Analyzing the contribution of Rwinkwavu marshland irrigation scheme on community livelihood improvement in Kayonza District, Eastern Rwanda

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Abstract— *Smallholder farmers across the world and particularly in developing countries have been facing a problem of food insecurity and slow rate of livelihoods improvement because of climate-induced droughts and lack of effective use of modern agricultural techniques. Rainfall patterns have become more unpredictable and inconsistent with the traditional farming seasons and practices. Faced with such challenges, together with the rising population growth and its pressure on natural resources as well as strategies to eradicate hunger, many governments adopted irrigation systems and wetlands development for agriculture to improve food security and welfare of farmers and community in general. This study aims to analyse whether and the extent to which the development of Rwinkwavu marshland and introduction of irrigation system for rice growing in the area have been impacting on the community's livelihoods improvement since the development of the marshland in 2014. Among the methodological approaches and tools used, a comprehensive desk review to explore available related research works in order to trace the gaps, field visit for researcher's own observation and collection of information on site and available data in different institutions, exploration of satellite imagery of the study area and combination of primary and secondary data to allow the comparison of land use and cover changes before and after the marshland development, questionnaire and focused group discussions were used to collect the farmers and community's view on the role of marsland transformation in livelihoods improvement. In addition, GIS was used to analyse and process spatial data of the land use/cover change of the area while collected data on community's view were processed in Microsoft Excel and analyzed using SPSS. The findings indicate that the Rwinkwavu marshland reclamation and transformation to modern rice growing area has highly and positively contributed to community livelihoods improvement. It was recommended further researches in other reclaimed areas countrywide in order to allow decision makers to have enough data that help to compare the efforts and investments made in the sector with the impacts on population. Further researches to compare and balance the benefits from transformation made with the benefits from on natural ecosystem services as well as the impacts on natural habitat are also recommended.*

Keywords*— *Agriculture, Community livelihoods, Irrigation system, Marshland development, Kayonza District.

I. INTRODUCTION

Global food security is a worldwide concern and the challenge is how to feed a growing population which currently is estimated at 7 billion and projected to reach 9.2 billion particularly with the projection from 5.8 billion in 2015 to 7.9 billion in less developed regions by the year 2050 [12]. In Sub-Saharan Africa (SSA), where most economies are largely agrarian-based, the demand for arable farmlands continues to be a thorny issue for many countries. The scarce arable land faces competition, soils are becoming exhausted and water becoming increasingly scarce, competition for fertile farming lands and limited access to any available farmland for many areas of SSA has led to people invading wetlands and other marginal areas for agricultural and other transforming activities. In this fight for survival, they often engage in unsustainable use of these natural resources, causing degradation and other adverse effects[1].

Due to increasing population growth, poverty reduction, and development efforts, wetlands are increasingly being utilized and transformed for more value addition in different parts of the world. Wetland development projects significantly impact on their ecological productivity and economic output and more often than not generate conflicts concerning control of the resources between different users for instance pastoralists and farmers or small-scale farmers and large-scale capitalist farmers [6].

Wetlands provide valuable ecosystem services to society. Despite this, in many parts of the world, wetlands have been degraded or lost, and demand for development, particularly from agriculture is putting pressure on many of those that remain [3]. Achieving environmental sustainability and at same time satisfying the need for increased food production, enhanced economic growth and poverty reduction, is an issue of growing importance the world over [8].Rwinkwavu marshland, the main focus of this study, is a place where most of the above conditions prevail though at a local scale. The area is experiencing population growth, poverty, ecological stress and limited productive resource base. The main natural resource available, the wetland, is increasingly becoming scarce as competition for control and access to, and its utilization increases amongst multiple and contested uses by various stakeholders within the local community [12]; [10]. The latest incidence is the entry of big-scale investment in agricultural activities, following the construction of a dam upstream and development of irrigation system to enable rice growing in the area since the year 2014 [2].

It has also been argued that most studies conducted on Rwandan wetlands have laid much emphasis on natural sciences largely on nutrient dynamics, water quality, aquatic ecology and fisheries, hydrology and catchment's modelling and vegetation dynamics with very little to do with human welfare and utilization impacts. On the same note these studies have not explored much into details of livelihood improvement for the local communities with respect to wetland utilization, conservation and management [10]; [4]. The assessment of the impact of these activities on the livelihoods of the local community is a case at hand.

II. MATERIALS AND METHODS

2.1 Description of the Study Area

Rwinkwavu Marshland is located in the Eastern Province, Kayonza District, stretching across three sectors namely Mwiri, Gahini and Rwinkwavu as indicated on Figure 1. It is located at agro-climatic zone of eastern savanna that was characterized, before the development of irrigation scheme, by rolling grassland with scattered trees and shrubs, short period of rain and long dry seasons and often large herds of grazing animals on the savanna that thrive on the presence of grass and trees [5]. Though, the climate of Rwanda is generally characterized by alternation of two wet seasons (SOND and MAM) and two dry seasons (JF and JJO), the area is characterized by low precipitation and the historical background indicate that it has been invaded by severe droughts [7]. The region has no river except small tributaries that feed wetlands and lakes which indicate that water is not abundant in the area.

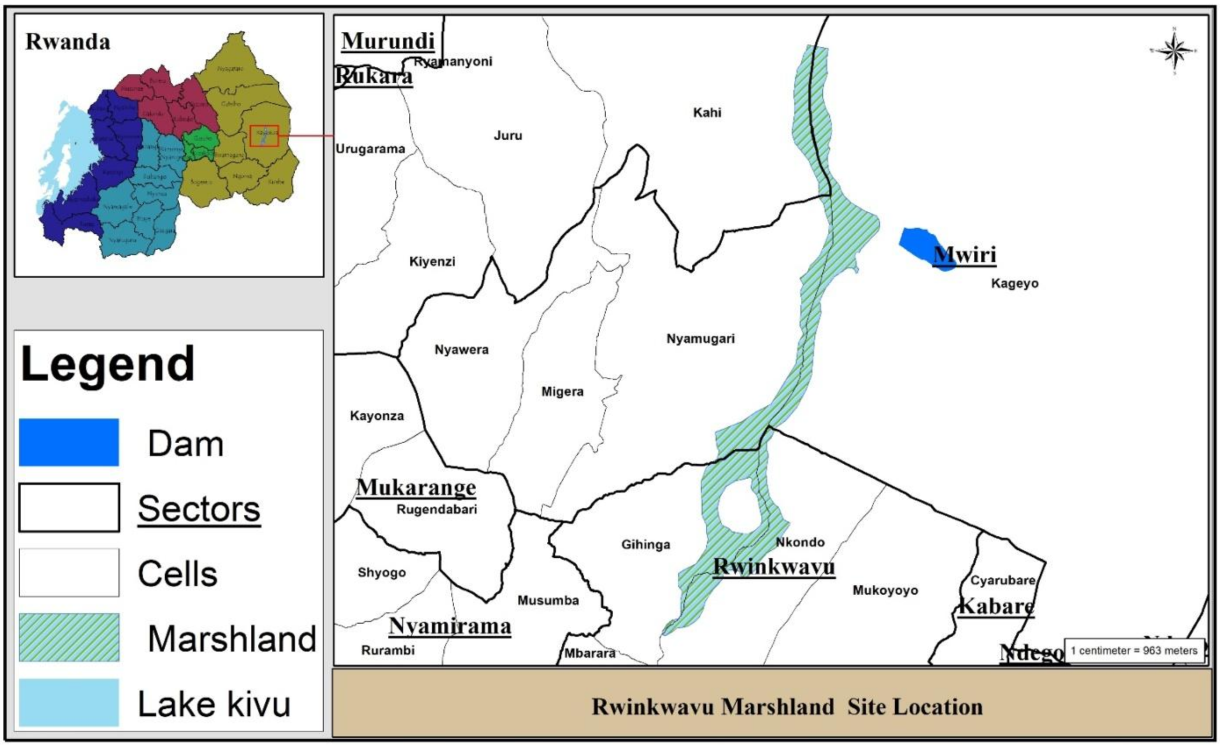

FIGURE 1: Map of the study area indicating the location of Rwinkwavu marshland

In Rwinkwavu marshland, the construction of the dam & irrigation infrastructures was implemented to enhance irrigated rice production in Rwinkwavu marshland of Kayonza District. Irrigation development works were executed in two phases: phase one of Rwinkwavu upper marshland have been executed during the period from 2013 to 2015, phase two of Rwinkwavu lower marshland have been executed in 2017-2018. The total area of the marshland covered by irrigation scheme is 1,600 ha and consequently the project beneficiaries practicing irrigated rice farming in the scheme are made up of 4468 beneficiaries, 2771 males and 1697 females) distributed in the three sectors. Among the key activities and infrastructures put in place by Rwinkwavu marshland development with irrigation system to allow water channeling in the marshland, include the construction of Rwinkwavu water reservoir located at 10km long upstream of 6.3 million m^3 of storage capacity and a maximum height of 9,50m of the embankment, and Kageyo dam of 5 million m3 located on right side in middle of the marshland, main irrigation canals of 56.9 km length with 7 main water intakes, 38.5 km length of main drainage canal and access roads along and inside the marshland of 31km length (MINAGRI, 2011).

2.2 Data Collection

For the purpose of this study, the researcher collected two categories of data: primary data consisting of spatial data collected on field in the study area, researcher's observations, information from focused group discussions as well as the questionnaire distributed to selected key informants by a calculated sample of 98 individuals representing the study population while secondary data were the available shapefiles from the mapping conducted during the development of Rwinkwavu irrigation scheme and satellites images. Both qualitative and quantitative data were collected through household surveys, focused group discussions, key informant interviews and community workshops to gather the views about the utilization of the scheme and the impact on community's livelihoods.

2.3 Data Analysis

Geographical Information System Tools was used to convert Spatial data collected on field into shapefiles as well as to digitize the satellite images of the study area retrieved for different periods on Google Earth in order to convert them into shapefiles that allowed to produce maps indicating the status of Rwinkwavu irrigation scheme before and after the development of Rwinkwavu irrigation scheme leading to detection of changes occurred in the area.

Data collected using questionnaire on the community livelihoods before and after the existence of the irrigation scheme were organized, processed using Microsoft Excel and statistically quantified in order to determine the changes in livelihoods of farmers practicing agriculture in the irrigation scheme. To this end, SPSS version 16 has been used. About Hypotheses testing, given the two hypotheses set as Ho: Situation is the same in the 2 distributions and H1: Situation is significantly different in 2 distributions, p-value and level of significance were determined from SPSS and helped to know which of the two hypothesis is to be accepted and come up with the decision making as per Table 1. Because the research questionnaire data consist of one sample and two variables, Paired sample t-test was used. This consists of a statistical technique that is used to compare two population means in the case of two samples that are correlated. Paired sample t-test is used in 'before-after' studies, or when the samples are the matched pairs. The output informations from this analysis helped the researcher to know whether the development of Rwinkwavu irrigation scheme has contributed to the improvement of livelihoods.

TABLE 1
HYPOTHESIS TESTING APPROACH FOR DECISION MAKING

p-value and significance level	Decision	Conclusion
When p-value is greater than alpha	fail to reject Ho	Situation is the same in the two distributions
When p-value is less than alpha	reject Ho	Situation is significantly different in the two distributions

III. RESULTS AND DISCUSSION

3.1 Land use/cover changes of Rwinkwavu marshland following the development of irrigation system

The information gathered from key informants of the current research as well as spatial data either collected in agriculture sector related institutions or collected on field indicated a total change in the land cover and use of the study area as indicated by Figure 4.1. Before the reclamation of the marshland by development of irrigation scheme in 2014 to 2015, the marsh was really a poorly managed natural resource with 31% of its portion used by local resident for grazing their pasture while the other part was used for multi-varied crop agriculture for only family subsistence.

Due to poorly managed agricultural practices in the marshland, the initially grown crops as indicated on the map, the harvest used to be highly threatened by climate related extreme events. Contrally, after the irrigation system was developed in the marshland, water to support good growth conditions of crops was ensured permanently, rice growing was adopted as a single crop in the reclaimed area, introduction of technology oriented agriculture and related training to farmers as well as market oriented agriculture among other have been the new chapter of land exploitation in the study area.

The physical features characterizing the study area before the marshland reclamation as per satellite image of 2011 on Figure 3 are mainly the shrubs and other natural plantations as well as some crops grown by local residents in the area. The information received on field and from different existing archive documents indicated that due to the fact that the marsh was not managed in terms of infrastructures and boundaries, it was likely to be threatened by floods during heavy rainy seasons and severe droughts during wet seasons all of which used to affect negatively traditional agro-farmers who relied on the marshland.

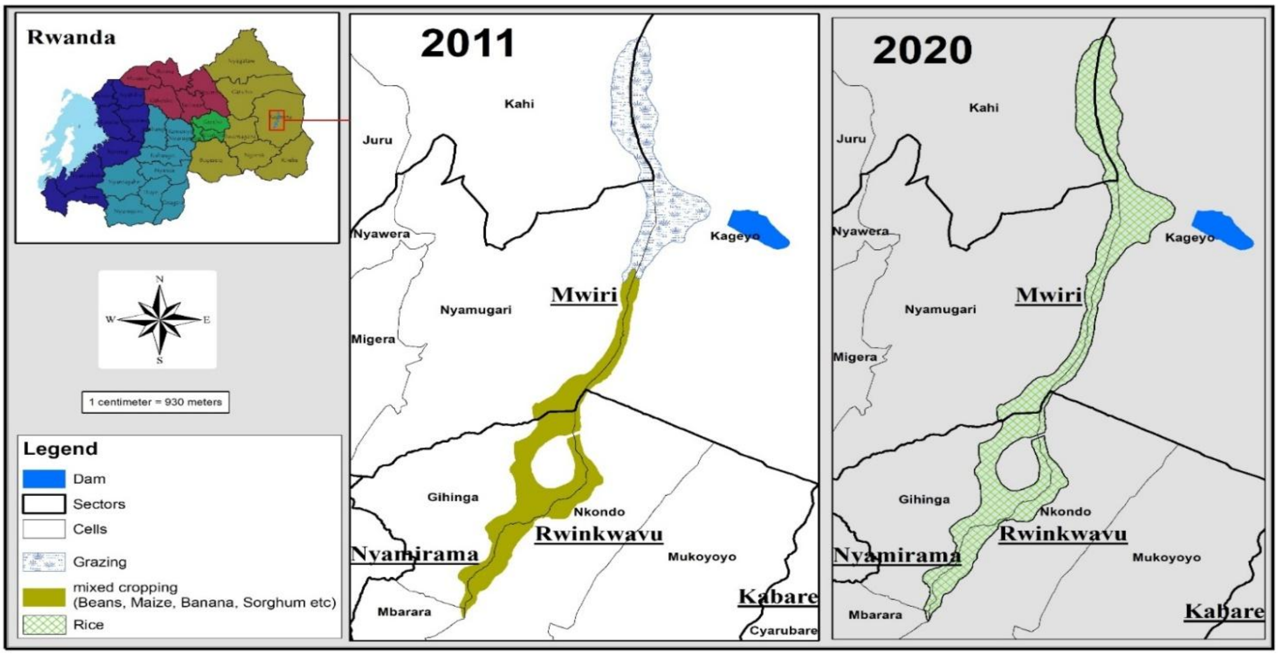

FIGURE 2: Map Comparing Land cover/use of Rwinkwavu marshland in 2011 and in 2020.

FIGURE 3: The upper part of Rwinkwavu marshland in 2011 compared to 2020 retrived from Google Earth

3.2 The impact of Rwinkwavu irrigation scheme to community livelihood improvement

The population size was 4468 rice farmers; the sample size was 98. After collection of data, participation rate was 100%. After editing, coding and entering data into SPSS version 22, the researcher generated tables to analyze and tabulation was made in order to present results of this research in a form that is reader friendly in terms of understanding.

3.2.1 Hypothesis testing based on Comparison of socio-economic situations of community before and after Rwinkwavu marshland reclamation.

The table below is an output of SPSS analysis by performing t test to test for the set hypotheses

TABLE 2
PAIRED SAMPLE T TEST OF HYPOTHESES

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Ensuring food security for family before irrigation scheme - Ensuring food security for family after irrigation scheme	-1.38776	.48974	.04947	-1.48594	-1.28957	-28.052	97	.000
Pair 2	Ability to pay efficiently clothes to the whole family before irrigation scheme - Ability to pay efficiently clothes to the whole family after irrigation scheme	-1.36735	.48456	.04895	-1.46450	-1.27020	-27.935	97	.000
Pair 3	Paying health insurance before irrigation scheme - Paying health insurance after irrigation scheme	-2.94898	.86600	.08748	-3.12260	-2.77536	-33.711	97	.000
Pair 4	Paying school fees of children before irrigation scheme - Paying school fees of children after irrigation scheme	-2.04082	.94070	.09502	-2.22941	-1.85222	-21.477	97	.000
Pair 5	Expanding my cropland and/or buying fertilizers before irrigation scheme - Expanding my cropland and/or buying fertilizers after irrigation scheme	-2.52041	.73540	.07429	-2.66785	-2.37297	-33.928	97	.000
Pair 6	Ability to construct/rehabilitate my residential house before irrigation scheme - Ability to construct/rehabilitate my residential house after irrigation scheme	-2.45918	.57738	.05832	-2.57494	-2.34343	-42.164	97	.000
Pair 7	Regular employment before irrigation scheme - Regular employment after irrigation scheme	-3.32653	.90560	.09148	-3.50809	-3.14497	-36.364	97	.000
Pair 8	Buying household assets before irrigation scheme - Buying household assets after irrigation scheme	-1.92857	.81544	.08237	-2.09206	-1.76509	-23.413	97	.000
Pair 9	Transport means before irrigation scheme - Transport means after irrigation scheme	-2.84694	.56262	.05683	-2.95974	-2.73414	-50.093	97	.000
Pair 10	Access to bank credits before irrigation scheme - Access to bank credits after irrigation scheme	-2.87755	.82818	.08366	-3.04359	-2.71151	-34.396	97	.000
Pair 11	Expanding to other business (Transport, shop, services, etc) before irrigation scheme - Expanding to other business (Transport, shop, services, etc) after irrigation scheme	-3.58163	.73110	.07385	-3.72821	-3.43506	-48.497	97	.000
Pair 12	Monthly income (in Frw) before irrigation scheme - Monthly income (in Frw) after irrigation scheme	-1.41837	.57299	.05788	-1.53324	-1.30349	-24.505	97	.000

Ho: situation after irrigation scheme development is the same as situation before.
Ha: situation after irrigation scheme development is significantly different from the situation before.

Student t-value from table ($t_{0.025; 97}$) is 1.985. All calculated values in the table above are between -21.477 and -50.093. They are out of the range -1.985 and +1.985. This means that we reject null hypothesis. Then, we conclude that situation after irrigation scheme is significantly different from the situation before. (Decision and conclusion may be done according to p-value of 0.000. It is less than alpha (0.05) which leads to the rejection of null hypothesis.) This improvement of socio-economic situation is obviously due the irrigation development works which allowed the effective and efficient exploitation of the marshland as well as the enhanced crop production.

This finding is in concordance with finding of Nabahungu (2011) in "Contribution of wetland agriculture to farmers' livelihood in Rwanda" where he says: "The rice in Cyabayaga was the largest contributor to household income providing on average $ 1045 per household per season."

3.2.2 Correlation analysis between Impacts of wetland reclamation and livelihood improvement

Based on the content of the questionnaire for the comparison of the livelihood of community without marshland reclamation and what became the changes in livelihood following the marshland reclamation, the following correlation analysis was generated.

TABLE 3
PAIRED SAMPLES CORRELATIONS ANALYSIS

		N	Pearson Correlation	Sig.
Pair 1	Ensuring food security for family before irrigation scheme & Ensuring food security for family after irrigation scheme	98	.845	.000
Pair 2	Ability to pay efficiently clothes to the whole family before irrigation scheme & Ability to pay efficiently clothes to the whole family after irrigation scheme	98	.777	.000
Pair 3	Paying health insurance before irrigation scheme & Paying health insurance after irrigation scheme	98	.	.
Pair 4	Paying school fees of children before irrigation scheme & Paying school fees of children after irrigation scheme	98	.436	.000
Pair 5	Expanding my cropland and/or buying fertilizers before irrigation scheme & Expanding my cropland and/or buying fertilizers after irrigation scheme	98	.494	.000
Pair 6	Ability to construct/rehabilitate my residential house before irrigation scheme & Ability to construct/rehabilitate my residential house after irrigation scheme	98	.786	.000
Pair 7	Regular employment before irrigation scheme & Regular employment after irrigation scheme	98	.506	.000
Pair 8	Buying household assets before irrigation scheme & Buying household assets after irrigation scheme	98	.604	.000
Pair 9	Transport means before irrigation scheme & Transport means after irrigation scheme	98	.880	.000
Pair 10	Access to bank credits before irrigation scheme & Access to bank credits after irrigation scheme	98	.832	.000
Pair 11	Expanding to other business (Transport, shop, services, etc) before irrigation scheme & Expanding to other business (Transport, shop, services, etc) after irrigation scheme	98	.573	.000
Pair 12	Monthly income (in Frw) before irrigation scheme & Monthly income (in Frw) after irrigation scheme	98	.950	.000

Based on the results indicated in Table 3, we say that the reclamation of Rwinkwavu marshland and development of irrigation system that improved agricultural practices is positively correlated with situation after which indicate the improvement of community's livelihood if we look at the Pearson correlation values that are between 0,777 and 0,95 on the major factors indicating improvement of livelihood. In fact, when the Pearson correlation is statistically significant (p-value less than alpha) that is to say that the situation before was described by lowest categories of Likert scale (impossible, very low level, low level, moderate) while the situation after is described by highest categories of Likert scale (high level, very high level). This is an indicator of a very good improvement. Therefore, Rwinkwavu marshland has significantly contributed to community livelihoods improvement.

3.2.3 The extent Contribution of Rwinkwavu marshland rice irrigation scheme

TABLE 4
COMMUNITY'S PERCEPTION ON THE SIGNIFICANCE CONTRIBUTION TO LIVELIHOODS

	Moderate significance	High significance	Very high significance
To beneficiaries' improvement of social relations	6.1%	28.6%	65.3%
To beneficiaries' general livelihood improvement	11.2%	74.5%	14.3%

The contribution of Rwinkwavu marshland rice irrigation scheme on community livelihood improvement is qualified to be at a high level and is due to the good production of rice after irrigation practice as indicated by figure the respondents 'views in Table 4 where the researcher during the field trips in the study area has realised a very high production as well as a good organization of production market without forgetting a well-managed rice production value chain in place. According to the information collected from field, the enhancement of social relations is due to a number of factors such as collective rice harvesting system, farmers working in cooperatives, grouping farmers in zones and forming micro socio-economic solidarity funds (ibimina) among others which all gather farmers together in their daily activities related to the rice production in the marshland compared to the activities before marshland reclamation which were undertaken on individual scale.

IV. CONCLUSION

In conclusion, the present study has revealed that Rwinkwavu marshland has completely changed in terms of land use and cover as a result of its reclamation and development of irrigation scheme that allowed the shift from traditional practices like multivariate crops cultivation, grazing and exploitation for usual natural ecosystem services to strategic management of the marshland and technology based practices for rice growing. The positive impacts from the marshland's reclamation are not only proven by the high production found on stores of farmer's cooperatives during and after the harvest period, but also by the improvement of the socio-economic status of the community as indicated by the statistical analysis performed during this study which indicate a high positive correlation between the shift to modern agriculture in the marshland with the improvement of the livelihoods. However, this study covered only one marshland among many that have undergone reclamation, and this called for further researches in other areas in order to gather sufficient data that can allow to compare the benefits from reclamation such natural resources with the naturally offered ecosystem services.

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