ANALYSIS OF IRRIGATION DEVELOPMENT TO CROP PRODUCTION IN THE KIREHE DISTRICT CASE OF NASHO IRRIGATION SCHEMES.

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Abstract:

Only nine percent of potential irrigation areas are currently irrigated in Rwanda. In other countries in Eastern and Central Africa such as Ethiopia, Uganda, Kenya, and Tanzania, two percent on average of cultivated areas are under Irrigation (FAO, 2015). In Rwanda water resources are abundant. However, they are not well evenly distributed. Rwanda has about 6 to 7 billion cubic meters of surface water, 4.5 to 5 cubic meters of groundwater, and 27.5 cubic meters of rainwater. (NISR 2017).

This research aimed to analyze the current status and contribution of water use in agriculture through irrigation development to crop production in Nasho irrigation schemes located in the Nasho sector and a small part in the Mpanga sector of Kirehe District, Eastern Rwanda from 2012 to 2021. The methodology used was desk review, and group discussion with fifteen key local and field staff representatives was employed as data sources. Microsoft Excel and statistical analysis facilitated data analysis. As a finding, 100 percent of the reviewed reports and discussions from the focus group highlighted Center Pivot Sprinkler, fixed sprinkler, and hand move sprinkler as the major irrigation systems under practice, and beans, soybeans, fresh beans, and maize are the major grown crops. The beans' production increased from 400kg to 1,800 Kg/Ha in Nasho II, maize increased from 1,460 to 6,180 Kg per hectare. The schemes also adopt new crops after irrigation development such as fresh beans, soybeans, and tomatoes. The mean total investment before irrigation development was 7,078,608 Rwandan Francs, while benefits from their production were 239,769,392 Rwandan Francs, However, the main total investment after irrigation development was 58,685,010 Rwandan, Rwandan Francs, and the benefit is averaged on 776,614,990 Rwandan Francs.

The finding of this study will help the policymakers to plan the expansion of the areas under irrigation, as Rwanda has abundant water resources to increase irrigation's potential areas, and this finding will encourage the private sector to invest in irrigation development as it is more profitable more than non-irrigated agriculture.

Keywords: Farmers, Irrigation, Crop production, Kirehe district, Nasho Irrigation Project, Water management.

1. Introduction

The agriculture sector is the most powerful form of the economic sector worldwide in Sub-Saharan Africa (SSA), agricultural development remains the main vehicle to end poverty because a big part of the population depends on agriculture for their livelihood, (Shiferaw et al., 2014). However, agriculture by its nature is highly affected by climate variabilities such as a change in rainfall, temperature, sunshine variations, and drought, (You, 2008).

Irrigated agriculture contributes to 40% of the world's food availability from less than 20% of the cultivated area highlighting the role of irrigation in global food security as acknowledged by Turral (2010). Hedley (2014). It is estimated that 75% of the grain production in China is dependent on irrigated farming.

In Rwanda, agriculture is crucial for the economic growth and reducing poverty, as the mainstay of the economy, it accounts for 30 percent of gross domestic product (GDP) in 2019 and employs 70% of the population, regarding the past and current climatic issues of low rainfall, high temperature in Eastern Rwanda, and the current climate change effects worldwide cause negative effects on rainfall distribution, then the water scarcity remains a critical problem to impact the agricultural production, specifically crop production. (FAO, 2015&WFP, 2015).

Irrigation initiatives in Rwanda appear as small-, medium-, and large-scale schemes. Small-scale irrigation involves individual smallholder farmers, commercial farmers, and community enterprises, such as cooperatives, working on land ranging from 0.10 to 10 hectares. Small farming benefits from subsidies of 50 percent from the government to support their small-scale irrigation equipment and installation. Medium irrigation schemes include marshland and hillside irrigation schemes ranging from (10 to 100 hectares), to a large-scale (more than 100 hectares), developed with the Government of Rwanda (GoR) initiatives and development partners (DPs), or private commercial farmers (MINAGRI, 2014a).

The current status of the developed area with irrigation infrastructures stands at 66,840.5 ha, which is equal to 11.33% of the total potential irrigable area which is 589,711 ha (marshlands developed on 37,273 ha, hillsides developed on 8,780 ha and Small-scale irrigation (SSIT) developed on20,787.5 ha), and the government plans to expand the areas under irrigation to 102,284 ha by 2024. Nasho Irrigation schemes are among the schemes developed by the Government of Rwanda from 2009 to 2011 that cover 600ha (total command area), and in 2016 the Government of Rwanda is collaborating with the Howard G. Buffett Foundation (HGBF) to improve agricultural productivity in the country. The system pump water from Cyambwe lake into the field through centers Pivot on 1,173Ha to increase incomes and reduce the poverty through increased agricultural productivity.

The need to understand the contribution and key achievements of the developed Nasho Irrigation schemes regarding crop production is the purpose of this research paper. This can be analyzed by comparing the crop production before irrigation development and after the initiation of the project.

2. Material and Methods

2.1. Description of the Study Area

The study presented was conducted in the Nasho and Mpanga sectors of Kirehe district in the Eastern Province of Rwanda on different types of irrigation systems in Nasho schemes including sprinkler irrigation, and center-pivot irrigation systems, schemes

named Nasho I and NashoII irrigation projects.

Kirehe District is located in the southern part of Eastern Province; it is one of the driest districts in Rwanda and receives an average annual rainfall of less than 900 mm). The average rainfall for Rwanda the average rainfall is 1250 mm per annum: The average temperature in the Eastern parts of the district is more than 21 degrees Celsius (MINAGRI, 2012a) while the national average of 19 degrees Celsius (MINAGRI, 2012a). The agriculture in the district has potential due to the availability of water resources like rivers but farmers are suffering from drought due to the weather conditions. There are two schemes of irrigation developed in this area the first one covered 600 ha of the total command area and currently, the total area under covered by the new irrigation project is about 1280 ha in the Nasho sector, Kirehe District of Eastern Province.

Figure 1: *Nasho map indicating the*

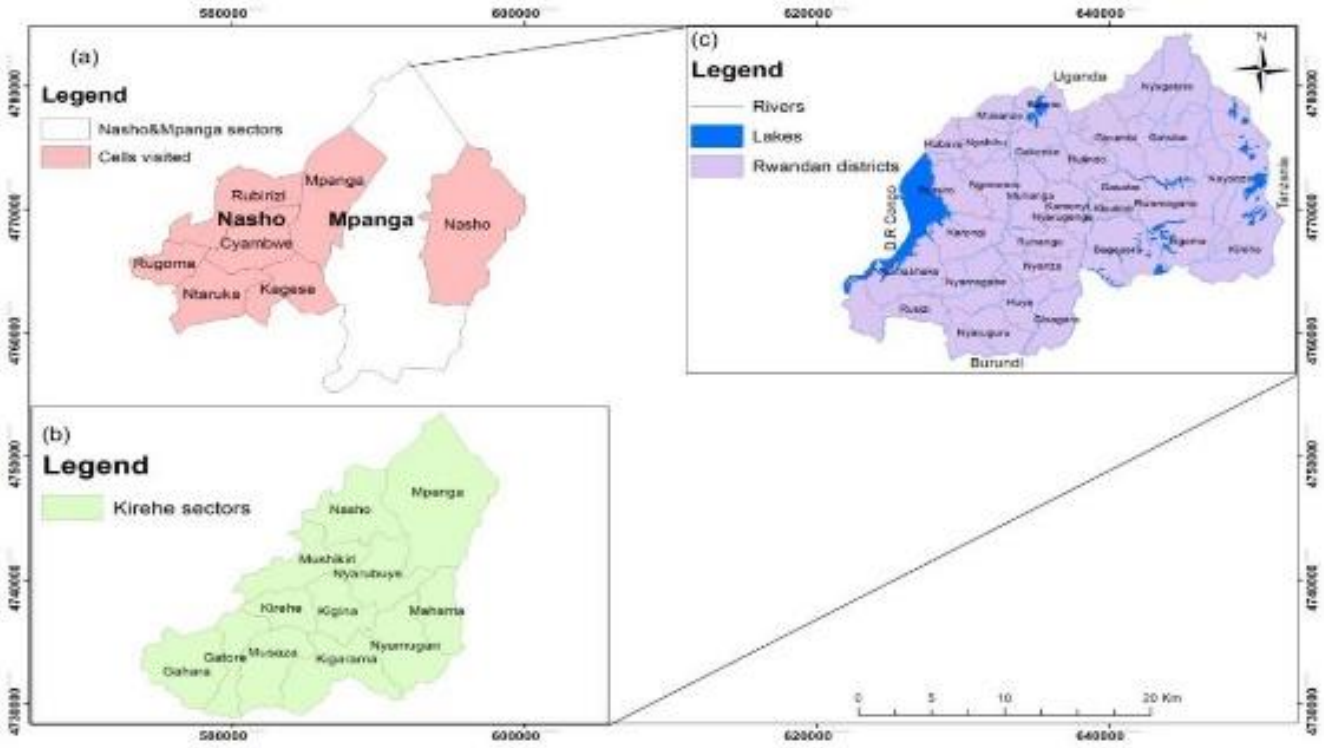

Figure 1. Study area under the irrigation scheme.

2.2. Sampling and Data Collection Techniques

The study pre-formulated checklists and undertook focus group discussions with 15 different Representatives in the study area. The discussion with the group was mainly focused on the contributions, opportunities, and Challenges of developed irrigation schemes in the study area. This also helped to extract the inner feeling or perception of the discussants about the overview of the Nasho irrigation schemes. Group discussion will give the descriptions of how farmers experienced the change of the value of the irrigated land especially identification of intangible factors for crop production change. The discussion with the farmers' cooperative committee, famous old inhabitants near the schemes, the field agronomist, and the District agriculture officer will be about the following areas: Land use that was in place before irrigation development, different types of crops grown before, agriculture practices, if there is cooperative before irrigation development and Economic benefits the of the developed irrigation scheme, different crop under irrigation, effects of irrigation on crop production.

Documentary sources were used as secondary data obtained from Journals, Textbooks, Water user's association records, MINAGRI reports, NISR reports, and other written materials about irrigated agriculture. Such documents allowed the researcher to acquire relevant information to support the research findings. However, it is important to note that these research instruments are not equally limited; rather, they serve to complement each other.

3. Results

According to You *et al.* 2011; Burney and Naylor 2012), Water application is considered an essential input that can help farmers to build resilience to the effects of erratic rainfall and drought. In this way, irrigation helps farmers to intensify crop production during the rainy season and dry season. Therefore, given that Rwanda has many potential water resources from numerous river basins, lakes, and wetlands (Nabahungu and Visser 2013), irrigation development is given priority in the Strategic Plan for Agricultural Transformation (SPAT), which guides national agricultural policies in Rwanda (Bizoza and Havugimana 2013). Although an estimated total land area was fully developed with irrigation schemes irrigation potential of roughly 589 000 ha was identified, (Bizoza 2014) Irrigation schemes have allowed farmers to move from rain-fed agriculture to diversified high-value crops, hence resulting in increased cropping intensity and land productivity.

The country has registered 66,840.5 ha under irrigation (MINAGRI Annual report 2020-221). This implies that there is still potential to improve agricultural productivity by expanding irrigated land area. The development of irrigation, as a strategy aimed toward agricultural production growth, rural livelihood improvement, and food security, necessitates enormous investments.

Since in 1960 the irrigation development was started in marshland schemes, during this time the irrigation schemes were largely centralized and were government-controlled and designed systems without farmer input and robust plans regarding their operation and maintenance, (Kadigi, et al., 2012).

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). On the other hand, small-scale farming is the majority and most of them are 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 a sustainable solution for the improvement of farmers' stable income.

In this study, the findings were presented based on the set of objectives, the Microsoft Excel and Crop Watt software was a major tool for data collection and analysis.

3.1.Irrigation status in the study area

The government of Rwanda has recognized the importance of irrigation development for better water management and crop production as well. It is in that framework that the Immediate Action Irrigation Project (Government Fund Irrigation Project-GFI) was initiated in the area in 2011 to develop a pressurized irrigation scheme and by 2016 the Howard Buffet Foundation Nasho Irrigation Project was introduced in this region to utilize the available water toward improving agricultural production and people's livelihood at large (DDS, 2019). The research then undertakes the current research to assess the irrigation development to crop production in Nasho irrigation schemes. The results of the study in Table 1 revealed that the status of irrigation development in the study area is 44.9 percent of the total irrigated area in the Kirehe District, the types of irrigation systems applied in Nasho Irrigation schemes are the fixed, hand move Sprinkler, and Center Pivot Irrigation Systems, the main irrigated crops are maize, beans, soybeans, and fresh beans. This result supports the findings of the NISR 2021A report on the types of irrigation used and the irrigable land in the District.

In Nasho I 250 ha of the Scheme is irrigating properly the remaining area was not irrigating properly due to the damaged irrigation equipment and there are no spare parts at the market. This finding supports the (report of the Auditor General of state finances,2015). Only 0.54 percent of agricultural land in Kirehe is under irrigation and 44.9 percent of irrigated land is located in Nasho Sector this small percentage of area under irrigation this is contributing to this study made by FAO in 2015 only nine percent of Rwanda's potential irrigation areas are currently irrigated, the surface irrigation occupied a big part of 33.9 percent followed by a center pivot on 29.7 percent and 15.2,12.8 and 8.4 percent on sprinklers, flood, and traditional irrigation respectively.

3.2. The status of crop production in the study area

Discussion with focus group hundred percent highlighted the main irrigated crops listed as maize on 43.45 percent, beans on 20.2 percent, and soybeans on 17.3 percent, and the remaining area of 19.05 percent was designed to produce fresh beans in every season A that begins in September to January of the year.

The use of chemical fertilizers was increased from 3,801 Kg to 5, 204.2 Kg for soybeans and 7,800 to 20,167.8 Kg/maize, between 2017 and 2021, respectively.

Furthermore, the finding certified the increase in the use of chemical fertilizers in the irrigation schemes facilitated by crop intensification programs similar to the study conducted (Nsabimana, 2021) irrigation sought to increase access to productive inputs (improved seeds and fertilizers), due to increased land under consolidation.

Rainfall distribution in the study area was expected only in the two wet seasons and typified by short high intensity storms. Dry

season storms are uncommon and tend toward small showers of low intensity

Table 4 and figure 2 represent the available effective rainfall in the study area, its crop water needs, the duration of crops in the field and It is clear that the water requirement for maize, beans, soybeans, and fresh beans could not be met only by the available rainfall, so the needs for a supplement of water through irrigation application to ensure successful crop production. Table 4.6 Show that the total effective rainfall is 971.6 mm and the total crop water requirement is 2,005 m, the net water deficit is 1,033.4 mm which has to become from irrigation supplement.

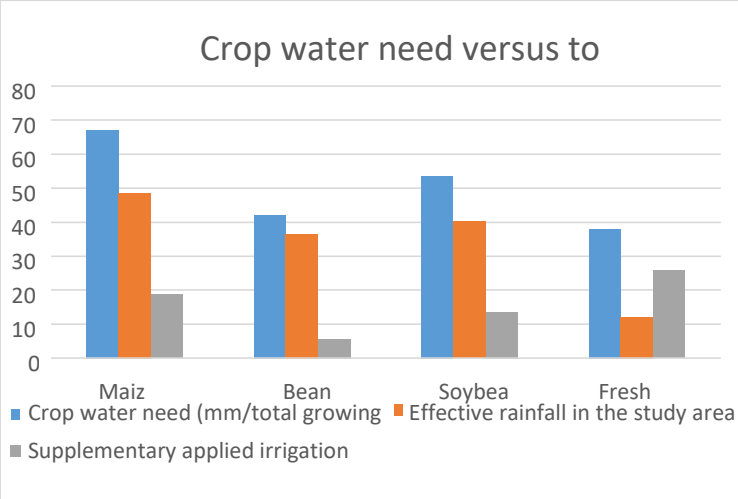

Figure 2 Comparison of Effective rainfall, Crop water needs, and Irrigation application

Figure 2 shows the available effective rainfall in the study area, its crop water needs, the duration of crops in the field and It is clear that the water requirement for maize, beans, soybeans, and fresh beans could not be met only by the available rainfall, so the needs for a supplement of water through irrigation Productivity is expressed in the quantity of output or value of output (which is relative to the market) per unit of input consumed: the yield of products harvested is an indicator of the productivity of land, expressed in Tons/ha. Based on the information presented in table 6, the results show the increased benefits in irrigation schemes as the benefits after irrigation development for maize ranging from 644,305,295 Frws to 958,345,928 Fwrs with the Mean of 776,614,990 Frws, compared to the benefits from maize crop before irrigation ranging from 174,294,360 Frws to 414,100,158 Frws with the Mean of 239,769,392 Frws. Maize production is more profitable under irrigation.

application to ensure successful crop production. Table 4.6 Show that the total effective rainfall is 971.6 mm and the total crop water requirement is 2,005 m, the net water deficit is 1,033.4 mm which has to become from irrigation supplement.

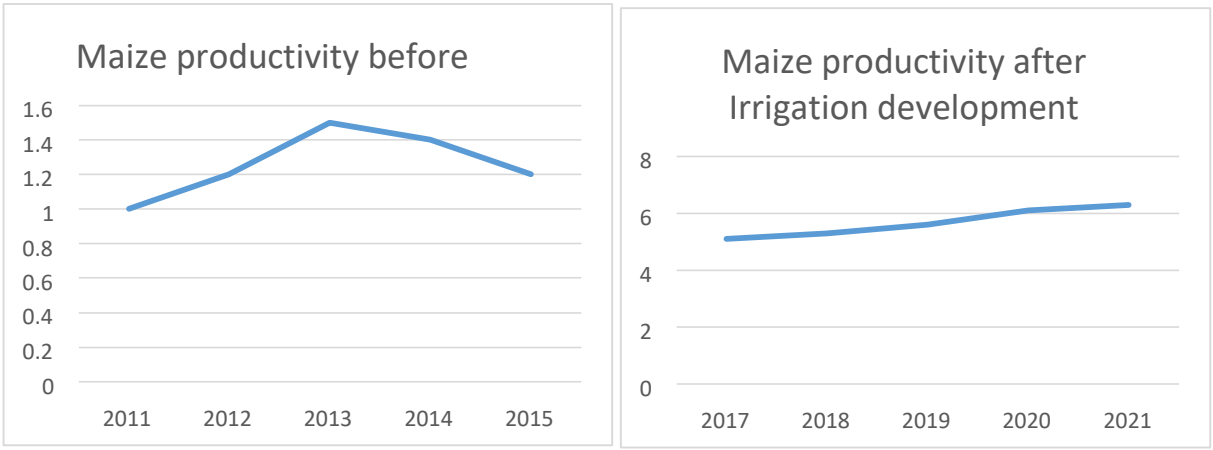

Figure 3. Productivity of maize before and after irrigation development

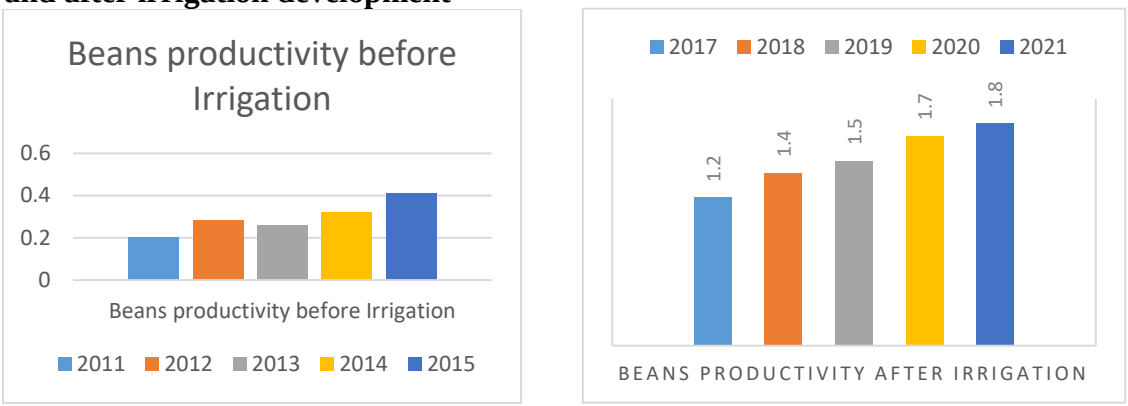

Figure 4: Comparison of beans

The results found in figures 3 and 4 that Beans produced 0.4 T per hectare and the production increased up to 1,8 T per hectare after. Similarly, Maize yield increased from 1,46T to 6.18T per hectare, before and after, respectively in Nasho II irrigation scheme and the yield of beans increased from 0.38 T to 1.51 T per hectare and Maize yield has increased from 2.2 T to 5.8T per hectare in Nasho I irrigation Project. This means that water irrigated to plants increases the crop production for maize and beans in both Nasho irrigation schemes both irrigation systems. This expresses that the irrigation scheme contributed to increasing crop production the scheme also produces 7.5T per ha of fresh beans and 1.5 T per ha of soybeans. The finding is similar to the report made by NISR 2020A that the productivity on large scale area for maize is at 5.85Tone per hectare in Kirehe District and the Several studies by Chiza (2005) on Pangani and Rufiji basins of Tanzania Resulted that irrigation increased crop yield per hectare, for example, rice, maize, tomato, and onion from 1.5 to 4.1, 1.1 to 3.3, 2.0 to 3.0, and 2.5 to 3.5 tons in the Rufiji basin, and from 2.0 to 5.3, 1.1 to 4.9, 2.0 to 4.0 and 2.5 to 4.0 tons respectively in the Pangani basin (Cited in Fanadzo 2012).

4. Conclusion

This study was conducted mainly to focus on the analysis of irrigation development on the crop yield in Eastern Rwanda, Kirehe District, at Nasho irrigation schemes. The researcher employed a group discussion of fifteen key informants, namely; WUAs members (6), sub-catchment officials (6), and local government officials (3), working with the irrigation project in the Kirehe district from 2011 to 2021. The study has noticed that irrigation has significantly improved crop production in the study area.

The results of the study indicated Sprinkler as the main irrigation system under practice. Regarding the grown crops, soybeans, 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 1,800 Kg per hectare after, and Maize produced 1,460 kg per hectare which increased up to 6,180 Kg per hectare after. Therefore, irrigation development in the study area is not a substitute for other factors of crop production it is used as a complementary factor among other agricultural production inputs.

In 2018 the EDPRS 2 targeted strategy was to develop 100,000 ha under irrigation, of which 65,000 ha of marshland and 35,000 ha would be hillside irrigation. According to the same report MINAGRI will plan to develop 60,000 ha of additional irrigated land, 75 percent of marshland and 25 percent would be hillside through public investments, and 20,000 ha through private sector investments. The Strategic Plan for the Agricultural Sector (PSTA4), under Rwanda's EDPRS 3, (2018-2024).

Focused on innovative approaches for a productive, green, and market-oriented agricultural sector, the objective of promoting the commercialization of agriculture value chains in the country. Currently practices irrigation on 62,207.5ha, but the government plans to expand this to 102,281ha.

In conclusion, there is an urgent need to conduct a rehabilitation for 250 ha of his developed rice marshland to stop its progressive degradation which is jeopardizing its profitable farming business, thus leading rice farmers and the local population into poverty.

Acknowledges

The researcher would thank the Ministry of Agriculture and Animal Resources (MINAGRI) for the support to avail data. Special thanks to Kirehe District agriculture officers and to the field technicians and Cooperative leaders who helped me to daily record the data.

Conflicts of Interest

The research declares no conflicts of interest regarding the publication of this paper.

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List of Tables

Table 1 the view of irrigation status in the whole District.

District	Area under Agriculture Ha	Irrigated land in District Ha	% of Irrigated land in District	Irrigated area in Nasho Ha	% of Nasho Irrigated land compared to District
Kirehe	728,000	3,946	0.54	1,773	44.9

Table 2: Types of irrigation used in Kirehe

District	Surface irrigation	Flood Irrigation	Drip irrigation	Sprinkler irrigation	Pivot Irrigation	Traditional Techniques
Kirehe	33.9	12.8	-	15.2	29.7	8.4
	1,340.2	503.8	-	600	1,173	329

Table 3: Types of irrigated crops

Irrigated crop	Frequency	Percentage
Maize	15	100
Beans	15	100
Soybeans	15	100
Flesh beans	43	10.75

Table 4: Rainfall distribution in the area

Meteorological Measurement	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	An. Av
Av. Precipitation(mm)	69	100	104	128.06	92	20	9	34	86	102	127	100	971.6
N. of wet Days per Month	10 32 %	10 35 %	13 42 %	17 57 %	14 45 %	3 10 %	1 3 %	4 13 %	9 30 %	14 45 %	15 50 %	12 39 %	122 33%

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Table 5: Approximate values of Seasonal Crop Water Needs

Crops	Crops growing period (days)	Crop water need (mm/total growing period	Effective rainfall in the study area (mm)	Supplementary applied irrigation(mm)
Maize	152	670	484	186
Beans	105	420	365	55
Soybeans	140	535	401	134
Fresh beans	85	380	121	259
Total		2,005	1,371	634

Parameters	*Fertilizers cost*	*Seeds cost*	*Land Preparation*	*Sowing cost*	*Weeding cost*	*PHHS cost*	*Irrigation cost*	*Total Investment cost*	*Production(T)*	*Cost for production*	*Benefits*
	After Irrigation										
Mean	53,205,200	452,672.00	1,245,060	990,374	364,000	671,500	1,756,204	58,685,010	4,176.50	835,300,000	776,614,9
Min	51,880,500	376,532	990,416	741,457	250,000	623,800	1,172,000	56,034,705	3,686	700,340,000	644,305,2
Max	66,063,000	488,072	1,860,000	1,479,000	682,000	798,000	2,744,000	74,114,072	4,693	1,032,460,000	958,345,9
N			15								
	Before irrigation Development										
Mean	6,002,106	6,352	507,000	102,450	171,500	289,200	0	7,078,608	1,299.20	246,848,000	239,769,3
Min	5,280,000	6,740	401,000	128,000	178,900	251,000	0	6,245,640	1,003	180,540,000	174,294,3
Max	8,180,000	8,962.50	782,680	251,700	238,000	438,500	0	9,899,843	2,120	424,000,000	414,100,1
N											

Table 6: Comparison of production cost versus investment cost before and after irrigation development for maize.

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