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Contribution of Nasho and MpangaIrrigation schemeto Socio-Economic Development of Farmers

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ABSTRACT: Agriculture is currently the backbone of Rwanda's economy and the main source of employment and economic activity to high number of citizens. The sector is still subsistence regardless of some irrigation initiatives under practice toward improving its production. This research aimed to assess the contribution of Howard Buffet Foundation Nasho Irrigation (HBFNI) Project to farmers' socio-economic development in Nasho and Mpanga sectors of Kirehe District, Eastern Rwanda from 2013 to 2019. The stratified sampling method selected 400 respondents from 2,099 beneficiaries of (HBFNI) Project. The field visit, structured questionnaire and desk review were employed as data sources. Both Microsoft Excel and Pearson Correlation of the Statistical Package for Social Sciences (SPSS) facilitated data analysis. Regarding the results, 94 percent highlighted Sprinkler as the major irrigation system under practice under influence of rainfall, soil types highlighted by 56 and 28 percent, respectively. The beans, soybeans and maize are the major grown crops. The Beans' production increased from 400 to 1,500 Kg/Ha before and after, respectively. Similarly, Maize production increased from 1,000 to 5,500 Kg/Ha. In addition, domestic animals rose from 1,520 to 3,867, before and after, respectively. Monthly income of 300,001- 500,000 Rwfs was recorded by 28 people who increased up to 285 people.Finally, the Pearson's correlation analysis showed that irrigation and its associated factors had a positive relationship with socio-economic development ($r = .997$, $p < 0.047$) at a significance level of 0.05 with highest positive coefficient of ($r=.997$). Therefore, it was concluded that the expansion of Howard Buffet Foundation irrigation projects or similar projects within other parts of the country would contribute to people's socio-economic development. Also, policy makers can benefit from this research by understanding the way forward in expanding the irrigation practices in Rwanda.

Key words: Farmers, Irrigation, Kirehe district, Nasho Irrigation Project, Socio-economic Development

I. INTRODUCTION

In developing countries, irrigation tends to be stereotyped as equity reducing, in competition with other uses for scarce water resources, and often resulting in negative impacts for women and other disadvantaged groups (Smith 2004). In Sub-Saharan African countries where reduction in income inequality comes from land reform and changes in land tenure, it has a tendency to increase agricultural productivity because of the resultant intensification of labor input on land (Mwabu and Thorbecke 2004& Evans, and King, 2012).

In Rwanda, agriculture is currently the backbone of economy and the main economic activity for the people of Rwanda providing employment to about 86% of the total population (Nahayo et al., 2016). The sector contributes 47% of Rwanda's Gross Domestic Product (GDP) and accounts for about 80% of the foreign earnings from the exports of the primary products of coffee, tea, hides and skins, pyrethrum and horticulture (Bizuhoraho, T., 2018&GoR, 2018). The report of the World Bank (World Bank, 2011) indicates that over 80% of the population derives their survival from agricultural sector. In Rwanda, about 68% practice agriculture as an income generating activity (NISR, 2016).

The economy of Kirehe District is mostly dependent on agriculture and livestock, which occupy the majority of the labor force (Habineza et al., 2020 &DDP, 2019). However, drought has progressively affected many sectors including

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Nyamugali, Mahama, Kigarama, Nasho and Mpanga sectors and irrigation was one of sustainable answer for agriculture production and population welfare (DDP, 2019).

In order to solve the issue of lower productivity related to lower income, the Government of Rwanda through Ministry of Agriculture and Animal Resources (MINAGRI) in partnership with Howard Buffet Foundation elaborated an Irrigation project that use solar system to pump water from Cyambwe lake into field through Pivot centers on 1,173Ha with objective to increase incomes and reduce the poverty through increased agricultural productivity (Habineza et al., 2020 & DDP, 2019).

Regardless the fact that the project objectives are bound on increasing incomes and reducing poverty through increased agricultural productivity, it is good to conduct a systematic research on the socio-economic benefits gained by farmers while working with the project. Therefore, the current research deeply analyzed the contribution of Nasho irrigation scheme on the social and economic development of the farmers in the scheme. This change can be analyzed by comparing farmers' socio-economic development before and after working with the project, specifically within Nasho and Mpanga sectors of Kirehe district where the project operates.

II. MATERIALS AND METHODS

2.1 Description of study area

This study was conducted in Kirehe district located in the eastern province of Rwanda, at 133 Km from the country's capital Kigali. Kirehe district shares borders with Tanzania in East separated with Akagerariver, in the south borders with Burundi. In the west the Kirehe District shares border with Ngoma District and Kayonza District in north (DDP, 2019).

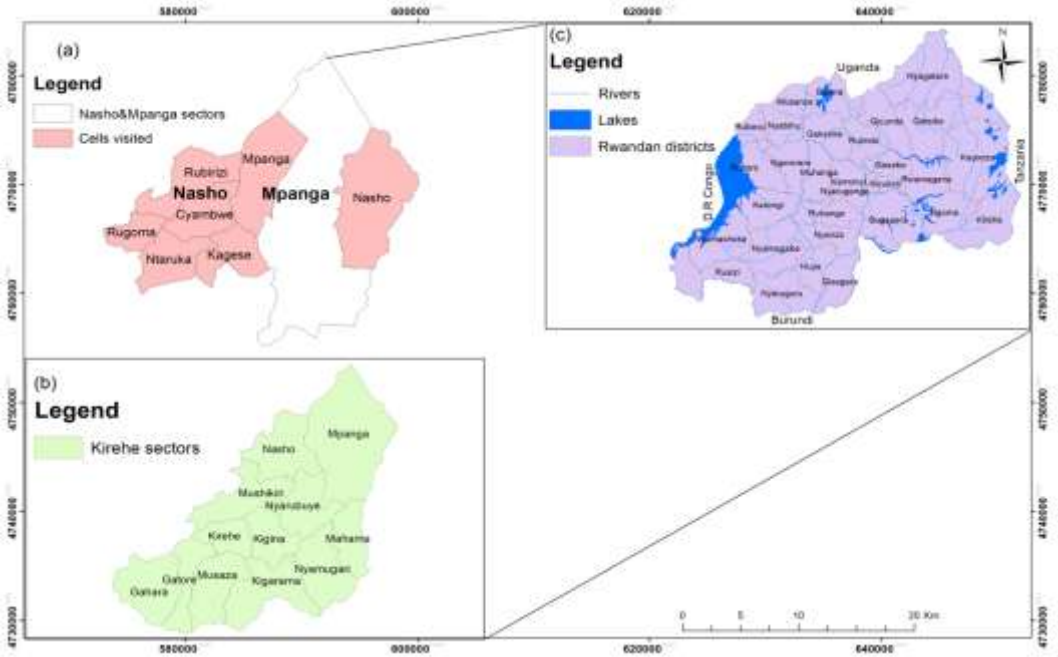

Figure 1: Map indicating the location of (a) the study areas, (b) sectors bordering the study areas and (c) districts of Rwanda bordering with Kirehe district.

2.2 Population of the study

The study employed2,099households which are members of Nasho Irrigation Cooperative (NAICO) andbeneficiaries of the HBFNIPlocated in the Cyambwe, Kagese, Ntaruka, Rubirizi and Rugoma cells in Nasho sector and Mpanga cell in Mpanga sector of Kirehe district (Figure 1).

2.2.1 Sample size and sampling method

The sampling procedures were undertaken in order to select a sample formNasho Irrigation Cooperative (NAICO) members and beneficiaries of the HBFNIP. The authors applied the Yamane formula expressed in equation (1).

$$n = \frac{N}{1+N(e)^2} \quad \ldots\ldots(1)$$

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Where n is sample size, **N** is thetotal population **e** is the margin error which was fixed at 5 percent. Therefore, the sample size was obtained by applying the equation (1):

Thereafter, the authors calculated the sample per each sector considered by this study. However, in order to be sure that each sector was taken into consideration, the authors employed the proportionate sampling method to determine the number of respondents per sector as follows:

$$ni = \frac{Ni * n}{N} \quad (2)$$

Where ni**is** the sample size proportion to be determined, Ni stands for respondentswith irrigation in each cell of sectors considered by the study, n is the sample size calculated in equation 2 and N is the total population considered by the study.

Table 1: Study population and sample size

Sector	Cell	Total members	Sample Size
Nasho	Cyambwe	1,469	279
	Rubirizi	525	100
	Ntaruka	3	1
	Kagese	48	9
	Rugoma	3	1
Mpanga	Mpanga	51	10
Total		**2,099**	**400**

2.3 Datasets collection and analysis

The authors collected primary data on the demographic status of respondents, irrigation scheme and associated factors, irrigated crops and their production, domestic animals' production and proof of socio-economic development. The structured questionnaire translated in Kinyarwanda facilitated the respondents to easily provide relevant answers. The secondary data were collected from the annual reports of the visited cooperatives.

Moreover, secondary data on factors (elevation, land use, rainfall, soil texture) which impact on the irrigation were mapped by using the Geographic Information System (GIS). The considered datasets were of 2013 to 2016 (before irrigation scheme) and 2016 to 2019 when the irrigation scheme was operating within the considered study areas.

For the data analysis, Microsoft Excel was used to present the analyzed data and its Pearson Correlation evaluated the extent to which the Mpanga and Nasho irrigation scheme contributes to the social and economic development of farmers.For this correlation analysis, the authors recognized the fact that a p-value smaller than 0.05 indicated a statistically significant association (at 5 % level) and a p-value larger than 0.05 reveals no statistically significant association between two variables tested.

III. RESULTS

3.1 Demographic characteristics of respondents

The results in Table 2 showed that 57.25 percent of respondents are aged between 21 and 40 years old followed by those aged between 40 and 60 years old who scored 30.75 percent. This age category of respondents can indicate that beneficiaries of the project are family heads and that the project contributes to family wellness not at individual level.

Regarding the marital status as indicated in Table 2, 69 percent of them are married. Those who are widow (ers) and single occupied low percentages of 10.75 and 13.5 percent, respectively. The results in Table 2 indicated that 64.6 percent were male and 35.4 percent were female. This expresses that this irrigation project respects gender balance and that as long as both women and men are benefiting from the project, the family income can be balanced and equitable as well.

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Table 2: Demographic characteristics of respondents

Characteristics		Frequency	Percentage
Age	21-40 years	229	57.25
	40-60 years	123	30.75
	>61	48	12
	Total	**400**	**100**
Marital Status	Single	51	13.5
	Married	296	69
	Widow(er)	71	10.75
	Divorced	27	6.75
	Total	**400**	**100**
Education background	Primary	252	68
	Secondary	33	26
	Bachelor	24	6
	Total	**400**	**100**
Gender	Female	142	35.4
	Male	258	64.6
	Total	**400**	**100**

3.2 Factors associated with Nasho-Mpanga irrigation scheme

3.2.1 Rainfall variability

Rainfall variability was recorded in Kirehe District and was associated to causing water scarcity (drought) which impact son crop production in this area. The authors asked respondents to highlight key factors that impact on the irrigation and rainfall was mentioned. Thus, it spatial distribution was made in order to indicate each part of the study area with its monthly rainfall.

According the rainfall distribution demonstrated in Figure 2, the highest annual mean rainfall of 82.6 mm is at large extent recorded within Nasho cell of Mpanga sector and Ntaruka cell of Nasho sector. The lowest annual mean rainfall (66.02 mm) is registered within Rubilizi and Mpanga cell (Figure 2).

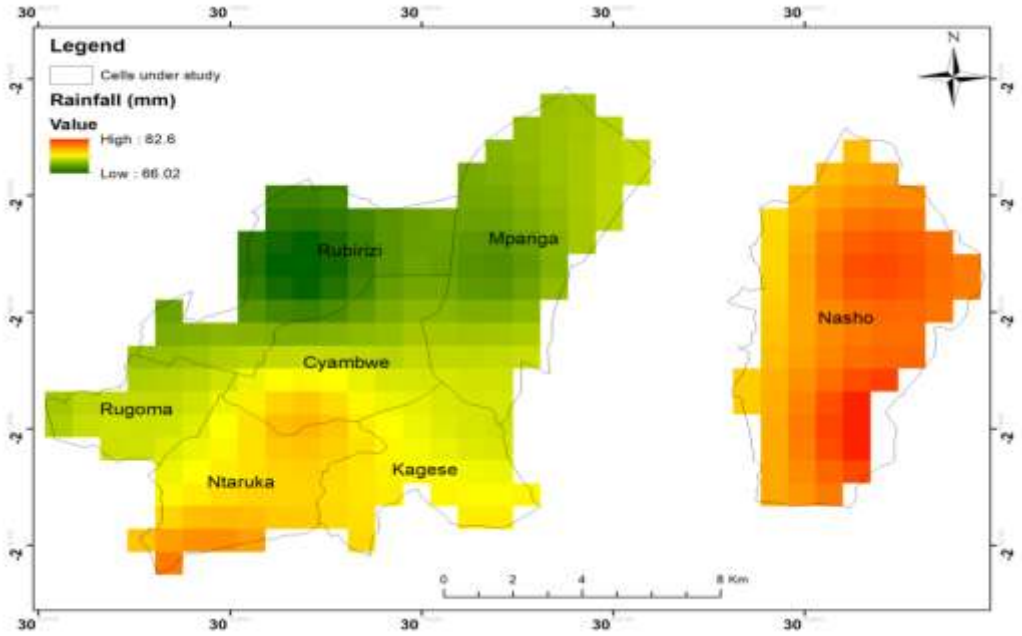

Figure 2: Spatial distribution of the average monthly rainfall in the study areas

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3.2.2 Soil characteristics

The soil features were also asserted by respondents among factors which affect the success and/or failure of Nasho-Mpanga irrigation scheme. And as illustrated in Figure 3, it is observed that within the considered cells of Nasho and Mpanga sectors, sandy clay loam is the major dominating soil types mainly in Ntaruka, Kagese and Rugoma cells.

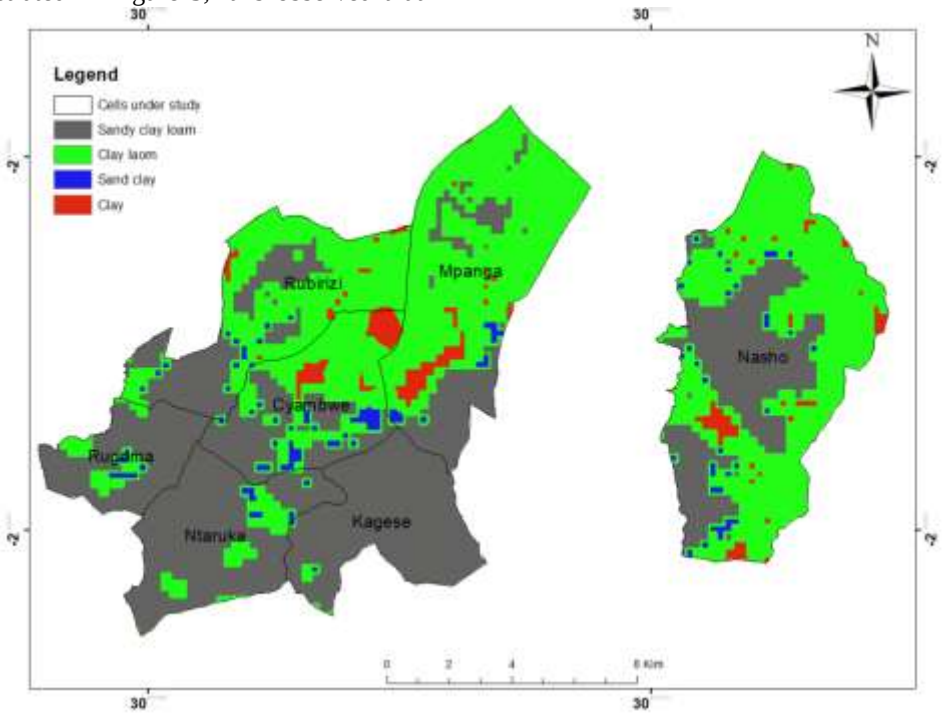

Figure 3: Soil types of the considered study areas

3.2.3 Land use and land cover

The land use and land cover differentiates land uses like cropland, grassland, settlement, water bodies and forestland. This classification can help to better detect the suitable land for each development activity including agriculture. This fact was recognized and then the authors chose to indicate the historical land uses over the study area. The authors employed land use and land cover maps ranging from 2000 to 2019 (see Figure 4).

The results in Figure 4 indicated that Nasho and Rubilizi cells of Nasho and Mpanga sectors are largely built-up, respectively. The areas with extended cropland are Rugoma, Ntaruka, Kagese and Cyambwe cells of Nasho sector (Figure 4).

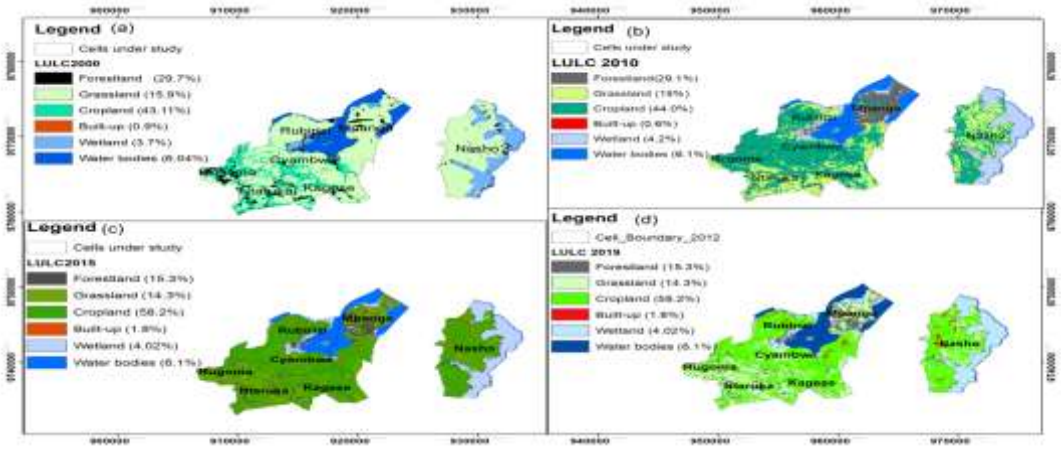

Figure 4: Land use and land cover within the study areas

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3.2.4 Elevation

The topography of the area is reported to facilitate the runoff which may harm the irrigation water quality. This is likely possible in Rwanda which is mountainous country and was recognized by authors where elevation was added among the factors that affect irrigation at Nasho and Mpanga. The results in Figure 5 indicated that Ntaruka, Kagese and Rugoma cells are highly elevated compared to the remaining cells.

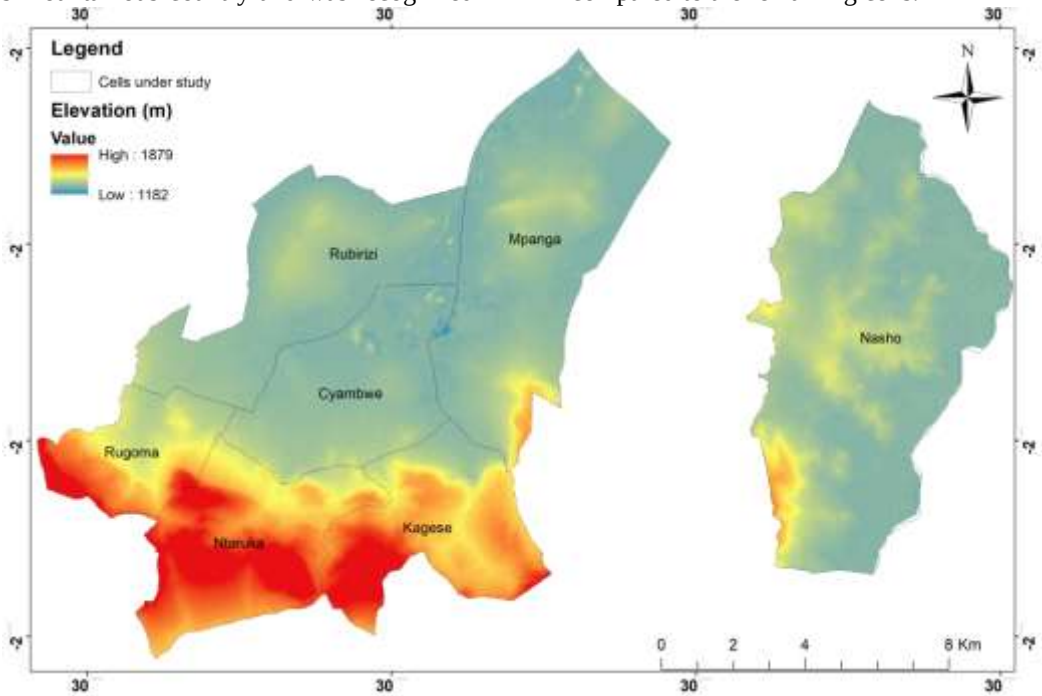

Figure 5: Elevation of Nasho and Mpanga sectors

3.3 Irrigationpractices and fertilizer application at Nasho and Mpanga

As indicated in Table 3, all respondents (400) confirmed that they practice Sprinkler irrigation in their respective croplands. In addition, as indicated in Table 3, all respondents (400) confirmed that they are benefiting from the Howard Buffet Foundation Nasho Irrigation Project.

Furthermore, the results in Table 3 showed that 100 percent of all respondents listed maize, beans, and soybeans as the major crops irrigated in the scheme. The remaining 10.75 percent highlighted flesh beans among the crops irrigated in the Howard Buffet Foundation Nasho Irrigation Project (Table 3).

For the fertilizer application, the study took into account both before initiation of the project (2013- 2016) and after the project (2016-2019) as well. As shown in Table 3, it was noticed that only after project, fertilizers were applied as 5,794 to15,022 Kg/soybean and 11,608 to 22,572 Kg/maize, between 2017 and 2019, respectively.

Table 3: Irrigation practices and fertilizer application

Irrigation practices		
Irrigation practices	**Frequency**	**Percentage**
PracticeSprinkler	400	100
Surface irrigation	0	0
Micro irrigation	0	0
Drop irrigation	0	0

Applied chemical fertilizers			
Seasons A and B	Fertilizers (Kg/crop)		Total Land(Ha)
	Soya	Maize	
2013-2016	-	-	
2017	5,794	11,608	1,173

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2018	10,300.80	17,412.30	
2019	15,022	22,572	

3.4 Changes on socio-economic development of irrigation project beneficiaries

The results in Table 4 showed that beans, maize and soybeans are the major crops grown under the scheme and recorded high production after compared to their production before. Beans production became 1,500 Kg instead of 400 kg and maize production increased from 1,000 to 5,500 Kg per hectare, before and after, respectively. This expresses that the irrigation scheme contributed to increasing crop production.

Table 4: Crop production of project beneficiaries

Crop name	Crop production (Kg/Ha)	
	Before irrigation	After irrigation
Beans	400	1,500
Flesh beans	-	7,500
Maize	1,000	5,500
Soybeans	-	1,500

Source: Annual reports of NAICO

Furthermore, in Table 5, respondents certified that they bought and reared 3,867 of domestic animals compared to 1,520 domestic animals reared before working with the project.

Table 5: Domestic animals reared by farmers

Animal name	Number	
	Before	After
Cattle	127	459
Goats	689	1,438
Sheep	31	175
Pigs	236	775
Chicken	437	1,120
Total	1,520	3,867

Source: NAICO and other farmers' annual reports, 2020

According monthly income, Table 6 showed that before working with the irrigation project, the majority of respondents (270 out of 400) could have a monthly income ranging between 0 and 100, 000 Rwandan Francs.However, after joining the irrigation project, the monthly income increased and 285 of 400 now have a monthly income worthy 300,001 and 500,000 Rwandan Francs (Table 6).

Table 6: Monthly income of respondents

Monthly income in Rwfs	Before	After
0-100,000	270	-
100,001- 300,000	97	39
300,001- 500,000	28	285
500,001-700,000	4	76
700,001- 1,000,000	1	-
Above 1,000,000	-	-
Total	400	400

Source: Field survey, 2020

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Furthermore, the analysis in Table 7 indicated that after working with the irrigation project, people's economic development increased and enabled 102 to have regular employment compared to 89 before.

In addition, parents have been able to pay their health insurance as well the school fees of their children. This was certified by change son the number of before and after working with the project. The numbers increased from 53 to 62 and 58 to 61 people, respectively (Table 7).Accordingly, those how could buy and/or build new houses before joining the Howard Buffet Foundation Nasho Irrigation Project were 75 but increased to 78 (Table 7).

Table7: Proofs of socio-economic development

Naming	Before	After
Regular employment	89	102
Paying health insurance	53	62
Paying schools of children	58	61
Building/buying new houses	75	78
Buying household assets	56	43
Access to bank credits	22	33
Expanding business	19	21

Source: Field survey, 2020

3.4 Contribution of irrigation project to socio-economic development

The results in Table 8 generated a Pearson correlation of 0.997 and a P-Value = 0.047. From the Pearson's correlation matrix, in Table 8, it is noted that irrigation had a positive relationship with socio-economic development of the project beneficiaries (r = .997, p< 0.047) at a significance level of 0.05 with highest positive coefficient of (r=.997).

Table 8: Correlation analysis

		Irrigation practice	Socio-economic development
Irrigation practice	Pearson Correlation	1	0.997*
	Sig. (2-tailed)		0.047
	N	3	3
Socio-economic development	Pearson Correlation	0.997*	1
	Sig. (2-tailed)	0.047	
	N	3	3

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

IV. DISCUSSION

Maintaining well-functioning irrigation systems is a crucial condition for sustainable development of agriculture and different countries are executing several policies to ensure development of agriculture (FAO, 2015). The government leaders in the Sub-Saharan Africa where Rwanda is located have recognized the role of irrigation in ensuring crop production and food security (Xie et al., 2014). This dates since 1960 and was characterized by the irrigation schemes established during this time were largely centralized, and were government-controlled and designed systems without farmer input and without robust plans regarding their operation and maintenance (Kadigi, et al., 2012&Xie et al., 2014).

High demography growth associated with reliance on subsistence agriculture under rainfall variability makes the Rwandan agriculture sector uncertain. This is coupled with rapid cropland reduction which decreased from 0.95 ha in 1960 to 0.25 ha in 2010 leading to 0.10 ha by 2050 (Nahayo et al. 2016&Narayanan, K., 2014). On the other hand, the small-scale farming is the majority and most of them are under rain-fed whereby the production is very much affected by climate variability (Mutiro, J. and J. Lautze, 2015). This expresses how much irrigation development can

serve as sustainable solution toward improvement of farmers' stable income.

In 2016, the Howard Buffet Foundation Nasho Irrigation Project was introduced in eastern province, largely threatened by water scarcity and affecting crop production (Geoffrey, G., et al., 2015). The project aimed to utilize the available underground water toward improving agricultural production and people's livelihood at large (DDP, 2019). The above recognized and this study undertaken to assess the contribution of the project on the socio-economic development of its beneficiaries. The results of the study in Table 3 revealed that the main type of irrigation systems applied by the Howard Buffet Foundation Nasho Irrigation Project is the Sprinkler Irrigation system.

The research conducted by the Food and Agriculture Organization of the United Nations (FAO, 2015) indicated that irrigation contributes to water management, increasing crop production, income and job creation. Similarly, the results of this study agreed with the statement. As indicated in Tables 4 and 5, both crop and domestic animals' production increased compared to the period before working with the Howard Buffet Foundation Nasho Irrigation Project. Furthermore, Tables 6 and 7 certified the increase in monthly income and other socio-economic benefits which resulted from working with the irrigation project.

Therefore, it can be noted that the Howard Buffet Foundation Nasho Irrigation Project has significantly contributed to the economic development of its beneficiaries in Nasho and Mpanga sectors of Kirehe district in the Eastern province of Rwanda.This was mainly proved by the Pearson's correlation matrix (Table 8) that irrigation had a positive relationship with economic development of beneficiaries ($r = .997$, $p < 0.047$) at a significance level of 0.05 with highest positive coefficient of ($r=.997$).

V. CONCLUSION

This research was conducted with the aim of assessing the contribution of Irrigation to socio-economic development, Case of Howard Buffet Foundation Nasho Irrigation Project in Kirehe District, Eastern Rwanda. The authors employed a sample of 400 representing 2,099 farmers working with the project in Nasho and Mpanga sectors of Kirehe district from 2013 to 2019. The results indicated that Sprinkler is the main irrigation system under practice. Regarding the grown crops, beans, soya and maize are the major crops and the results indicated that before the project Beans produced 400 kg per hectare which increased up to 1,500 Kg per hectare after. Growing crops and rearing domestic animals whose production increased compared to before working with the project led to raising monthly income. It was noted that 85 people recorded a monthly income ranging between 300,001 and 500,000 Rwfs, but their number increased up to 285 people after. Finally, the Pearson correlation analysis of $r=0.997$ and a P-Value = 0.047 expressed that the irrigation project significantly improved the socio-economic development of its beneficiaries.

VI. ACKNOWLEDGEMENTS

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