTAL Frequency	TOTAL Percentage
Biological Soil and water conservation measures						
1. Mixed Cropping	100	88.0	98	83.1	198	83.9
2. Intercropping	71	60.2	65	55.1	136	57.6
3. Crop Rotation	41	38.0	49	41.5	90	38.1
4. Indigenous agroforestry	26	22.0	34	28.8	60	25.4
5. Fallow	22	18.6	25	21.1	47	19.9
6. Alley cropping	26	22.0	21	17.8	47	19.9
7. Minimum Tillage	15	12.7	18	15.3	33	14.0
8. Mulching	8	6.8	23	19.5	31	13.1
Mechanical Soil and water conservation measures						
1. Cultivation on ridges/rows	93	78.8	88	77.0	181	76.7
2. Stone bund/barrier	76	64.4	83	70.3	159	67.4
3. Traditional dams/water Retention ditches	76	64.4	81	68.6	157	66.5
4. Traditional cut-off drain/Drainage systems	58	49.2	44	37.3	102	43.2
5. Terraces	30	25.4	22	18.6	52	22.0
Soil fertilization systems						
1. Fresh farm yard manure	73	61.9	87	73.7	160	67.8
2. Composting	82	69.5	75	63.6	157	66.5
3. Crop residue	48	40.7	37	31.4	85	36.0
4. Green Manure	8	6.8	12	10.2	20	8.5
5. Weed burning	4	3.4	6	5.0	10	3.0

3.1.1. Indigenous Biological Soil and Water Conservation Measures

The indigenous biological soil and water conservation measures practiced by farmers include: Mixed cropping, intercropping, crop rotation, indigenous agroforestry, fallow, alley cropping, minimum tillage and mulching. The most reported being mixed cropping with around 84% of respondents. The mixed cropping system is a traditional cropping system in most of the regions of Rwanda. However, since 2008 due to the crop intensification programme (CIP) which emphasize monoculture, there is reduction of mixing crops in Rwanda. Despite CIP interventions, in the study area most of the farmers are still using this mixed cropping system mostly by mixing maize with climbing beans, and potato (Figure 1). This is an indigenous technology used by the farmers because of the lack of stakes for climbing beans. In fact, the beans climb on the maize and both crops produce good yield.

Figure 1. Mixed cropping of maize and beans.

The indigenous agricultural practices systems like crop rotation, intercropping and mixed cropping are known to be veritable cultural ways of controlling pest build-up in arable crop production [10]. The results from this research are in line with findings of [11] which indicated that the traditional farming systems found in the high land of Rwanda are representative of highland agriculture in East Africa where over 65 million people cultivate mixed cropping systems. Some literature on bean-maize intercropping and mixed systems confirm that mixed cropping systems are more productive than intercropped systems [12], because sometimes intercropping systems are not optimized to the environment [12].

3.1.2. Indigenous Mechanical Soil and Water Conservation Measures

The indigenous mechanical soil and water conservation measures practiced by surveyed farmers include cultivation on ridges/rows, stone band/barrier; traditional dams/water retention ditches, traditional cut-off drain/drainages systems and terraces. The most practiced Indigenous Mechanical Soil and water conservation measure was cultivation on ridges /rows with about 77% of the respondents.

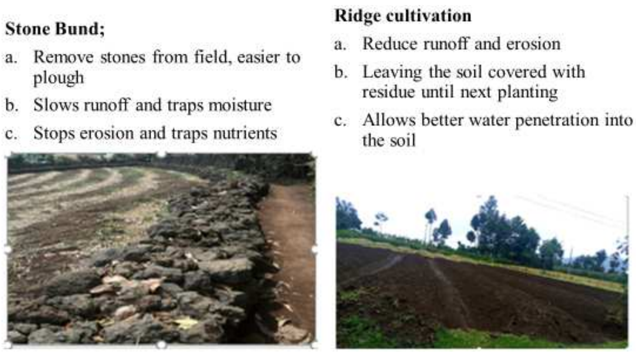

Figure 2. Stone bund and Cultivation on ridges/rows.

Cultivation on ridges/rows (Figure 2) is the most cultivation techniques known in the study areas. The farmers are used to cultivate on continuous ridges for controlling the runoff. According to [13], cultivation on ridges/rows is appropriate for fields with high permeable soil and moderate slope. The technique also increases the water holding capacity of the soil and infiltration rate. The techniques also are combined by using stones bunds as well as digging traditional water retention ditches (Figure 3). [14] argued that the technique helps to prevent run-off and conserve soil and water.

Figure 3. Traditional dam or water retention ditch.

3.1.3. Indigenous Soil Fertilization Systems

The indigenous soil fertilization systems used by the farmers include: fresh farm yard manure, composting, crop residue, green manure and weed burning. The most practiced indigenous Soil fertilization system was fresh yard manure reported by 68% of respondents. Farm yard manure is the major sources of organic fertilizers used in the study area mainly for potato and maize cultivation. The group discussions relieved that the farmers cleaned the animal fodders, animal bedding leaves and crop weeds mixed with animal dugs away from the animal shed and depose them to a pit for decomposition but sometimes the farmers using this manure as fresh products. The combination of farm yard manure and inorganic fertilizer was reported to produce significantly high yields compared to the treatment where no manures or fertilizer were applied [15].

Figure 4. Rising cows in fallowed land for releasing manures.

Due to the high cost of manure transportation, the farmers used to raise their cows in fallowed land (Figure 4) so that it releases the fertilizer in the farms.

The most indigenous green manure crops species used in the study areas are the dodoki (Ikidodoki), igisura (*Urtica dioica*), Kimbazi (*Tithonia diversifolia*), Tephrosia vogelii, (Umuruku), and some exotic like leaves of *grevilia robusta*, *Alnus Acuminata*, *Leucaena sp* and *Calliandra sp*, *Sesbania sesban* (L.). The farmers reported that pruning *Leucaena sp* and *Calliandra* also serves as a source of green manure although this technology had low adoption levels in the study areas. Burning crop residues into the field is an indigenous method of fertilization. During the dry season, the farmers used to collect the crops waste and other weeds and burned and mixing the ash with the soil and serve as soil fertility. In Rwanda burning crop residues is now prohibited to reduce greenhouse gas emissions and increase organic matter in the farms.

3.2. Major Socio-Economic Factors Affecting the Adoption of IKS for Soil and Water Conservation

A binary logistic regression model was used to test the influence of Socio-economic factors on the adoption of IKS for soil and water conservation (Table 2).

Table 2. Binary logistic regression model for the socio-economic factors influencing adoption of IKS in Soil and water conservation.

Variables	**ß**	***S.E.***	***Wald***	***Sig.***	***Exp (B)***
Gender	-0.492	0.522	0.886	0.347	0.612
Age	0.004	0.355	0.000	0.991	0.996
Education	-0.028	0.273	0.011	0.918	0.972
Occupation	0.964	0.702	1.889	0.169	2.622
Land ownership	0.19	0.401	0.000	0.123	3.45
size of land ownership	0.315	0.493	0.409	0.523	1.371
Log Likelihood	122.186				

Source: Author, computed from survey 2018.
ß= Beta, probability of type II error in any hypothesis test
S. E= Standard Error
Wald test = used to test the true value of the parameter based on the sample estimated, show the relationship within or between data items.
Exp (B) =odds ratio

The Coefficient estimate that gender (*ß* =-0.492) had a negative influence on the decision of the farmers to adopt IKS for soil and water conservation but there was no significant difference at 10% level of significance. [16] also found that gender did not have any relationship with the application of the soil and water conservation since women are more engaged in farmlands. On the contrary, [17] observed that male headed households had higher chance to involve in soil and water conservation practices since constructing and maintaining soil and water conservation practices demand much labor. However, the age of the farmers had a positive influence on the application of IKS for soil and water conservation (*ß* =0.004) but there was no significant relationship between age of farmers and application of IKS for soil and water conservation since p value is greater than 0.1. This implies that increasing the age of the farmers also increases the level of applying IKS for soil and water conservation meaning that older farmers tend to use more indigenous knowledge than young farmers. Similar results were found by [16] that age of the heads of household had a positive influence on the adoption of soil and water conservation measures because younger farmers are less likely to use soil and water conservation practices continuously. This may also be justified by the fact that younger farmers have small size of land than the old ones. Education level of the farmers (*ß* =-0.028) had a negative influence on the application of IKS for soil and water conservation. This means the higher the education level of the farmers, the lower the probability of applying the IKS for soil and water conservation. It is known that the farmers who took all their time in on-farm employment have more commitment to the improvement of the farm activities. Similar findings were made by [18] that illiterate farmers are better to be involved in the adoption of soil and water conservation measures than educated farmers who are usually engaged in off-farm activities. On the contrary, [16] reported that increased education level of households' heads has a strong and positive impact with the level of adopting soil and water conservation measures. [19] also noted that formal education can provide advantages to the farmers to understand the scientific principles related to the use of Indigenous soil and water conservation practices. It is also interesting to note that the occupation of the households positively (ß =0.964) influences the application of indigenous knowledge for soil and water conservation which means that the on-farm activity is one of the potential socio-economic factors that have a greater influence on the application of IKS for soil and water conservation practices. The odds ratio showed that household heads who are engaged in off -farm activities adopt IKS for soil and water conservation 2.622 times greater than those who are not engaged in the off- farm activity. This result is confirmed by the findings of [20] who reported that off-farm activity is positively correlated with the adoption of soil and water conservation practices. The most income from the farmers are coming from the off-farm activity, the farmers must invest more in soil and water conservation. However, [18-21] found that the more the farmers are involved in off-farm activities, the more negative influence on continuing use of soil and water conservation practices.

Land tenure is an important factor that promotes sustainable soil and water conservation. In the study area, land ownership and size of the farm ownership had respectively a positive impact (*ß* 0.19) and (*ß* =0.315) on the application of IKS for soil and water conservation. This means that increasing owned land and land size will increase the probability of applying IKS for soil and water conservation. The positive coefficient of land size means that farmers with larger land holding had a higher probability of adopting IKS for soil and water conservation. This was also reported by [16] that farm size is positively associated with the adoption of soil and water conservation practices. However, [22] reported a negative relationship between land size and the adoption of soil and water conservation practices.

3.3. Factors Hindering Adoption of Indigenous and Modern Soil and Water Conservation Measures

There are numerous factors that prevent the farmers to practices indigenous and modern soil and water conservation (Table 3).

Table 3. Factors hindering adoption of Indigenous and Modern soil and water conservation measures.

FACTORS	MUKAMIRA		BUSOGO		TOTAL	
	Frequency	%	Frequency	%	Frequency	%
Indigenous soil and water conservation measures						
1. Require high labor	80	67.8	51	43.2	131	55.5
2. Government Policy on soil and water conservation	38	32.2	40	33.9	78	33.1
Modern soil and water conservation measures						
1. High cost	57	48.3	53	44.9	110	46.6
2. Require high knowledge	33	28	36	30.5	69	29.2
3. Lack of required materials	16	13.6	18	15.3	34	15
High Maintenance	12	10.2	11	9.3	23	9.7

Source: Survey data, 2018

These challenges differ from household to household depending on socio-economic situations of the households. The most limiting factors for adopting indigenous knowledge systems in soil and water conservation is the lack of labor (55.5%) especially for transporting manure from home to the fields, followed by the government policy (33.1%). Conventionally, agriculture and research priorities are determined by policy makers with little involvement of the farmers [23]. During group discussion, it was noted that most of the farmers have difficulties in manure transportation and manpower for digging the traditional water retention ditches. The households who have fewer members abandon or adopt fewer measures which require much labor. Some farmers reported that to overcome this challenge, they prefer to graze into the farmland so that the livestock may leave manure in the farm. In fact, most farmers claimed that they wish they could get wheelbarrows for transporting manure instead of depending on their head loads. To reduce costs of soil and water conservation measures, modern soil and water conservation structures such as modern cut-of drains are sometimes constructed in community works through the support of the government.

3.4. Effectiveness of Indigenous and Modern Soil and Water Conservation Measures

The majority of the respondents (40.7%) recognize that the integration of modern and indigenous soil and water conservation measures is most desirable and can be sustainable (Table 4).

Table 4. Effectiveness of Indigenous and Modern Measures Soil and water conservation measures.

Measures	MUKAMIRA		BUSOGO		TOTAL	
	Frequency	%	Frequency	%	Frequency	%
Modern Soil and water conservation	32	27.1	34	28.8	66	28
Indigenous Soil and water conservation	36	30.5	38	32.2	74	31.4
Combination of both	49	41.5	47	39.8	96	40.7
Total					236	100

Source: Survey data, 2018

For example, the chemical fertilizers combined with manure provide higher yields than manure alone or chemical fertilizer alone. The combination of indigenous and modern techniques can reduce also the soil degradation and higher cost to maintain the soil protection structures. During field observations, it was noted that that there is no difference between indigenous and modern soil and water conservation measures, but the difference exists only on the strength and cost of modern as compared to traditional/indigenous measures. In the study areas, there were some modern erosion control ditches which have failed due to the lack of maintenance.

4. Conclusion

The farmers in the study areas have widely adopted a number of indigenous farming and soil and water conservation measures such as crop rotation, intercropping, mixed cropping, indigenous agroforestry, fallow, alley cropping, minimum tillage and mulching as indigenous biological soil and water conservation measures; stone bund/barrier, cultivation on ridges/rows, traditional dams/water retention ditches, traditional cut-off drain/drainage systems and terraces as frequently used indigenous mechanical soil and water conservation; and compost, farm yard manure, crop residues, green manure and weed burning as the most common indigenous soil fertility systems used by the farmers.

The binary logistic regression analysis also showed that age, occupation of the head of households, land ownership and the size of land ownership have a positive influence of the adoption of indigenous knowledge for soil and water conservation. Despite the function and role of indigenous soil and water conservation measures, agricultural policies and policy makers often ignore its relevance in agriculture planning. The majority of farmers prefer to use both modern and indigenous measures as they believe that this can be most suitable solution to the problem of erosion control and soil fertility improvement.

The promotion of indigenous soil and water conservation systems is needed and the agricultural extension officers should be trained on how to integrate both modern and indigenous knowledge systems in farming practices. The indigenous knowledge systems in soil and water conservation practices should be appreciated and recognized by policy makers, experts, researchers and development agents during the introduction of modern soil and water conservation technologies. In other words, modern soil and water conservation measures should come in to improve the indigenous soil and water conservation rather than replacing them. It is believed that this may likely reduce the cost spent on constructing modern soil and water conservation structures and increase adoption of improved soil and water conservation measures.

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