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Implications of Water Policy on Irrigation Performance in Rwanda.

''Case Study Eastern Province''

Defended on 04/09/2018 Before the Following Committee:

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DECLARATION AND CERTIFICATION

Declaration

I, **BIZUHORAHO Theobald**, master student, registered under, PAUWES/2016/MWP16, hereby declare that, this thesis represents my personal work, realized to the best of my knowledge. I also declare that all information, material and results from third parties, have been fully cited and referenced in accordance with the academic rules and regulations.

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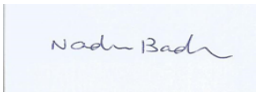
Certification

This thesis is the candidate's original work and has been prepared with our guidance and assistance. Therefore, it is certified for submission as final version done with our approval as official University supervisor, and all corrections were added as recommended by the examination committee.

Signature:  **Date:** 12th September 2018

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DEDICATION

To:

All Farmers of Eastern Province of Rwanda.

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May God Bless You All

ABSTRACT

In Rwanda, Agriculture is the back bone of the country economy, therefore, in line with African Union Agenda 2063, SDGs and CIP program, GoR initiated different programs to develop hillside and marshland irrigation in different regions of the country. Hence, those initiatives were supported by formulation water resources policy and irrigation policy. Therefore, the general purpose of this study, is to assess the implications of water policy on irrigation performance, in Eastern Province of Rwanda. The study focused on identifying the effect of water use permit; Assessing the roles of public and private participation and Evaluating the Impact of WUAs on irrigation performance. Hence, three different irrigation sites were selected from different districts of Eastern Province, namely Gashora irrigation site, of Bugesera district; Nasho/Mpanga irrigation site of Kirehe district and Kagitumba irrigation site of Nyagatare district. A total sample of 563 farmers were selected randomly and responded to the questionnaires. In addition, WUA leaders and local leaders were also interviewed in the period of May 2018. The collected data were analysed using SPSS software, version 23, to test the significance of the result. Therefore, based on the result, the major source of water was from the rivers and lakes. Meantime, farmers from Nasho/Mpanga and Kagitumba have water use permit whereas that Gashora do not have. Therefore, having water use permit accelerated safe use of water and increased ownership of the irrigation infrastructures. In addition, during this study, the participation of public sector is much more implied, 94.3% of the respondents testified that they got training on irrigation practises at the beginning of the agriculture season. The trainings are given by government institutions through their respective cooperatives. Therefore, this training facilitates the repairing of some irrigation infrastructures damage occurs frequently in the irrigations sites. In addition, 98.6% of the respondents were member of WUA, and this study revealed that, both of WUA Nasho/Mpanga irrigation site and Kagitumba, are much stronger than that of Gashora irrigation site, due to that at Gashora irrigation site, its WUA is new and they do not have water use permit. The farmers enumerated the profit from WUA, such as getting subsidies, farm management training, easily selling their harvest and small credits from WUA which help to boost irrigation performance. But, the farmers claimed also, some challenges, like high cost of irrigation machines and insufficiency of spare party on the market, disaster; and energy source which is not enough, and those who use their own pumps, the cost of fuel is much more expensive, but the leaders are much encouraged to partner with the farmers to solve them while attracting the private sector to support the government where it is needed for the sake of improving irrigation and achieving food security.

RESUMÉ

Au Rwanda, l'agriculture est la pierre angulaire de l'économie du pays. Conformément à l'Union Africaine Agenda 2063, SDGs et programme CIP ; le Gouvernement Rwandais lançais différents programmes de développement et de l'irrigation colline marécageuse dans différentes régions du pays. Ces initiatives ont été appuyées par la formulation d'une politique des ressources en eau et celle d'irrigation. Par conséquent, l'objectif général de cette étude est d'évaluer les implications de la politique de l'eau sur la performance de l'irrigation, dans la province orientale du Rwanda. L'étude s'est concentrée sur l'identification de l'effet du permis d'utilisation de l'eau ; Évaluer les rôles de la participation publique et privée et évaluer l'impact des Association d'Utilisateurs d'Eau. Ici, trois sites d'irrigation différents ont été sélectionnés dans différents districts de la province orientale, à savoir le site d'irrigation de Gashora, dans le district de Bugesera ; Site d'irrigation de Nasho / Mpanga du district de Kirehe et du Kagitumba du district de Nyagatare. Un échantillon total de 563 agriculteurs a été sélectionné au hasard et a répondu aux questionnaires. En outre, les dirigeants AUE et les dirigeants locaux ont également été interviewés dans la période de mai 2018. Les données recueillies ont été analysées à l'aide du logiciel SPSS version 23, pour tester la signification du résultat. Par conséquent, la principale source d'eau provient des rivières et des lacs. En attendant, les agriculteurs de Nasho / Mpanga et de Kagitumba ont un permis d'utilisation de l'eau alors que Gashora n'en a pas. Par conséquent, l'utilisation de l'eau permet d'accélérer l'utilisation sûre de l'eau et d'accroître la propriété des infrastructures d'irrigation et de réduire les coûts. En outre, au cours de cette étude, la participation du secteur public est beaucoup plus impliquée, 94,3% des répondants ont déclaré qu'ils reçoivent une formation sur les pratiques d'irrigation au début de la saison agricole. Les formations sont dispensées par des institutions gouvernementales à travers leurs coopératives respectives. Par conséquent, cette formation facilite la réparation de certaines infrastructures d'irrigation. En outre, 98,6% des répondants étaient membres de AUE, et cette étude a révélé que, les deux AUE Nasho / Mpanga site d'irrigation et Kagitumba, sont beaucoup plus forte que celle du site d'irrigation Gashora, en raison de ce que le site d'irrigation Gashora, son AUE est nouveau et ils n'ont pas de permis d'utilisation de l'eau. Les agriculteurs dénombrés au profit de AUE, telles que l'obtention des subventions, la formation en gestion agricole, la vente facilement leur récolte et de petits crédits de AUE qui aident à améliorer les performances de l'irrigation. Mais les agriculteurs ont également fait valoir certains défis, tels que le coût élevé des machines d'irrigation et l'insuffisance de la part de rechange sur le marché, la catastrophe; et source d'énergie qui ne suffit pas, et ceux qui utilisent leurs propres pompes,

le coût du carburant est beaucoup plus cher, mais les dirigeants sont beaucoup encouragés à collaborer avec les agriculteurs pour les résoudre tout en attirant le secteur privé pour soutenir le gouvernement où il nécessaire pour améliorer le secteur d'irrigation et réaliser la sécurité alimentaire.

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LIST OF ACRONYMS

12YBE : Twelve Years Basic Education

AU : African Union.

AUE :Association des Utilisateurs d'Eau

CIP :Crop Intensification Program

C.O.V.A.M.I.S : Cooperative for Valorisation of Mpanga Irrigation Scheme

DBO :Design Build Operate

EDPRS : Economic Development for Poverty Reduction Strategy.

EICV III : Enquête Intégrale sur les Conditions de Vie des ménages (in French)

:The third Integrated Household Living Conditions Survey (In English)

GDP : Gross Domestic Product.

GoR : Government of Rwanda.

K.A.B.O.K.U : Koperative y'Abahinzi Borozi Kagitumba-Umuvumba

K.O.A.I.G.R : Koperative y'Abahinzi Ivomerera Imyaka, Gashora-Rilima

KWAMP : Kirehe Watershed Management Project

LWH : Land Husbandry, Water Harvesting and Hillside Irrigation.

MINAGRI :Ministry of Agriculture and Animal resources Development.

MINIRENA : Ministry of Natural Resources.

PPP : Public Private Participations

PSTA : Strategic Plan for the Transformation of Agriculture in Rwanda

RAB : Rwanda Agriculture Board

REMA : Rwanda Environment Management Authority.

RNRA : Rwanda Natural Resources Authority.

RWFA : Rwanda Water and Forestry Authority.

SDGs : Sustainable Development Goals.

SPAT : Strategic Plan for Agriculture Transformation

SPSS : Statistical Package for the Social Sciences

VUP : Vision 2020 Umurenge Program.

WUA : Water Users Association.

DEFINITIONS OF KEY TERMS

Irrigation performance: is one of the means of monitoring and evaluation of an irrigation schemes, for the sake of ensuring the fulfilment of the planed objectives and goals. The performance of irrigation schemes is assessed, using the production and productivity indicators; profitability indicators; Equity indicators; rational utilisation of resources indicators; sustainability indicators and non-agricultural activities indicators. Those performance indicators allow us to inform the agriculture decision makers on operations, maintenance; water management practises; crop production; environment management finally allows to search for funding and support services of the irrigation schemes (Andreas et, al.,2002).

Water Policy: Refers to the strategic decision-making, planning and choosing the appropriate processes that water sector and its individual components can be exploited without compromising or deteriorating its nature (Jonathan, 2011).

WUA: Water Users Association or Water User Board, or Water Users Organisations, is a group of the water users, such as irrigators, swimmer, fishermen, who group their financial resources, infrastructures resources, and human resources together for enhancing the operations, management and maintenance of the established water resources.

Water Use Permit: is defined as a written contract or agreement between a water user agent, association or cooperative and Government or Institution in charge of water use or water resources management, this contract should govern and aims at safe exploitation of water resources (Aldrich, 2017).

CHAPTER 1. INTRODUCTION

1.1. Background of the Study

Over 800 million of people all over the world suffer from the hunger and great party live in developing countries; mostly due to unproductive agriculture technology and natural extremes (FAO, 2015). For achieving, sustainable development goals (SDGs) especially in its goal 2 and 6, together with African Union (AU) Agenda 2063 in its Aspiration 1, goal 10 and 13, both aiming at ending hunger, food security, improving the nutrition, promoting productive agriculture and ensuring the availability and sustainable management of water resources for all (UN, 2015; AU,2014). An ultimate productive Agriculture strategies and policies, aiming at increasing water use efficiency in irrigation, must be implemented for boosting the food demand expected to increase 60%, for feeding the world population (FAO, 2016).

Globally, fresh water withdrawals rate is 3,928 million km^3 per year and approximately 70% of that water, is consumed in agriculture in irrigated cropland (USGS, 2017; AQUASTAT, 2016; Mateo Sagasta *et al*, 2015). Over past century, an area equipped with irrigation have been doubled, approximately from 1.4 million km^2 in years 1961 to 3.2 million km^2 in 2012 (AQUASTAT, 2016; FAO, 2017). Meanwhile the existing water resources management strategies, policies enforcement, infrastructures are not suitable for this high-water demand and use in irrigation mainly in the countries of Africa (Wallace, 2000; Evans *et al*, 2008; Robert *et al*,2002; Rotgerd *et al*,2012; Scott *et al*.2013; Yu Li *et al*, 2017; Engin *et al*.2017).

In Africa, area under irrigation is estimated to be over 6 million hectares, which covers 4% of total cultivated in Africa, comparing to Asia which counts 37% of all total cultivated area and Latin America count 14% of total cultivated in America (You *et al*,2010). It has been proven that different tools for water resources management policy such as: Water Users Associations, water use permit, public / private participation and strong institutions have a great impact to the crop harvest on irrigated land and water resources management in general (Georgina, 2016; Knox, *et. al* 2012). A study conducted in Ghana and Ecuador showed that high water pricing has a great effect on the reduction of water demand in Agriculture and increase water use efficiency, hence the farmers shift from high crop water demand to low water crop. But this have a negative impact on crop variabilities, employment and farmer's income (Patricia, 2015; Christian, *et al.* 2017). Water use permit increases the ownership responsibility on water resources management while the water users' associations help the government to

decentralise the water resources management activities to the hands of the people (Varma *et al*.,2012). Meantime as the Public / Private participation increase the level of awareness and facilitate the knowledge transfer in maintenance, the private sector help in establishing sustainability of irrigation infrastructure where the government is not able to initiate them (Reuben *et al*. 2012). Generally, irrigation performance is increased once there is the partnership between the different water actors and proposed Agriculture and water policies.

Rwanda, an African developing country, with over population mostly depending on Agriculture, is counting around 12 million of population on high scenario projection in year 2017, with population density 468 inhabitant per km^2 (NISR, 2012). This lead to the overexploitation of hill land, soil erosion, hence the soil productivity decreases, leading to challenges in the livelihood of the farmers (World Bank, 2015). For ensuring food security of this population, the Government Rwanda, jointly with different partners, initiated different irrigation projects and programs such as: Economic Development for Poverty Reduction Strategy (EDPRS), Strategic Plan for Agriculture Transformation (SPAT), Land Husbandry, Water Harvesting and Hillside Irrigation (LWH), Kirehe Watershed Management Project (KWAMP); Vision 2020, Vision Umurenge Program (VUP), and Crop Intensification Program (CIP), as an alternative way for boosting food production. These programs are mostly focusing on development and construction irrigation infrastructure marshland; hillside irrigation; land husbandry activities as well as post-harvest promotion (Mbonigaba, 2013; World Bank 2016; MINAGRI,2017). It is in this regard, is very important to conduct a study on implications of water policy on irrigation performance in one of the irrigation projects initiated in this program.

1.2. Problem Statement

Agriculture sector in Rwanda is the backbone of the country's economy, it contributes over 33% of GDP of the country (Booth *et al.*2014, World bank,2015), as well as generates over 89% of the employment to the Rwandan citizens (Word Bank, 2016). In addition, 80% of all Rwandan population are agriculture farmers mostly rain fed dependent, with average agriculture land less than 0.59ha (FAO, 2016). Ensuring sustainable food security, for Rwandan whose population density, increased from 414 inhabitants per km^2 in 2012, to 667 inhabitants per km^2 in 2017 on high projection(NISR, 2012), requires Agriculture development practises, shifting from subsistence Agriculture to fully commercialised and productive Agriculture through development of irrigation, as one of the alternative way proposed by the Government of Rwanda to boost agriculture production, through CIP, a program which intends to boost

Agriculture production (World Bank, CIAT, 2015; EICV III; MINAGRI, 2017). Therefore, from year 2009, the irrigation plan 2011-2017, was planning to cover 100,000 ha and in year 2016 over 60,000 ha have been accomplished and over 101 watersheds, marshland development and hillside irrigation were developed (Collins et al.2015, MINAGRI, 2017). Much focus was put to the Eastern Province because of water shortage in this area due to an extended drought, while this Province has fertile land; enough lakes and marshes for practising the irrigation on large scale (REMA, 2017; The Newtimes, 2017).

Therefore, improving water use in irrigation, and establishment of effective policy for achieving irrigation performance, is needed. Water resources management policy and irrigation policy define how to use water effectively in irrigation in Rwanda, through water use permit, water user association; public and private sector participation, while we ensure among the water users, sustainable exploitation and protection of water resources and achieving irrigation performance (MINIRENA,2011; MINAGRI, 2017). For this sake the research and studies of water policies implication for irrigation allows us, to identify the physical inputs, human needs and institutions efficiency that are playing, a key role in improving water use efficiency hence help us to achieve irrigation performance.

Water use permit helps for better water use, water saving and increase the ownership responsibility. The farmers allocate the water resources to the highest perennial crops instead of annual crops and it increases water savings technologies (Laura, *et al.*2013; Sara et al. 2015; Christain et al.2017). Once there is no water use control and permit, it can lead to pollution and water logging as well (Narayanaan, 2014). Meanwhile it can also slow down the feasibility of the irrigation development once the water uses permit delays it can lead to crop harvest failure meanwhile water use permit also may help us to plant the crops, which requires low water requirements and increases the control of water abstraction rate. Therefore, it very important to carry out the analysis of the effect water use permit, on irrigation performance in the different marshes and hillside irrigation in Eastern Province

Small farmers of the developing countries are suffering from, funding themselves, in construction of the irrigation infrastructures, management of existing, value adding of Agriculture harvest and marketing of their Agriculture commodities (Dittoh *et al*., 2010). The Private sector participation helps them and their Government to construct the irrigation infrastructure; provide quality seeds, training to the farmers, to ensure the quality and technologies of harvesting the crops and purchasing the harvested crops regarding to the agreed price through the different contract that have been proven to be successful (Varma *et al*.,2012).

Meanwhile, as the Private seeks the profit, this may lead to the overexploitation of the water resources and monopoly then the public people lacks their implication to the development of irrigation. Also, the people may feel as if someone must come to initiate the water management projects, then once the private sectors are not available water management activities in irrigations slows down. Therefore, assessment of role of the public and private participation on irrigation performance is noteworthy, for being sure if the people are having enough knowledge and training to sustain the irrigation performance once the private sector will hand over the projects or withdraw their contract.

Water Users Association intends to promote water use efficiency, to decrease the water management costs, to promote the effective use of incentives in water use, timely dispute solving and water use equity for the sake of improving the water user's involvement in water decision-making and getting effective water use allocation among water user competitors (IWMI, 2003; UNDP, 2006). The Government reduce the expenditure to irrigations and as well, the farmers get knowledge easily on irrigations management because all activities are decentralised to the hands of farmers through WUAs (Vernillion, 1992; Small *et al.*, 1991). Meanwhile, A study conducted in Eastern Province, of Rwanda, proved that some WUA operate in bureaucracy way (Narayanaan, 2014), this may slow down the payment or dams' maintenance activities and lead to infrastructure failure, reduction of the irrigation performance and the private sector may also retrieve the contract because of lack of public participation. Hence, the intended irrigation harvest is reduced. Therefore, for achieving the desired food security through irrigation development and performance in Eastern Province, WUA is key factor that can lead to the management of water use and serve as bridge between water resources instructions and water abstractors for the sake of decentralising the water management to the hands of water users.

1.3. Objectives

The overall objective of this study is to assess the implications water policy on irrigation performance in Eastern Province of Rwanda. Therefore, the following are the main objectives of this study:

- Identifying the effect of water use permit on irrigation performance.
- Assessing the role of public private participation on irrigation performance.
- Evaluating the Impact of Water Users Association on irrigation performance.

1.4. Research Questions

- How is the water use permit affecting irrigation performance?
- What are the roles of Public and Private Participation on irrigation performance?
- What are the impacts of Water Users Association (WUAs) on irrigation performance?

1.5. Justification of the Study

In line with AU Agenda, 2063, Aspiration 1, goal 10, 13 and SDGs Goal 2, 6, this research is very important for the decision makers and private institutions because it will equip them with evidence based on the impact of water resources policy on Agriculture productivity. Hence, this will help them to achieve modern and productive agriculture through irrigation performance development, hence Rwanda, and Africa in general ensure food security and effective water resources exploitation.

1.6. Scope of the Study

This study was carried out in Eastern Province of Rwanda, within selected districts Bugesera, Kirehe and Nyagatare, in the farmer's cooperatives such as K.O.A.I.G.R; C.O.V.A.M.I.S; and K.A.B.O.K.U operating in the respective irrigation sites: Gashora irrigation site of Bugesera District, Nasho/Mpanga irrigation site of Kirehe District and Kagitumba of Nyagatare District. In addition, the different WUAs leaders of the different WUAs operating in those irrigation sites also were interviewed on their role in improvement of irrigation performance as well as sector agronomist also were interviewed in which a irrigation site locate was interviewed.

CHAPTER 2. REVIEW OF THE LITERATURE

2.0. Introduction

This chapter describes the literatures related to this specific objective of this work. The literatures were retrieved from the books, officials report and scientific papers published in highly reviewed journals and they are references according to the academic rules and regulations.

2.1. Water Use Permit

Competition among the water users have been increased from over last decade, due to high population growth, demographic patterns change, water scarcity, impact of climate change and water quality deterioration (Evans et al., 2008; Wang et al., 2011; USGS, 2013). Water rationing and water allocation among the water users, requires having water use permit for achieving effective water equity and equality allocation (Georgina et al., 2016).

Due to high water demand for irrigation productivity, issuing water use permit to the users, is one of the policies that helps to measure the quantity of water extracted periodically, solving the conflict among the water competitors, limiting the overexploitation of water resources, ensuring the maintenance and effective irrigation operations (Diovany et,.2017). Water use permit is defined as the written contract or agreement between a water user agent, association or cooperative and Government or Institution in charge of water use or water resources management, this contract should govern and aims at safe exploitation of water resources (Aldrich, 2017).

It has been proven, that water use permit, helps the farmers to allocate water to high productive crops. As well as preventing, water logging formation and over exploitation of water resources, because the farmers extract the quantity of water needed, consequently it reduces water and soil pollution, and helps to achieve effective water resources management and planning (Narayanaan, 2014; Alden et al., 2017).

2.1.1. Water Use Permit Application in Rwanda

The Ministry of Natural Resources (MINIRENA), together with the affiliated institutions, is in charge of Rwandan water resources management and Transboundary water resources (Josiane et al, 2017). One of the roles and responsibilities of MINIRENA is in charge

of formulating and oversighting the water resources management policy, strategic and plan for better and sustainable water use in Rwanda and riparian water resources (MINIRENA, 2011).

Rwandan water resources management policy of 2011, together with the water law, no 62 /2008 of 10/09/2008 putting in place the use, conservation, protection and management of water resources, define the processes and who must have water use permit, for better water allocation among competitor's actors and helping efficient water use planning (RNRA,2014). Improving water use permit is one of the ways, to increase the quality of water resources, which is scarce nowadays and increase the ownership responsibility to manage the water resources (Spellman, 2010).

2.1.2 Water Use Permit Categories in Rwanda

Rwandan water law No62/2008 of 10/09/2008 putting in place use, conservation and management of water resources regulations in Rwanda, in its chapter 5, Article 32 till 40 defines the regimes and categories of water use permit. As well as the irrigation policy and water resources management policy define so, therefore water use permit in Rwanda is issued in three different regimes depending on the intended water use activities (RNRA, 2014, MINIRENA, 2011).

Declaration regime: is issued to water users that cannot have much impact negatively on the natural hydrological cycle; health; on public safety and security finally does not affect the diversity of the aquatic environment. For example, tourist, training and research activities, water resources modelling activities and monitoring or navigation.

Authorisation regime: is given to the water abstractor or intended water users that may have the impact on natural hydrological cycle, natural health and public safety and security. This kind of regimes also is issued to the water users that can harmful the quality of water and aquatic environment. For example, surface and underground water abstractors, the drainage of any swamp or other land; surface water retention storage; wastewater or effluent discharge into water bodies; use of water for hydropower generation.

Concession regime: is issued to water users that intending to have major impact on the natural hydrological cycle, may bring serious danger to health, public safety and security, which may reduce the quantity and quality water, and which may cause serious danger to aquatic species and life in general. For example, aquaculture projects and fishing activities; sport,

leisure and recreational activities in water resources; the establishment of infrastructures and facilities for leisure.

Water use permit application file should be presented to the Ministry in charge of Water Resources. The decision of granting or denying the issuing for regimes right is taken democratically and with clarity after concerting the fulfilment of the requirements. The water allocation in Rwanda should be allocated, with the priority of supplying to the people, agriculture (including animals) and hydroelectric power energy production (MINIRENA, 2011).

2.2. Public and Private Participation in Irrigation Development

An area under irrigation is increasing, as alternative for adaptation to climate change and water availability meanwhile for the small farmers, funding themselves, in construction of the irrigation infrastructures, its management, value adding of Agriculture harvest and marketing of their Agriculture commodities is quiet not easy (Dittoh et al., 2010). Private sectors implication and commitment with public sectors, is inevitable agent for achieving food security and developed agriculture (World Bank Group, 2017)

Public Private Partnership (PPP) is defined as a contract between Government, statutory entity and private sector, in which the private sector undertakes substantial financial, technical and operational, financial, building and ensuring the operational project design for specified period of time. the private receive money as return profit, depending on the type contract (National Treasurer, 2004; Peter, 2005; Verma, 2012).

Worldwide, countries are incorporating the PPPs in irrigation development because the private sectors are bringing the resources that help to meet the huge investment and increase the projects delivery and operations (Florian, 2017). The Key driving force to achieve strong PPPs, includes effective good governance and accounting systems are major key points. In addition, any public support or any form PPPs or subsidies in irrigation; help to increase the knowledge and capacity of smallholder's farmers (Dittoh et al., 2010).

2.2.1. Main Successful PPPS Contract in Irrigation

Private partnership in any irrigation project appears in the different form depending on the type of contract between Private sector and public sector or government for providing the goods and services in operations and maintenance of irrigation project initiated. Mostly the

private sectors involve in providing the seeds to the farmers, training of the farmers, ensuring the quality and technologies of harvesting the crops and purchasing the harvested crops regarding to the agreed price through the different contract that have been proven to be successful (Varma et al.,2012).

Farm Services contract type: The Private sector initiate an agreement or contract with the public sector or communities of managing the farms either off farm services and on farm services. Meanwhile both government and private entity bears the responsibilities of maintenance and operations services for better management of the water infrastructures. The services that could include in services contract are channel rehabilitation, emergency repairing, design engineering, billing and collection of user's charges (Verma et al., 2012).

Operation management and maintenance contract type: in this PPPs contract, the private sector takes the responsibilities of all operations, maintenance and management activities of the irrigation services, but the properties remain to the hands of public sector. The services that could be covered includes the collection of fees from government as incentives and from the farmers. The private sector may also assure the services management but it uses the offices, vehicles, and others of public sectors once the infrastructure needs the rehabilitation and any reconstruction, the private sector involves in contract (World Bank group 2017).

Lease contract type: the private sector takes the government's infrastructures and uses them under specified period of time and rent. This approach is very important when the government does not have much money to invest, then the private sector use the resources time before handing over to the government, and pay renting money (Peter, 2005).

Concessions contract type: The Government imposes and sets the specified conditions and rules under which the private institutions and companies will operate. The private sector brings its own investment. The private sector agrees to bear the construction, providing services, maintenance, and management of irrigation infrastructures. Therefore, the investment cost and other financial costs have to be covered by the incentives or other fees either from the government or irrigation infrastructures users (World bank, 1997; World Bank, 2017).

Design Build Operate (DBO): This type of PPPs agreement, the private sectors involve in designing and building a public facility, then after is handed over to the government or public sector and then the constructed facility remains in the hands of public within certain time. While the DBO and Finance contract involves that, the private sector design build operates and finance

the public entity before handed back to the public sector (MoLG, 2011; World Bank Group, 2017).

Table 2.1: Types of Private Public partnerships and responsibilities

PPP Contact	Asset Ownership	Operation &maintenance	Capital investment	Commercial risk	Typical duration
Service contract	Public	Public and private	Public	Public	1-2 years
Management contract	Public	Private	Public	Public	3-5years
Lease	Public	Private	Public	shared	8-15 years
Concession	Public	Private	Private	Private	20-30years
Build Operate Transfer	Public and private	Private	Private	Private	25-30years
Divestiture	Public and private	Private	Private	Private	Indefinite or limited licence

Source: world Bank 1997; Peter, 2005; FAO, 2008; Verma, 2012.

On farm, activities include ploughing, planting, pruning, water application, and harvesting, while off farm activities involve post-harvest activities like: transportation, storing, processing and marketing. The farmer's services are the one, which may help to improve the water user's performance in Agriculture and intervene much in development of irrigation performance and increase the farm employment. In addition, the farmer's services may be incorporated or separated from the irrigation Operation Management and Management (Weiliang *et al*., 2016).

2.2.2. Role of Public Private in Agriculture Development

The PPP helps to transfer and strengthens the irrigation technologies, human resources development and social capital development. Those transfers are done by extension development of new agriculture technologies and assist the rural development and poverty alleviation for developing the poor people (Burton, 2002). The technical programs that the

private sectors involve in crop and livestock management, or farming systems development, involving machinery and equipment, seeds development, and fertilisers (FAO,2013). Public sectors involve in educational programs water resources management, farm management and marketing or by empowering the organisation by forming the credits societies, self-help groups, water use association, farmers associations and livestock cooperatives (Ponnusamy et al.,2017; Verma et al., 2012).

The private sector partnership in Agriculture development could be handicapped or favourited by government policies and regulations. Once the government strengthens and harmonises the quality control, systematic monitoring, regulations and policies, this will give the working filed and allow the private sector to compete for the market (Burton et al., 2002). The private sector participation is increased by removing the obstacles for technologies transfer, throughout the policies reforms, removing the barriers to privatizations, trade barriers eliminations, promoting private policies development and removing the input monopolies (Umali, et al., 1992; Florian, 2017).

The success of PPPs can be affected by payments modality and mechanisms between the farmers. The irrigation managers and farmer managers, the incentives payment scheme, selection of productive crops and the procedures of the incentives payment are the major factors that favour the private partnership in general. Meanwhile the private partnership can be handicapped by the inefficient farmers' institutions organisations such as cooperatives, trust and water use associations functionality and the understanding of the farmers on willingness to pay water services, as it is one of the inputs to production, the management, fertilisers and access to the market (World Bank Group, 2017).

Land ownership also is key factor that affect positively or negatively depending on the land ownership, some countries, the people have full access on land either marshland and upland, while others the land is for government, this can affect the private participation (OECD, 2014). As well, the private sector counterpart may affect the functionality and output, policies, taxations, restricted to foreign investment and legal restriction to PPP (World Bank Group Bank, 2017).

2.3. Water Users Association

Mostly the farmers are facing the water scarcities adaptation strategies, due to inefficient and lack technical knowledge transfer, government water institutions bureaucracy functionality,

extremes consequences and water scarcity, water users associations, is one of the policies, which helps to complete the irrigation management activities transfer from the government to the farmers (Koc et al.,2006; Degol et al., 2017). The WUA helps the government to reduce the expenditure to irrigations and as well, the farmers get knowledge easily on irrigations management because all activities are decentralised to the hands of farmers (Vernillion, 1992; Small et al., 1991).

Water User Associations started from earlier in 1990s, as way of decentralising the water management activities to the small farmers (World Bank, 2003). The Water Users Associations intend to promote water use efficiency, to decrease the water management costs, to promote the effective use of incentives in water use, timely dispute solving and water use equity for the sake of improving the water user's involvement in water decision-making and getting effective water use allocation among the water users competitors (IWMI, 2003; UNDP, 2006). The effective functionality of WUAs have been proven to solve the problems related to the failure of irrigation management in Kyrgyzstan, and it have been proved also, that the people participated much in and found the response of problem without intervention of the Government rather this last, intervene once it is highly needed (Groenfeldt, et al.,2000). The WUAs establishment help also the effective Irrigation Management Transfer and helps to take the immediate remedy on the issues of irrigation infrastructure and inappropriate water allocation (Rebecca t al., 2017).

For achieving successful WAUs, we must use bottom up approach instead of top down approach, because the decision for being effective must be inclusive, this requires that the ordinary farmers and other types of water users have to have common agreement and understanding for having common goal and objectives of water resources management (IWMI,2003).

2.3.1. Water User Associations Overview in Rwanda

From 2011, the Government of Rwanda, recognised and approved the WUAs as recognised institutions, by Ministerial order No 001/11.30 of 23/11/2011, putting in place irrigation Water Users Association as way of improving water use efficiency and improving irrigation management practices (MINAGRI, 2017). Together with water resources management policy 2011 and Irrigation policy, 2013 describe and establish the role and responsibility of WUAs in irrigation scheme (GoR, 2017; MINAGRI, 2013; MINIRENA, 2011). WUAs is single entity in charge of signing and implementing the irrigation management

transfer with MINAGRI and the district where it operates, WUA also is in charge of operations and maintenance of irrigation infrastructures and is only organisations, which hold water use permit (GoR, 2017). The main responsibilities of WUA in irrigation as it is stipulated by the Ministerial order, includes maximising the transparency in all water users, promoting democratic view during water related decision making, while ensuring the minimising waste of water, and avoiding overwatering and flooding control around the irrigation ditches.

2.3.2 Principles of WUAs

In many developing countries, including Rwanda, introduced the different policies which influence positively the use of water and management of water resources in Agriculture, through WUAs intervention, and it improves as well participation of the farmers mostly the women and gender equality (Alison *et al*. 1996; Uysal & Atis, 2010). The WUAs are responsible for appropriate water allocation and effective water use efficiency, through a decentralisation of the activities and self-financing to improve water use efficiency in agriculture and the sustainability of WUAs in general (Lee *et al*, 2015). Meantime some principles have to govern WUAs to ensure its sustainability, for the sake of improving and enhancing water use efficiency (*Table 2.2*).

Table 2.2: Principles of WUAs management and performance

Principles	**Description**
Adequate and reliable water supply	A WUA is well organised when there an effective water supply and when on farm infrastructures are properly managed by WUA members.
Legal status and participatory	A WUA have to be managed and became a legal entity with the elected leadership voted by its members.
WUAs organised with hydraulic boundaries	A jurisdiction of the WUA should be the hydraulic boundaries of the delivery system.
The water delivery can be measured volumetrically	Each member has to get water and its quantity should be measured volumetrically
Equitable collection of WUA water charges.	A water uses charges have to be collected form the members and make payment for the cost of water.

Source: Wang *et al*., 2010

2.4. Irrigation

When there is lack of rainfall which is not sufficient to supply water to the crops, it is very necessary supply for an additional water from irrigation this watering of crops s added as an additional to supplement enough water to the crops. The different methods of irrigation used to supply water to the crops, including surface methods using gravity or using pressurised irrigation (FAO,2002). Meantime the different methods may have an advantage or disadvantages to the water resources or to the crops, hence it very important to consider while choosing an irrigation method to be used and measure its efficiency and performance.

2.4.1. Types of irrigation

A surface irrigation is one of the methods of irrigation used, by applying water on the crops using gravity flow on the surface of the field (Elias *et al*. 2007). Application of water by surface irrigation is done either through flooding an entire field and fill water in, it is known as also as basin irrigation whereas the field may be cut into pieces and apply water into small channels this type of irrigation also knowns as furrow or strips irrigation. On the other hand, a pressurised irrigation is another type of irrigation which consist of pumping water from water body and sprayed on the crops in the form of rainfall (*Fig.1*). The frequent types of pressurised irrigation include sprinkler irrigation which consist of pumping water and passes through the pipes and sprayed them in form of rainfall on the crops through the rotating sprinklers heads. Whilst the drip irrigation is another type of pressurised irrigation consisting of spraying water on crops in the form of droplet (FAO, 2016). The suitability of the crops on the type of irrigation most of the time depends on the type of irrigation. For instance, the basin irrigation generally is suitable for the crops which can resist to waterlogging at least for 24hours, like cereals; trees and folder crops (Kumar, *et al*., 2017).

Figure 2.1: Types of irrigation

Source: FAO,2016

2.4.2. Monitoring Irrigation Performance

The performance of irrigation scheme is measured for the sake of improving its intended yield. The role of motoring includes keeping the activities of the irrigation scheme developing; to determine the efficiency and effectiveness of the irrigation scheme and the impact may play to the th different stakeholders, therefore, we learn from the lessons learnt to forecast the future and disseminate the information to the others (Degol *et al*, 2017).

Normally every irrigation scheme has different objectives such as production; productivity; profitability; equity; rational utilisation of the resources and non-agricultural activities. Once the performance indicators of irrigation scheme are measured, they help to inform the decision makers on the improvement of operations management of irrigation scheme; water use management in the irrigation scheme; fund allocation and the needed input as well improvement of environment management (FAO,2002). A monitoring of the irrigation scheme helps to identify as well, how much inputs have to be invested in irrigation project. Therefore, an irrigation performance indicator grouped into technical performance indicator, Agronomic performance indicator, financial indicator; social economic performance, environmental and health performance indicator and managerial performance indicator (FAO,2002; FAO,2005; FAO.2016).

Generally, a technical performance indicator, is measured through the measurement of discharge from the pumps; water distribution in the field of the farmers; conditions of functionality of the pumps and other structures; level of condition of land grading; the rate of breakdown and repairing of the irrigation equipment; measurement of quantity of water used in the irrigation scheme and irrigation efficiency. Whereas an agronomic performance indicator helps us to identify the quality of crops and crop intensification, the inputs of agriculture practises, cultural practises and yield level as well as monitoring pest and diseases control. In addition, the financial indicator may be measured by taking into account of cost of water and energy supply; cost of repairing the irrigation schemes, marketing the costs and farmers' access to credit and private sector involvement in the development of the irrigation scheme, hence this helps us to determine the gross margin per crop and per area, raising farmers' income and well as net present value, the determination of cost benefit analysis and internal rate of return of the irrigation. All those indicators can't be achieved without social participation in the irrigation scheme, the socio-economic activities that may be determined through nutritional level of the families owing an irrigation scheme, change of living conditions, ability to pay some fees of

the families, employment creation; women participation, food security and services delivery and improvement as well adoption of the technologies. This helps again to identify the environmental performance indicator through monitoring of water quality change and its quantity; soil salinity, alkalinity, sodicity, acidity and fertility, the water related diseases and water logging as well poor drainage of the soil. Finally, the managerial irrigation performance indicator may be determined through the intensity of management of structures; knowledge management and training at all levels playing an important impact in irrigation scheme, without forgetting conflict resolution among the water users as well the role of farmers' organisation and management ability of the irrigation schemes (FAO, 2002; FAO,2005).

CHAPTER 3. MATERIALS AND METHODS

3.0. Introduction

This chapter, describes the area from which this study was conducted, materials used and the procedures taken to determine the sample size, data collection methods and analysis tools used to get the results.

3.1. Study Area

3.1.1. Location, Topography and Rainfall Characteristics

Rwanda is one of the East African countries with area 26338 km^2. It comprises four Provinces and Kigali city, namely: Northern Province; Southern Province; Eastern Province and Kigali City, the capital city. This study was conducted in Eastern Province, composed by seven districts, such as Nyagatare, Gatsibo, Kayonza, Ngoma, Kirehe, Rwamagana and Bugesera. Eastern Province, lays on total area extended on 9,813 km^2, is located in latitude -1045'00'' and Longitude 3030'00'' and it is located in tropical climate dominated by two dry season and two wet seasons (*Fig. 2*).

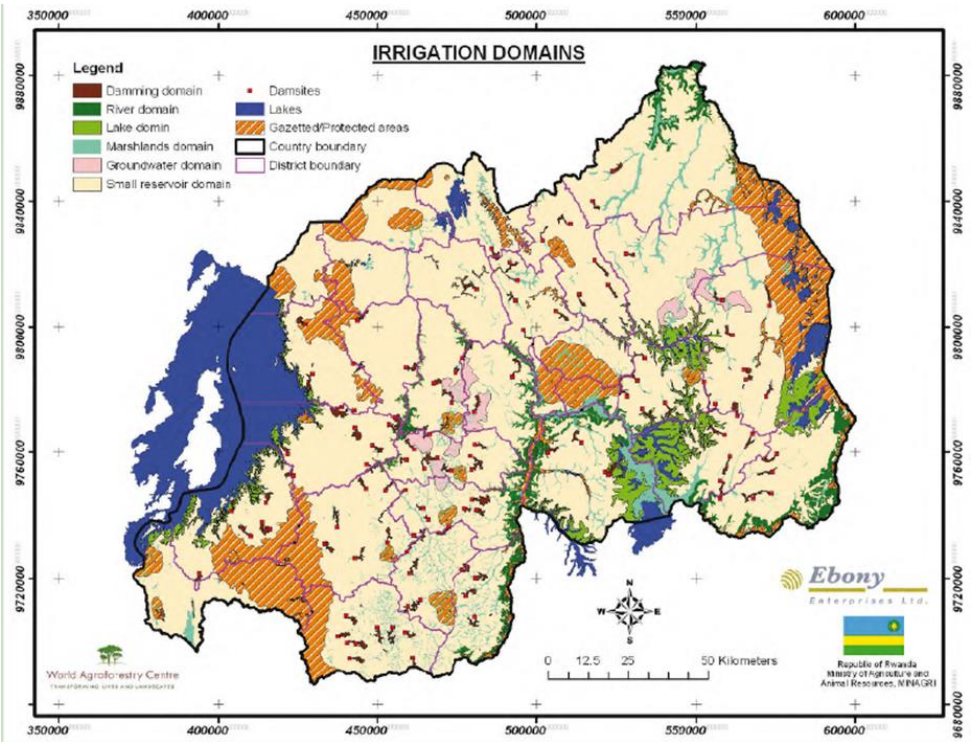

Figure 3.2: Rwandan Irrigation Master Plan

Source: MINAGRI, 2017

Bugesera District

Bugesera District is one of the seven districts, composing Eastern Province of Rwanda. It is boarded by Ruhango district; Nyanza district; Kamonyi district in west, while Kicukiro district, and Nyarugenge district in North. In addition, Ngoma and Kirehe districts in East finally in south there is Republic of Burundi (*Fig. 3*). Bugesera district covers an area of 1,954km^2, with population estimated to 391000, cultivating an average land size of 0.88ha. The topography of Bugesera district is characterized by soft hills and gentle slope hills ranging from 1000 m to 1400m. Average temperature of Bugesera district ranges between 18^0C to 26^0C with an annual rainfall ranging from 1000mm to 1200mm, moreover the hydrological network of Bugesera district, is dominated by interior lakes, with soils dominated by loamy and sandy loam mixture (Bugesera DDP, 2018).

Kirehe District

Kirehe district covers area of 1,118.5 Km^2, and this district is characterized by low altitude plain separated by hills and mountains ranging from 1350m to 1500m, which makes Kirehe district to be well favourable with irrigation and mechanization, in its marshlands. Kirehe district is boarded by Kayonza district and Ngoma district in the north; while in East, there is Republic of Tanzania however in South; Kirehe district is boarded by Republic of Burundi (Fig. 3). Kirehe district is characterized by low rainfall period, divided into two hydrological seasons that makes this district to be favourable to agriculture (Kirehe DDP, 2018).

Nyagatare District

Nyagatare district is located in North East of Eastern Province of Rwanda, boarded, with Republic of Uganda in North (Fig. 3). In East by Republic of Tanzania, in west by Northern Province and in South boarded by Gatsibo District. Nyagatare district covers an area of 1,920.11 Km^2; characterized by low hills dominated by granite rock and average altitude 1513.5m. The soil of Nyagatare is characterized by tightness of hum fair soils dominated by savannah. Moreover, the temperature is characterized by hot seasons with average temperature ranging from 25.3°C to 27.7°C, with annual low rainfall distribution, estimated to be 827 mm falls into two seasons, which makes this district to have water scarcity to satisfy the agriculture sector (Nyagatare DDP, 2018).

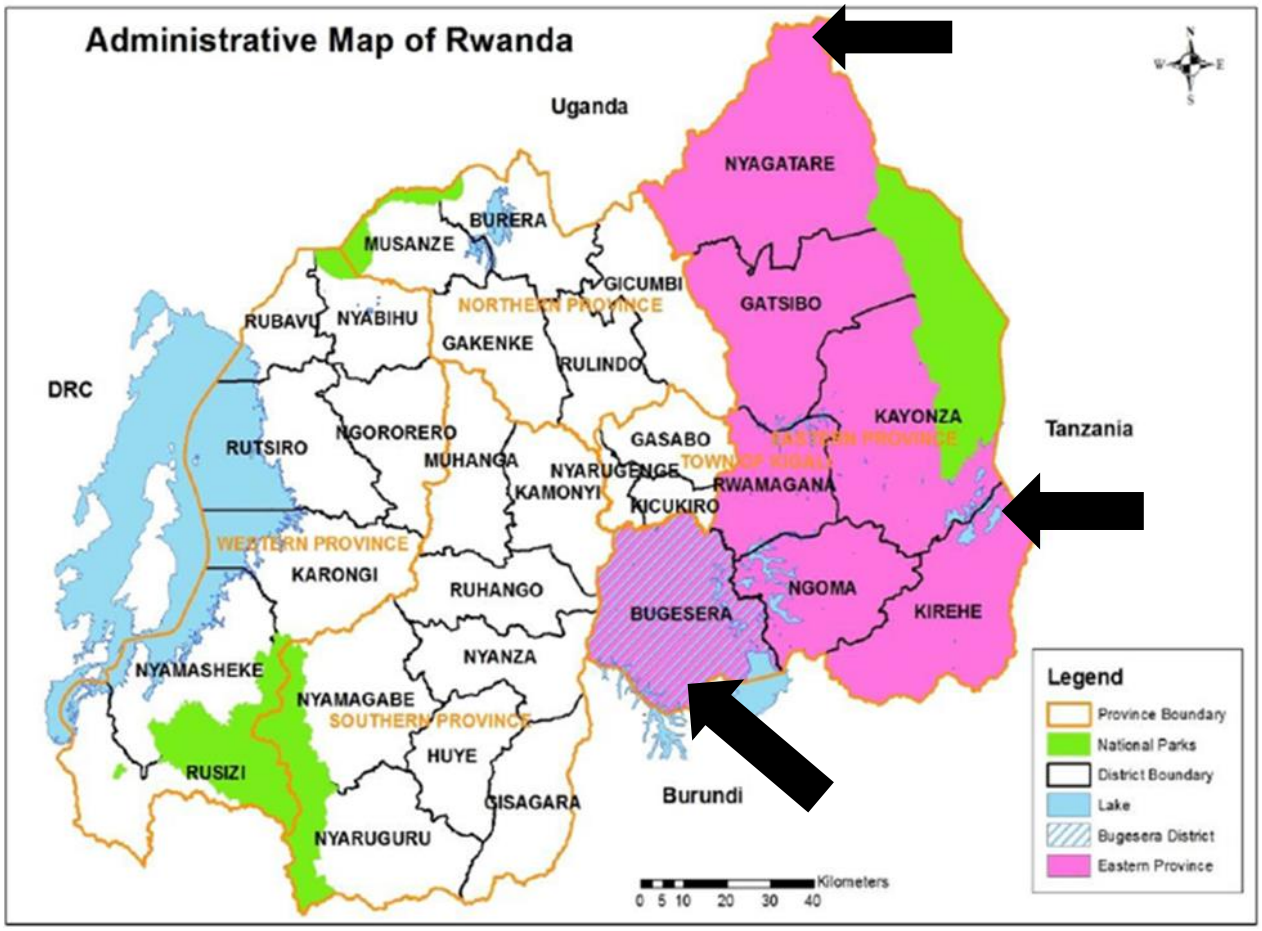

Figure 3.3: Administrative map of Rwanda

3.1.2 Socio Economic Aspect of the Districts Selected

Bugesera District

The EICV 3, revealed that in Bugesera district, over 80% of the all population of Bugesera district who have above 16years are agriculture famers, while 11 % of the population have other different jobs. The average of the employment and unemployment rate in this District is 84% and 0.9 % respectively. Agriculture sector combines livestock and farm activities contribute to 57% of all income from this district, while the wages income contributes to 19% and the business income generates 11% of income in this district. In addition, a mean size of agriculture to a household in Bugesera district is estimated to be 0.82ha while the land which is under irrigation is estimated to be 3.3% of total land of Bugesera district. Bugesera district sells around 27% of its agriculture product mostly dominated by fruits, vegetables and staple crops and over 64% of all population of Bugesera District are raising different types of the livestock (NISR, 2012).

Kirehe District

Third population census (EICV3) in 2012 showed that over 84.3% of population of Kirehe district are the agriculture farmers, 8.5% are the normal wages while the rest is unpaid wages. Agriculture sector in this district is occupied by 88.3%, followed by trading, manufacturing and other utilities. financial services occupying 4.9%, 1.8% and 0.7%, respectively. The agriculture sector in Kirehe district contribute to 54.4% of the household income, the wages income contributes to 23.6% and the transport services contribute to 2.3% of the general income. An average mean of arable land in Kirehe district is estimated to be 0.73ha per household and over 52% of the households use chemical fertilizers in their faming activities. Area, which is under irrigation in Kirehe district, is estimated to be 3.6% of total area of the district under agriculture farming activities. Kirehe district contribute to 23% of Agriculture commodities sold on market of Rwanda (NISR, 2012).

Nyagatare District

Nyagatare district is one of the seven districts of Eastern Province. the EICV 3, showed that 79.6% of all populations are agriculture farmers, while 7.4% are making trading as source of income. The principal income source is coming from agriculture sector which contribute to 45%, wages income generating 25% of income sources and rents; business income generates 9% and 8.6% respectively. The land use area under agriculture in this district is 0.77ha per household. In addition, Nyagatare district contributes to 27% of Agriculture commodities sold on the market. The area under irrigation is 5.6% of total area of the district while 64% of all household of Nyagatare district raise different type of cattle (NISR, 2012).

3.2. Research Design

This study aimed at assessing the effect of water resources policy on the irrigation performance in Eastern Province of Rwanda. It focused on: 1) the identification of role of water use permit on irrigation performance,2) the assessment of public and private participation in irrigation performance and 3) evaluating the role of water users association on irrigation performance. The study involved the qualitative and quantitative data, collected using descriptive research design. This study described the dependent and independent variables, as well as the evaluation of the relationship between independent and dependent variables in terms of percentages. It involved also primary and secondary data. The primary data collected using a written open ended and closed ended questionnaires administrated to the different sampled

farmers who use the irrigation in Eastern Province; interviews and direct observation in selected irrigation sites. While the secondary data were collected using desk reviews of different reports, programs and policy related to water resources management; Agriculture and irrigation in Rwanda.

Questionnaires addressed to the farmers who use irrigation, in the different districts of Eastern Province, namely Bugesera district; Kirehe district; and Nyagatare district in the respective Gashora; Nasho/Mpanga and Kagitumba irrigation sites. In addition, water user associations' leaders responded to the different questions related to the role of water users' associations in water management and irrigation development in general. Furthermore, also an interview was conducted to the local leaders in charge of agriculture in respective irrigation sites selected. The types of data wanted were qualitative and quantitative data, gotten using simple randomized probability sampling technics and purposive research.

The farmers responded to the different questions, which helped us to get the primary data. The questions were related to the source of water they use in irrigation; the types of irrigation they use. They also provided the response to the questions related to the availability of water; the reasons why water is not available; they also provided their view on how they know the exact time for irrigating the land and how they measure the irrigation performance. The farmers provided the responses related to the major crops they grow; the quantity of seeds they sow and the quantity of the harvest when there is enough water and when there is water shortage period. In addition, the people enumerated the major challenges and proposed the information for enhancing the irrigation performance in their respective farms. Besides of that, the people responded, to the questions related to the registration of their water sources; water use pricing; water availability and allocation; the stakeholder's involvement in irrigation performance; people participation in irrigation development; collaboration with the private sector; the time it takes to get water use permit an expiration, as well as the possible challenges they face during water use permit application. Furthermore, they also responded to the questions related to how many times they get the training on water management; who is in charge of that training if they are available; the repairing processes of the irrigation infrastructures; the different cultivation practices they use and how they measure the irrigation performance; irrigation infrastructures maintenance and the role of community work in irrigation infrastructures maintenance.

In addition, farmers responded to the questions related to the election of their WUA leaders, the role of WUA in water management knowledge transfer; water related conflict

resolution, erosion control operations, and functionality of the WUA. Trust to sell the yield to the cooperatives; the benefit of joining the WUAs; the quantity of water needed and used; water metering; means to combat sunshine period and climate change impacts; possible water resources management challenges they are facing and their proposed solution.

On the other hands, the WUA leaders, responded to the questions related to the time, a WUA was created, number of women and men composing a WUA; the main requirements of new member to join a WUA; the main responsibilities of WUA; main cause of water related conflicts among the water users and the main methods used for conflicts resolution. In addition, they responded to the question related to water use fees and if it is sufficient to cover all expenses incurred during water infrastructures maintenance. Means of collection water use fees and how the collected fees are managed, challenges they face in WUA and the strategies proposed to enhance water use efficiency in irrigation.

3.3. Sample Size Determination

The survey was conducted in Eastern Province, of Rwanda, in the respective irrigation sites Gashora; Nasho/Mpanga and Kagitumba. Due to that, the Government of Rwanda, through MINAGRI, initiated a long-term irrigation project, through PSTA and CIP; in order to achieve food security in Rwanda, especially in eastern region. Eastern province was selected for this research due to the extended drought, experienced there. Hence, much marshlands have been developed and hillside irrigation developed to enhance the food production and agriculture development. Therefore, three districts of seven districts, which constitute Eastern province were selected namely Bugesera district, Kirehe district and Nyagatare district, in respective irrigation sites Gashora, Nasho/Mpanga and Kagitumba.

As the Government of Rwanda and their key stakeholders, encouraged the people of Rwanda to work in cooperatives in which, the knowledge transfer and effective management can be easily disseminated, the main aim of this research was conducted in the different farmer cooperatives, which practice their agriculture activities in the different irrigation sites selected. Therefore, in Gashora irrigation site, 126 farmers compose K.O.A.I.G.R. a farmer's cooperative, practicing irrigation on an extended area of 129ha were selected. Although in Nasho/Mpanga irrigation site. C.O.V.A.M.I.S a farmer's cooperative composed by 300 famers who irrigate their lands on area 464ha were also selected. In addition, K.A.B.O.K.U, a farmer's cooperative composed by 1280 famers operating in Kagitumba irrigation site, practicing irrigation on extended area 900ha also participated in this research.

Therefore, a sample size of respondents was determined using Krejcie and Morgan table (*Appendix 5*); and the total numbers of 563 of farmers who use the irrigation in the respective irrigation sites were selected randomly to respond to the questionnaires. In addition, 5 water users association leaders were selected while 2 sector agronomists also were interviewed. Therefore, a formula, (1), was used to determine the sample, was summarized into the table in (*table 3*).

$$\mathbf{S= [X^2\ NP\ (1-P)]/\ [d^2\ (N-1)\ +X^2P\ (1-P)]} \qquad (1)$$

Where: X: Table value of Chi-Square, with d. f=1 for desired confidence level of 0.05=3.84

N: Population size

P: Population proportion (assumed to be 0.50)

d: Degree of accuracy (expressed as a proportion, assumed 0.05)

S: Sample size (Krejcie, *et al*, 1970)

Therefore, a sample size determined of respondents in the respective irrigation sites, are summarized into *table 3.3*

Table 3.3: Sample size number and distribution of respondents in the irrigation sites

Irrigation sites	**Sample size of Farmers**	**Leaders of WUA**	**Irrigation specialist/ Agronomist**
Gashora	97	1	1
Nasho/Mpanga	169	3	1
Kagitumba	297	1	1
Total	**563**	**5**	**3**

3.4. Data collection

3.4.1 Preliminary Data Collection

In accordance with the ministerial instructions No 003/2010 of 09/12/2010, published in official Gazette of the Republic of Rwanda No special 24/12/2010, regulating the research activities in Rwanda, first, I applied for a research authorization from RAB, which is an institution in charge of Agriculture development in Rwanda (*Appendix 1*). A preliminary survey conducted, at the different irrigation sites selected, to alert the farmers and to examine a real ground area, if my research questions will respond, to the current situation of water use in irrigation performance. Later from the 1st May to 30st May, 2018, I collected the data from field using different methods described in heading 3.4.2.

3.4.2 Data Collection Methods

The different methods used to gather the data included, the questionnaires; direct interview; direct observation and literature of the different books, programs related to irrigation performance in Rwanda.

Questionnaires*:* A total number of 563 questionnaires were administrated to the irrigation farmers selected randomly as well as, a total number of 5 water users association leaders also respondents. Therefore, 97 questionnaires addressed to Gashora irrigation site of Bugesera district; in addition, 169 of questionnaires administrated to Nasho/Gashora of Kirehe district finally 297 questionnaires administrated to the irrigation famers at Kagitumba irrigation sites to the farmers of Nyagatare District. Furthermore, a total number of 5 water users association were interviewed. The water users associations leaders selected were WUA's manager of Abahuje Umugambi-Kagitumba; WUA's president of Tuyakoreshe-Gashora; WUA's manager of Tuyakoreshe Mpanga lot 3; WUA's manager of Tuyasaranganye-Mpanga lot 1; and WUA's manager of Tuyabyazumusaruro-Mpanga lot2. To avoid bias during data collection, the original questionnaire was written in English language, therefore translated into Ikinyarwanda language, which is the mother tongue of the farmers. This helped the farmers to understand well the content, and where the technical terms were somehow not understood well, a researcher was near of them to give much explanation.

Interview**:** A semi structured and unstructured interview were used to gather the data. This kind of data collection was selected to allow the interviewees to express their mind freely in their own words and thoughts on how the water policy enforcement may help the enhancement

of irrigation performance. Also, three sector agronomists drawn from each district, where an irrigation site located were interviewed, more than three times depending on the different state and the situation of irrigation systems.

Sector Agronomist' interview: Those interviews helped to collect the information related to:

- The circumstances in which there is a need for private sector involvement in irrigation development
- The role of Government in sustainability of public/ private partnership in irrigation
- How the people and Government in general, benefit from the private /sector investment in Agriculture.
- The strategies that the government plans to attract more investor in irrigation development in Rwanda.

3.5. Data Analysis

The collected data were analysed using SPSS, 23 version. These data were interpreted and analysed, with references to the existing water policy and setting of irrigation performance in Eastern Province, then the conclusion and recommendation and policy brief were designed, for the sake of enhancing the sustainable water use in irrigation to meet the food demand while we are exploiting the water resources sustainably.

CHAPTER 4. RESULTS INTERPRETATION AND DISCUSSION

4.0. Introduction

This chapter describes the results found, on the different impact of water policy on irrigation performance in Eastern Province of Rwanda, with reference to the selected irrigation sites.

4.1 Socio-Economic Characterisation of Respondents.

The characterisation of socio economic activities of the respondents was based on the identification of their sex; level of education and description of their frequent farming activities. Hence based on the results, a total number of 563 respondents participated in this research, 52.8% were from Kagitumba irrigation site of Nyagatare district; while 30% were from the Nasho/Mpanga irrigation site of Kirehe district and 17.2% of the respondents were the farmers from Gashora irrigation site of Bugesera district *(Fig.4.4).*

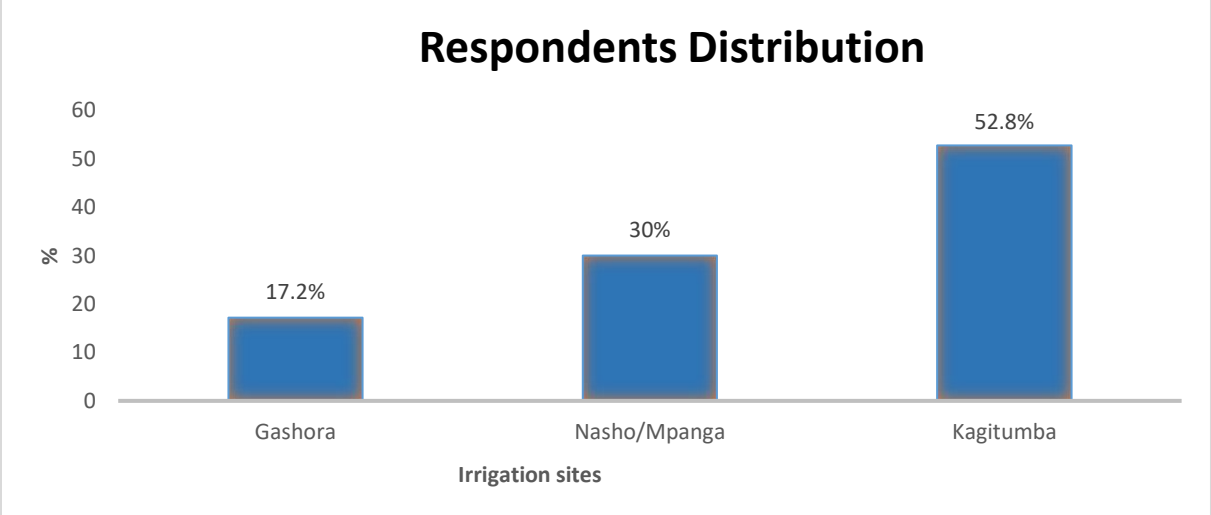

Figure 4.4: Respondents distribution in irrigation sites

On the other hand, gender balance is the key important issue in irrigation performance. As indicated from results, 56.3% of total respondents were female farmers while 43.7% were male farmers. As a matter of facts, 33% of the respondents were the female farmers from Kagitumba irrigation site, 16% were female farmers from Nasho/Mpanga irrigation site and 7.3% of the respondents were female farmers from Gashora irrigation site. However, 20% of the respondents were the male from Kagitumba irrigation site, 14% of the respondents were male from Nasho/Mpanga irrigation site and 9.7% of the respondents were Male farmers from

Gashora irrigation site *(Fig.4.5).* Therefore, according to MINAGRI (2010), agriculture sector in Rwanda are practised by the poor women estimated at 86% of the agriculture farmers in Rwanda, and they are characterised by lower level education. Around 23% of the female who are working in agriculture field have lower level of education comparing to their counterpart men, as most of the time, they practise subsistence farming and receive lower wages. Their product may lack market competition, while most of the women contribute a lot in value addition of the agriculture product in Rwanda (MINAGRI,2010).

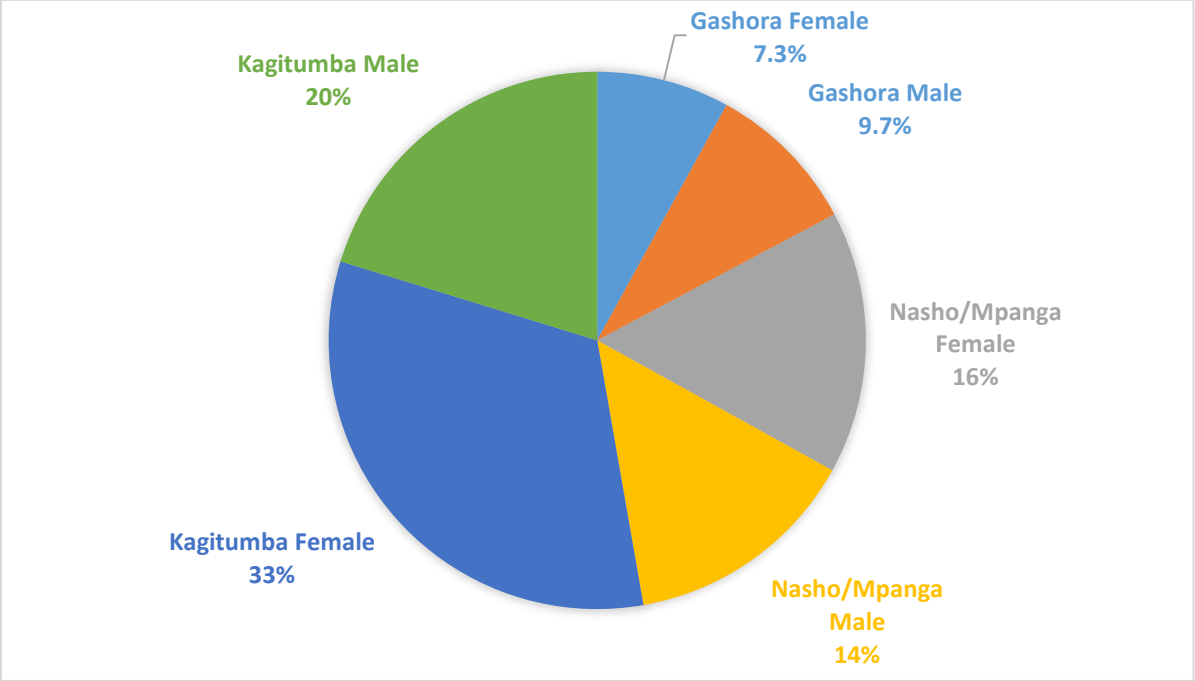

Figure 4.5: Gender distribution of the respondents by Irrigation site.

The level of education of the farmers play a vital role in the development of agricultural production due to the facilitation of knowledge transfer and enhancing learning that help in an environment protection and shifting from subsistence agriculture to fully agriculture with technology (Ayşegül, 2011; Porcedu, *et al*. 2007). During this study, 8.3% of the respondents did not attend any school and they did not have any basic knowledge on how to write and to read, whereas 86.3% of the respondents attended primary school; 4.6% of the respondents attended twelve years basic education (12YBE) and 0.7% were the university graduate. Therefore, among of them, 0.36% of all respondents were the university graduate from Kagitumba irrigation site; while 2.49% of all respondents were the farmers from Kagitumba irrigation site who attended 12YBE; on the other hand, 47.7% of the respondents were the farmers who attended primary education from Kagitumba irrigation site, while 2.13% of the respondents of the farmers from Kagitumba irrigation site, did not attend school. On the hand,

1.78% of the respondents were the farmers from Nasho/Mpanga irrigation site who attended secondary education whereas 22.56% of the farmers from Nasho/Mpanga irrigation site attended primary education and 5.68% did not know how to read and write. Though at Gashora irrigation site, 0.18% of the respondents who participated in this study attended university studies, and 16.16% of the respondents studied primary school finally 0.53% of the respondents did not know how to write and reading *(Fig.4.6).* Therefore, based on the findings, most people who participated in this study have basic knowledge on writing and reading so, the knowledge transfer may be facilitated once they are being trained on water management in irrigation.

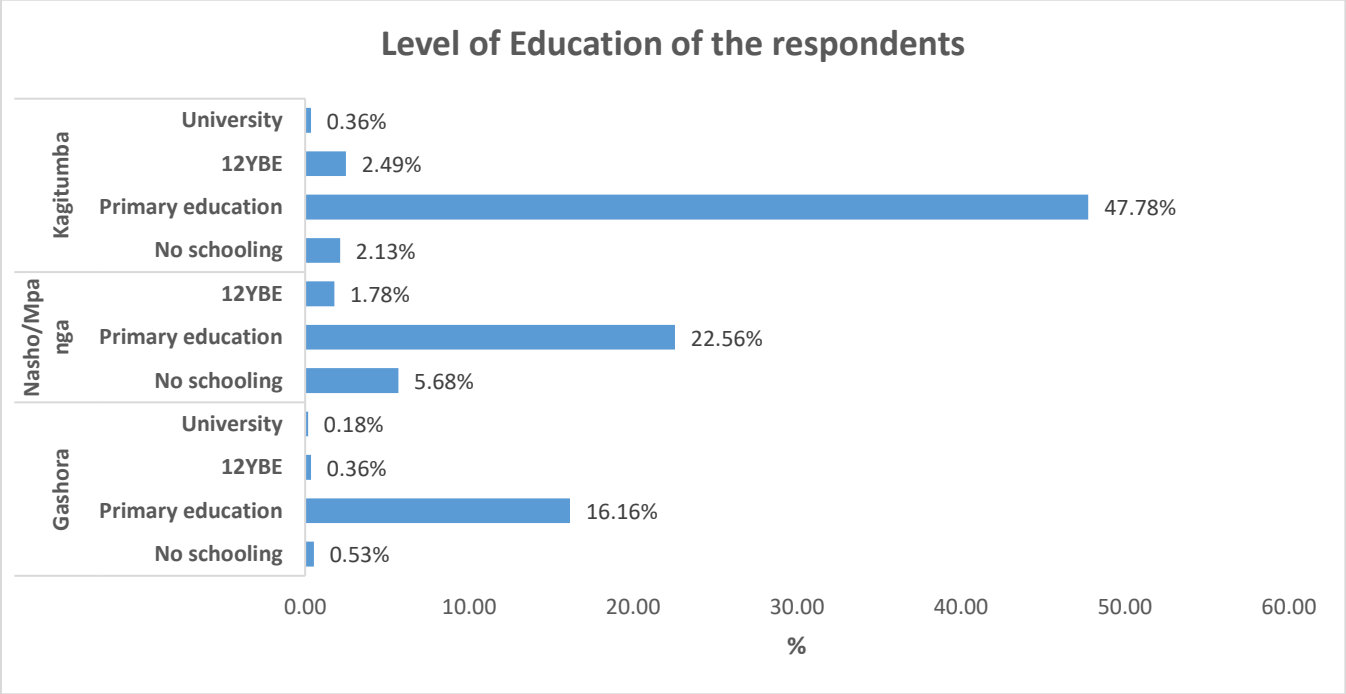

Figure 4.6: Level of education of the respondents

4.2 Effect of water use permit on irrigation performance

Water use permit, is one of the strategies used to control the rate of water abstraction and use rate. It contributes also to reduction of some conflicts that may rise between the water users and increases the ownership because every water user abstracts the quantity required and he/she has a right to use, hence contribute to water pollution.

4.2.1 Water Use Permit Application

Water use application in Rwanda, is applied at the Rwanda Water and Forestry Authority, which is an affiliated instutions of Ministry of Natural Resources. Water use permit takes 2 years to get it at the first time, because, of the preliminary processes including verifying how much impact, a project that is requesting a water use permit and its impact to the ecosystem.

Hence, the in charge instutions gives a cooperative, society, or company a water use permit. Studies carried out in this research were conducted in three different irrigation sites of Eastern province of Rwanda, namely Gashora irrigation site; Nasho/Mpanga irrigation site and Kagitumba irrigation site. Due to that, the farmers of those irrigation sites are grouped into the cooperatives, K.O.A.I.G.R; C.O.V.A.M.I.S and K.A.B.O.K.U respectively located in the sites under selected irrigation site. Water use permit is applied by the cooperatives to the Rwanda Water and Forestry Authority, therefore cooperatives once gets the water use permit, exclusively the famers who are members of it have the water use permit. A water use permits lasted 5years renewable.

Therefore, during this study, only two cooperatives of three, which compose the irrigation sites selected, we conducted in this study have a water use permit, such as C.O.V.A.M.I.S cooperative of Nasho/Mpanga irrigation site and K.A.B.O.K.U cooperative of Kagitumba irrigation site, However K.O.A.I.G.R cooperative of Gashora irrigation site do not have, water use permit. Even though having access on water is one of universal human right, but a project, which may abstract high amount, may endanger the other water bodies and the effective management of the water resources exploitation is not monitored. The management of water resources, either top down or bottom up approaches, help to increase while reducing the bureaucracy activities in the management of water resources use (Liuyang *et. al*, 2017).

4.2.2 Water Use Fees

Water use fees, is some amount of money fixed by the farmers, for the sake of getting some money to repair the infrastructures to pay some charges that may incurred during their irrigation activities. A lough water uses fees paid by the farmers, help the farmers to adapt and enhance the access to the viable solutions and improvement of technologies, once the incentives or direct support from the government or private is not available (LesLevidow *et, al*., 2014). In the irrigation sites selected of Eastern province of Rwanda, water use fees are paid to the elected water user association managers, together in the general assembly of the cooperative and Water users associations M&E committee. They decide which activity to be paid from the water use fees paid by the farmers and initiate it. Hence, they help the GoR to sustain the infrastructures initiated. Therefore, 77.4% of the respondents pay the water use fees while 22.6% do not, mostly dominated by the farmers of Gashora irrigation because not all of them do not have water use permit. The payment of the water use permit is based on land size which is under cultivation and the type of crops per season of agriculture. Therefore, for Nasho/ Mpanga irrigation site, normally the whole land of irrigation site was split into the small plots of

50m*30m (150sqm), hence per season of agriculture a farmer is required to pay 6000frw per a plot, when he/she cultivate maize. however, for the beans the water uses per unit of area (150sqm) a farmer pays 4500frw whereas horticultural crops such as tomatoes and water melon, a payment per 150sqm is 5000frw per season of Agriculture. Note that the season of Agriculture in is composed by three season A, B, and C. Season A, starts from September ending in February; while season B starts in March ends in June; then starts C in July and ends in September of the same year (NISR, 2017). Every season of Agriculture has some specific crops suitable with climatic conditions. Water use fees help the government to manage the irrigation, because the farmers can solve the simple technical issues, hence the government intervenes once there are some irrigation problems that cannot be afforded by the famers, themselves, through the water use fees paid. It increases also the ownership, because the farmers feel that the infrastructures and irrigation scheme are theirs.

4.3 Contribution of Public and Private Sector on Irrigation Performance

Public participation in irrigation performance is much more important, mostly in infrastructures management; knowledge transfer and sustainability of irrigation scheme.

4.3.1. Irrigation Management Training

The training on irrigation management, water use management and agriculture development in general are very important issues needed to raise awareness on sustainable Agriculture productivity and production, among the farmers who use the irrigation scheme established. Therefore, 94.3% of the respondents said that they get enough trainings per every agriculture season while 5.7% do not get training on irrigation management because they are too old to attend the training. RAB is an in charge of the training, where the skilled technicians and agronomist train the farmers on seed selection, pest control, soil erosion and water use efficiency in Agriculture. On the other hand, among the farmers, they vote for the Agriculture extensionists who help them to reinforce the training gotten on erosion control measures, irrigation practise in general, agronomic measures, seeds selection and pests' control. The training on public participation also is done through public works (Umuganda) held, at every last Saturday of each month. The irrigation engineers and extensionists always must have a moment to educate the farmers on the role of irrigation in Agriculture, as well the local leaders do so. Once there is a damage of some infrastructures, people through public work, known as also Umuganda in local language, plan and solve it together with the irrigation engineers. Umuganda is one of the development policies initiated by GoR, to increase the people

participation in development of their country. It is done once a month at last Saturday of each mother, whereby each village plan a communal work and all the people meet together for the communal interest. In 2015, Umuganda contributed over $25 million, and the activities were related to agriculture and construction of feeder roads (KT Press, 2015).

4.3.2 Irrigation Infrastructure Management

Irrigation infrastructures management involves building new ones and repairing the existed infrastructures once they are damaged, as well as protecting the existed. However, the repairing of the irrigation infrastructures most of the time requires lots of money, but once the people are involved fully in management and repairing, it increases the ownership and responsibility in management of irrigation infrastructures, hence reduces the inputs to management. Therefore, during this study, the different categories of the stakeholders involving in repairing the damaged infrastructures, but it depends on the intensity of damage, some need the intervention from the Government others are repaired by the trained farmers and skilled technicians operating on the irrigation site. Therefore, 3.7% of the total farmers who practise their farming agriculture at Nasho/Mpanga irrigation site use WUAs, once there are some pump failure or damage, the same as 24.2% of the farmers from Kagitumba use WUA a major actor in repairing the pumps and water supply channel and pipes. On the hand, in Gashora irrigation site, 13.6% of all farmers participated in this study, repair themselves irrigation infrastructures because they use their own pumps to pump water from the lake to the dam sheet dug. Whereas, 11.5% of the farmers from Kagitumba irrigation site repair their irrigation infrastructures themselves, 10.7% of the all the farmers, who practise their farming activities in Nasho/Mpanga repair their infrastructures once they are damaged. This shows that once the farmers are well trained on irrigation infrastructures repairing and management, facilitate the activities and reduce the expenditures spent on irrigation management. Whilst the permanent irrigation technicians allocated to each irrigation site help to repair some infrastructures like pumps and other hydraulic damage which requires lots of knowledge. Hence, 3.5% of the respondents use irrigation technicians from Gashora irrigation site whereas 15.6% of the respondents participated in this study from Nasho/Mpanga use irrigation technicians to repair some technical damage, likewise 17.1% of the all farmers from Kagitumba irrigation site use the permanent irrigation Engineers working at their irrigation site *(Fig.4.7).* The participation of the farmers in irrigation management in designing and implementation irrigation infrastructures contribute to the sustainability of the infrastructures while reducing the public expenditures and improve efficiency equity as well as improve standards of services (Ruth *et al. 1995;* Helene, 2004).

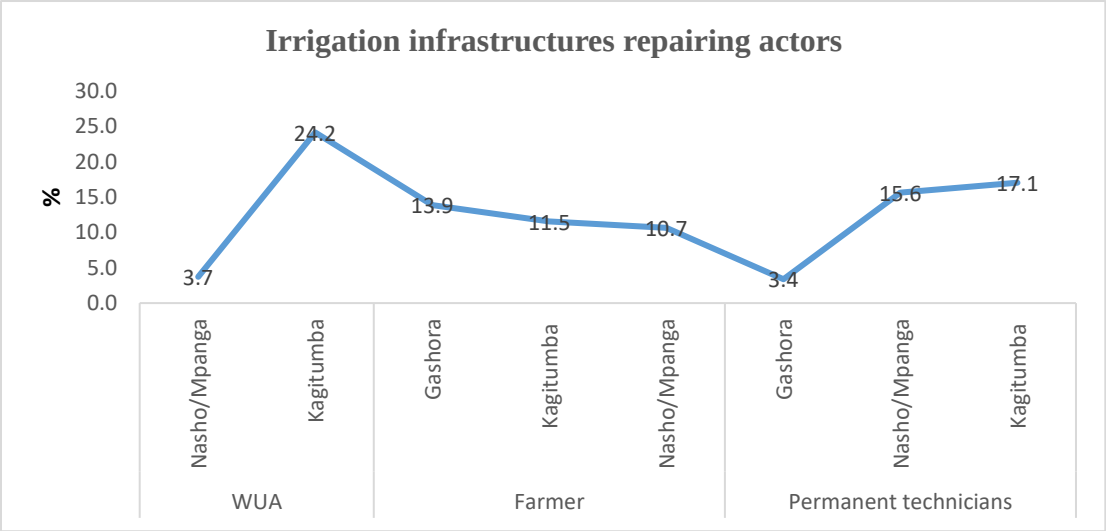

Figure 4.7: Irrigation infrastructures repairing actors

Generally, in Eastern province, 27.9% of the farmers use WUA to solve and repair the irrigation damage that may occur in their respective farms, through the water use fees paid at each Agriculture season. While 36.1% of the farmers solve themselves the irrigation damage occur likewise 36.1% of the farmers use the permanent irrigation engineers at the field to solve the occurrence pumps and supply of water failure and damage. Therefore, this active collaboration between those actors in irrigation management plays a vital role to the sustainability of irrigation infrastructures built.

4.3.3. Irrigation Performance Measurement

The measurement of irrigation performance is a key tool used to look at the distribution of water along the field and the impact at which is affecting the irrigation yield, for the sake of preventing water logging in the field and high drainage, which may lead to the death of some plant cells and causing wilting of the plant. Therefore, 0.4% of the farmers participated in this study, use field topography measurement, 0.7% of the respondents use soil moisture determination in their farms, and 98.9% use water distribution measurement using their own eyes. As matter of facts 0.4% of the farmers who use field topography measurement are from Gashora irrigation site, whereas 0.2% of the farmers using soil moisture measurement as one of the measurements of water distribution in the field, at the same irrigation site. Moreover, 16.7% of the farmers from Gashora, used water distribution in the field using their own eyes. Whilst 0.5% of the population from Nasho/Mpanga irrigation site use soil moisture determination to check the water distribution in the field, 29.7% of the farmers use water distribution determination using their own eyes. In addition to that, 52.8% of the farmers who used water distribution in the field methods were from Kagitumba irrigation site *(Fig.4.8).*

Generally, the irrigation performance is determined using the different indicators method which, related to technical indicators, agronomic indicators; financial performance; socio economic indicators, environmental indicators and managerial indicators. Therefore, monitoring and evaluation of irrigation performance the indicators using their parameters, helps to inform the decision makers on operations needed; maintenance and management of the scheme; water and environment management; crop production and funding needed (FAO,2002).

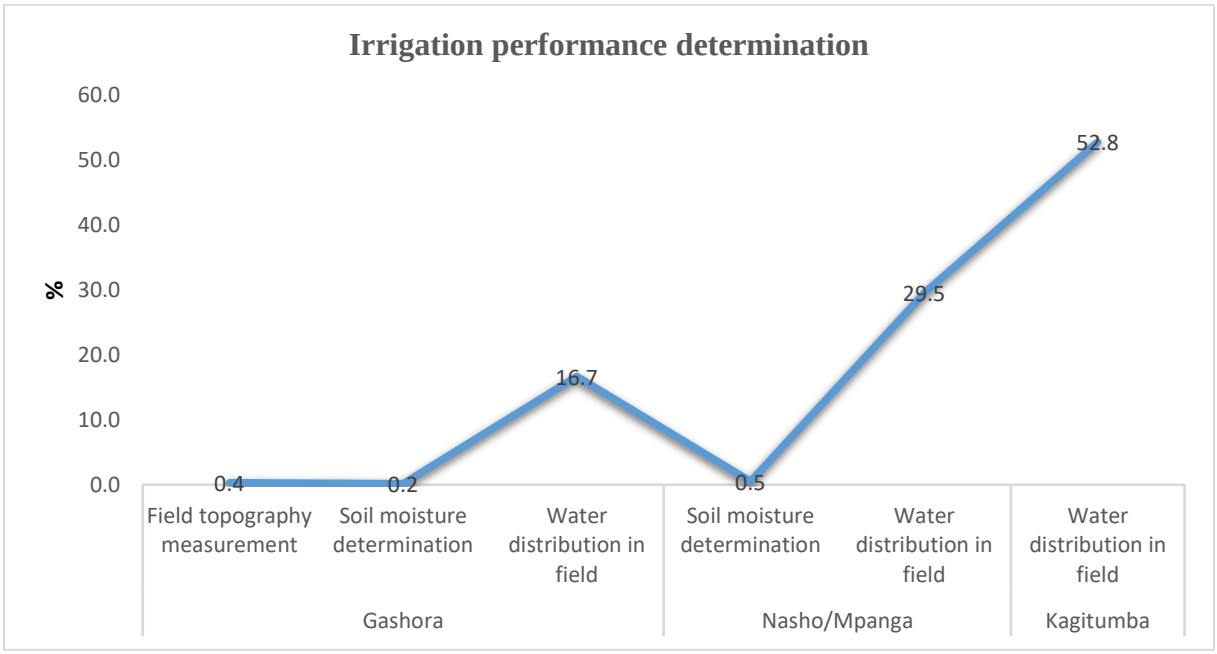

Figure 4.8: Irrigation performance determination

4.3.4 People Participation in Planning Agriculture

Planning Agriculture activities is one of the major issues, which accelerate the agriculture production and ensure food security among the citizens. Therefore, 39.3% plan for their farming activities; by following common calendar of crops set by the farmers in line with CIP program. On the other hand, 8.7% of the farmers plan their farming activities with regard to the labour inputs requirements and 0.5% follows the agronomic aspects when they are planning the crops plantation in their farms. On the other hand, 25.9% of the farms from Eastern province of Rwanda, plan the crops to be planted following the food security patterns and post-harvest technology requirements whereas 25.4% follow the market aspect of the crops planted and 0.2% of the farmers plan the plantation of the crops looking on local consumption potential. As matter of facts, 3.7% of the all the farmers from Gashora irrigation site plan their crops with

respect to the market aspect of the crops, whilst 3.7% of the farmers from Gashora irrigation site plan their agriculture activities with regards to the food security and 9.8% of them, as well follow common calendar crops set by the village meeting. Meantime, 11.7% of the farmers from Nasho/Mpanga irrigation site as well, plan their farming activities about the market aspect of the crops. In addition to this, 8.3% of the farmers from Nasho/Mpanga irrigation site plan their crops to be planted following the food security aspect whereas 9.9% of the farmers plan their faming activities following the common crops calendar set. In addition to this 0.2% of the farmers from Kagitumba irrigation site plan their farming activities with report to the local consumption at local market, whereas 9.9% of the farmers from Kagitumba irrigation site plan their agriculture activities regarding to the market aspect. 0.5% of the farmers from Kagitumba irrigation site respecting the agronomic aspects, 8.7% follow the labour requirements inputs and 19.5% of the farmers follow the common calendar aspect while planning Agriculture activities *(Fig.4.9).*

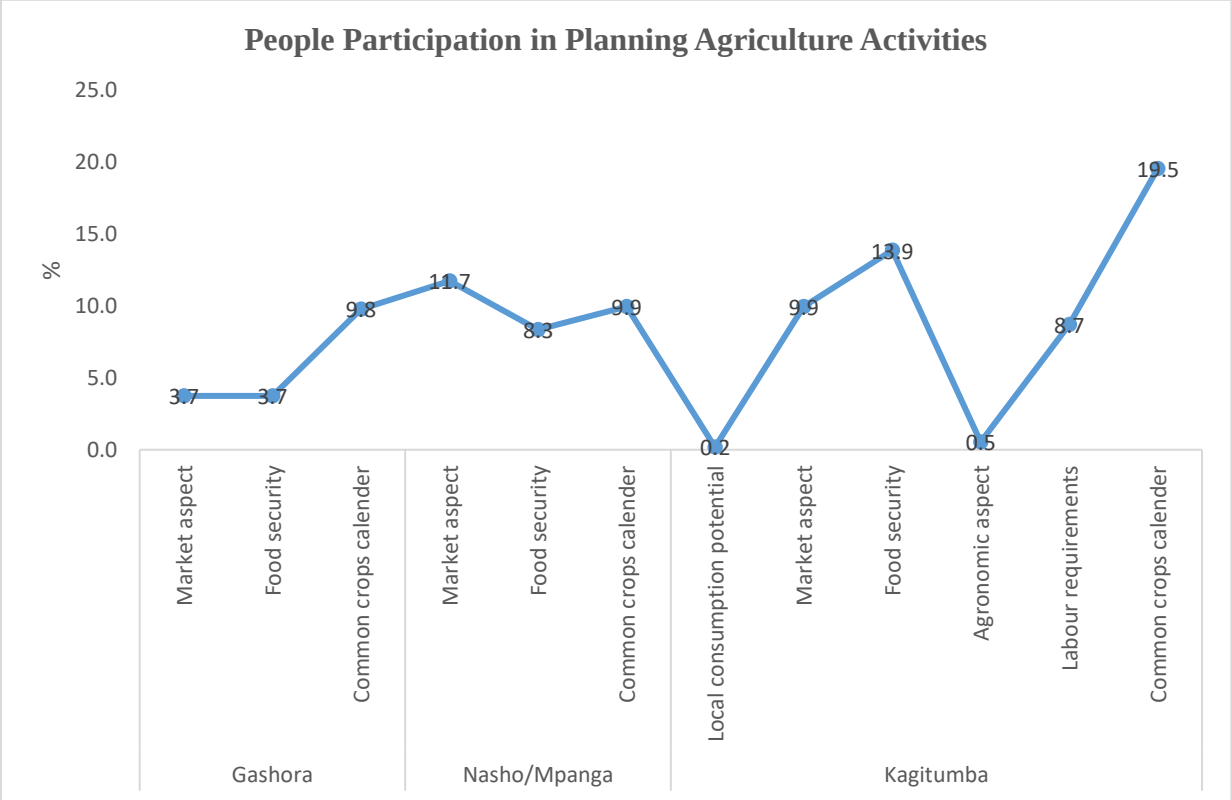

Figure 4.9: Planning agriculture activities aspect

Planning agriculture activities as well have to be in line with recording harvest and relate with the inputs. Normally recording the agriculture inputs and outputs is key issues, which facilitate the irrigation performance. Therefore, irrigators are advised to record the activities as soon as they initiate it, instead of waiting for the end of the season. This will help them to know exactly the inputs and compare with the harvest (FAO,2002). Hence, 79.6% of the farmers

participated in their study records the agriculture inputs and outputs whereas 22.4% do not record the agriculture inputs and outputs. Therefore, 13.7% of the farmers record their agriculture production both from the beginning of the agriculture season whilst 47.2% of the farmers records their farming inputs and output from the beginning of the agriculture production, finally, 18.7% of the farmers records their agriculture productivity at the end of the agriculture season.

4.4. Contribution of WUA to the Irrigation Performance and Development

WUAs, is a group of farmers or other water actors who are playing a direct role in water use. The main role of WUA includes the effective water use allocation among the water users; water infrastructures maintenance; repairing and management; water use fees collection and its management; and conflict resolution among the water users. Therefore, in this study, 98.4% of the farmers participated in this study were the members of the WUA at their respective irrigation site, whilst the remaining 1.6% of the farmers were not the member of any water users' association due to the different reasons such: oldness, renting the plot and the owner who is registered. However, those who rent the plot, and are not a member of the WUA association were willing to participate in the different activities of WUA due to the importance of it during irrigating the crops. The members of the WUA, finds the different importance and interest of it, such as: easily getting water subsidy; Farm management training and among others. Hence, 70% of the farmers enumerated that a major profit from WUA includes easily getting water subsidies from their WUA *(Table 4.4*). While 21% get training on farm management, in addition, 4.6% get the opportunities to sell their crops and 2% get some loans from their fellows' member of WUA easily, through tontines, which help them to solve some farming problems.

Table 4.4: Farmers' benefits from WUAs

Benefits from WUA	**%**
Easily getting water subsidy	70%
Farm management training	23.1%
Selling the harvest	4.6%
Credits services from WUA	2%
Others	0.2%
Total	**100%**

4.4.1. Main challenges of farmers in WUA

The farmers, of the different WUAs in their irrigation sites selected, meet some challenges related to the ability to pay water use fees as high cost of irrigation machine& repairing; inadequate water distribution in the plot and Lack of communication with the seniors' decision makers. Hence 3% of the farmers from Gashora irrigation site claimed, a challenge related to high cost of irrigation machineries and repairing of the pumps. The frequent occurrence of disaster such as flooding when it is raining and sunny when it is in sunshine period, which ruin their pumps installed in the lakes. About 10.4% claimed, insufficiency of source of energy to pump the water from the lake, so they use petroleum, with high. Likewise, it is very risky to store fuel in the respective house. Therefore, it slows down the irrigation performance in Gashora irrigation site. About 1.1% of the population are challenged by having ability to pay water use fees due to an imbalance between agriculture inputs and agriculture outputs as well as the market price which is lower than the inputs. Hence, an ability to pay water use fees becomes a problem, as well as it is harder to the farmers to get loans from the bank to be able to purchase the inputs. 2.7% of the farmers from Nasho/Mpanga irrigation site are challenged by high cost of irrigation machine and repairing the damaged infrastructure. The pipes used to irrigate their land are not sufficiently enough on market hence once, it is damaged, they cannot replace it easily and increase some conflicts related to the completion of irrigation materials. On the other hand, 10.2%, of the farmers encounter the challenges related to water distribution in their plots, due to lack of tanks to store the water pumped, and the infrastructures are mobile. Hence, due to the replacement of pipes at intake. The challenges related to disaster are also a challenge to the farmers because once there is rainy season, flooding ruin their crops and when there is an extended drought as well, their crops burnt. An access to the source of energy source also is great challenge to facilitate the farmers to pump water from the lakes, hence 12.9% of the famers from Nasho/Mpanga irrigation site, claimed the electricity supply is not sufficient to pump water from the lakes, because the available electricity quantity is not sufficient enough, to run the pumps. Whereas 3.2% of the farmers from Kagitumba irrigation site have a challenge of paying water use fees, but they find its importance meantime, an imbalance of agriculture inputs and outputs make them to get low price at the market, hence ability to pay water use fees becomes a challenge. 5.6% of the farmers claimed a high cost of the irrigation machineries and repairing processes while, 0.5% enumerated an inadequate water distribution in their plots due to some farmers turning back the rotation of centre pivot irrigation sprinkler. On the other hand, 35.3% of the farmers claimed disaster which most of the time ruin

their crops, either flooding and extended sunny shine slows down the irrigation performance in their irrigation site. Almost 8.6% of the farmers from Kagitumba irrigation site have shortage of energy supply which is sufficient to pump water from the river *(Table. 4.5).*

Table 4.5: The main challenges of WUAs in the respective irrigation site selected

Irrigation site	**The main challenges of WUA**	**%**
Gashora	High cost of irrigation machine& repairing	3%
	Disaster	3%
	Access to the source of energy	10.4%
Nasho/Mpanga	Ability to pay water use fees	1.1%
	High cost of irrigation machine& repairing	2.7%
	Inadequate water distribution in the plot	10.2%
	Disaster	3.4%
	Access to the source of energy	12.9%
Kagitumba	Ability to pay water use fees	3.2%
	High cost of irrigation machine& repairing	5.6%
	Inadequate water distribution in the plot	0.5%
	Disaster	35.3%
	Access to the source of energy	8.6%
Total		100.0

4.4.2. Interview with WUA Leaders

An interview conducted on the different water users association leaders in their respective irrigation highlighted, the different strategies aiming at enhancing water use in irrigation in Eastern Province of Rwanda. The interview was conducted in Tuyakoreshe-Mpanga lot III WUAs, created in year 2013 composed by 209 members; Tuyabyaze Umusaruro-Mpanga lot II WUAs created in year 2012 composed by 256 members; Tuyasaranganye-Mpanga lot I WUAs created in year 2013 made of 332 farmers; Tuyakoresheneza-Gashora WUAs created in year 2016 composed by 126 farmers and Abahuje Umugambi-Kagitumba WUAs created in year 2016 composed of 345 farmers. The WUAs leaders interviewed during this study include Water user's presidents and water users' Association managers. The water user's managers are the skilled farmers hired as an expert in water management and accounting to facilitate the farmers to enhance the water WUAs

functionality. A WUAs, is led by the 3 different committees, namely Executive committee; Monitoring and Evaluation committee and Conflict management committee, all of them are working together for the sake of improving the water use efficiency in irrigation scheme.
The different water actors forming a WUA, mostly are dominated by Agriculture farmers. A new farmer to get license and ability to be party of each water user association in Eastern province have to have at least a minimum land size required in irrigation scheme depending on the requirements mostly, varying from 150sqm of land, in addition, a location of land in the irrigation site; payment of water use fees and cultivating in irrigation scheme. An application is sent to the executive committee of WUAs; hence, during a general meeting of WUAs they accredit an application of farmer.

The main activities of a WUAs in the irrigation site, includes improving the water use allocation among the water users; management of irrigation infrastructures; water use fees collection and management; water quality management; conflict resolution among the water users and offering other related facilities related to enhancement of irrigation performance and Agriculture in general.

Water use involves having a water use permit as the water resources management policy of 2011, stipulates. Hence, except Tuyakoresheneza-Gashora WUAs, which does not have a water use permit; others WUAs namely from Nasho/Mpanga and Kagitumba have an Authorisation regime water use permit.

Even though water users are all committed to produce much, some conflicts may arise most of the time resulted from competition of water resources and insufficiency of irrigation equipment. Hence, the different conflicts are based on insufficiency of irrigation materials; changing the pipes among the irrigators mostly at Nasho/Mpanga irrigation site; delaying the payment of water use fees. However, the delay of water use fees payment also is common conflict cause due to that harvest and low price of it on the market. Once the conflicts arise, the different methods used by conflict management committees of WUA including the mediation and compromising conflict management method. While the Justice court can intervene depending on the intensity of the conflict or when there is over exaggeration resulting to the fight or destruction of infrastructures willingly, here the local leaders even may intervene in this conflict management but this extent is rare, water user association president said *(Fig 4.10*).

The people participation in management of irrigation, also rises when they are actively participating in some activities, therefore the water users decide together water use fees which varies from one irrigation site to another. The WUA leaders claimed that the existed water use fees are not sufficient, looking on what have been planned to be done in their respective

irrigation site, on average they are proposing 30000Frw/ha/Season. On the hand, the different methods used to collect the water use fees varies but frequent and feasible includes setting the deadline of payment of water user fees and using the communiqué through the cooperatives. The advocacy to the decision makers of Agriculture and water resources, is very important, therefore, the frequent methods used by the WUA leader to advocate for the members of the WUA, include using the local leaders and other public leaders to advocate for them in decision makers instutions. The farmers themselves through the elected committees manage the management of the water use fees as the figure 4.10 explains.

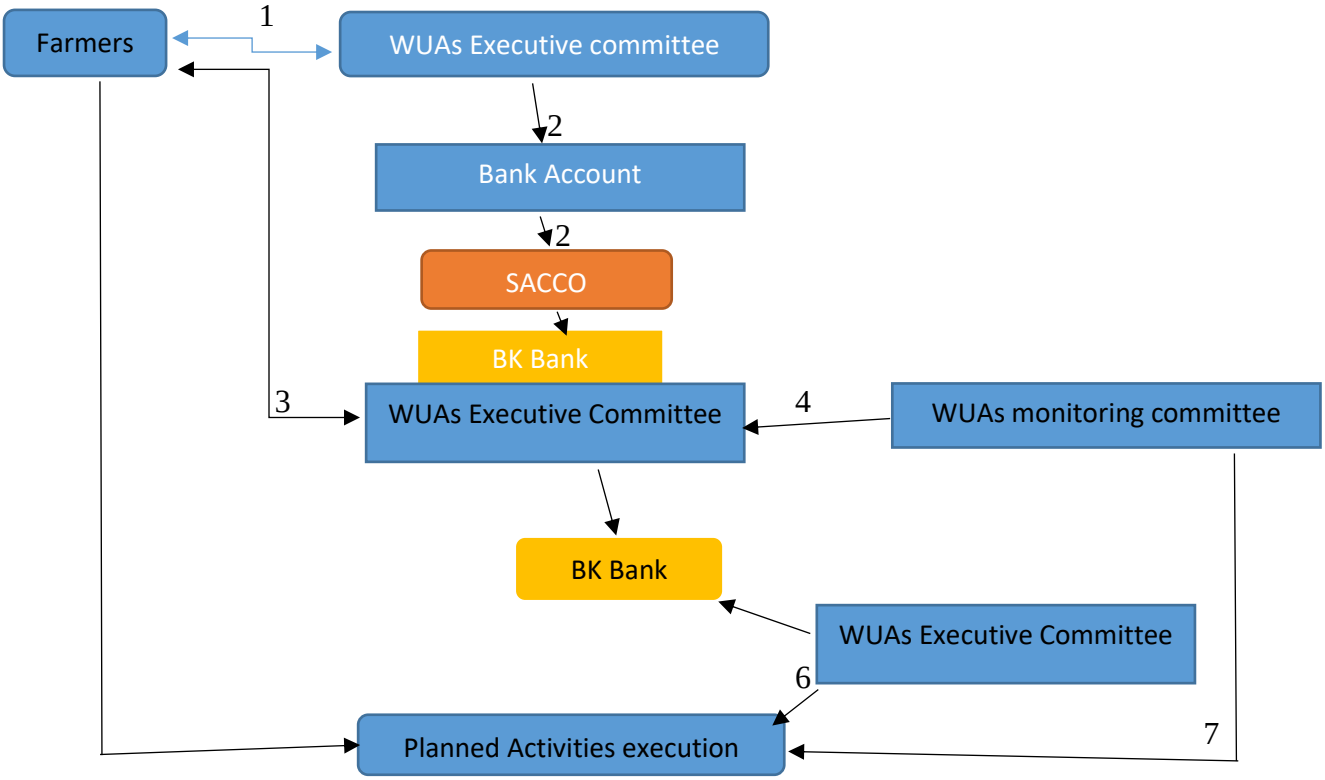

Figure 4. 10: Management of water use fees cycle

1: Water use fees collection

2: Cash Deposit

3: Planification/General Meeting

4: Monitoring &Evaluation

5: Authorisation to withdraw cash

6: Cash withdraw

7: Monitoring and Evaluation

The frequent challenges encountering in the WUAs includes delay in water use fees payment's insufficiency of irrigation infrastructures and the one exists is so difficulty to renew them because they are not available on local market. Lack of investors in irrigation and agriculture. Currently, the banks are investing 0.7% of loans given to the instutions in Agriculture, while over 70% of the Rwandans are the agriculture farmers (Igihe, 2016). lack of tanks to store water. Some suggestions proposed by the WUAs leaders, for the sake of

enhancing water use efficiency in irrigation includes making available the irrigation materials on the market; raising the electricity voltage and energy supply; and raising awareness to increase the private sector involvement in Agriculture.

4.5 Irrigation Performance and Agriculture Sector Analysis

4.5.1 Source of Water for Irrigation in Respective Irrigation Sites

In Eastern Province, irrigation is mostly dominating, due to an extended drought frequently faced. Maize crops; beans; and horticultural crops dominate the frequent crops irrigated in eastern province of Rwanda. The source of water used for irrigating the crops in the selected irrigation site is fully from the rivers and lakes, located near by the irrigation sites. Gashora irrigation site of Bugesera district, its irrigation scheme, is much more independent comparing to the others. The farmers mostly use their private pumps to pump water from Mirayi and Rumira lakes which surround their farms and store pumped water in dam sheet (Vale dam), dug in their respective farms (*Fig.4.11*). Later they use, stored water either by gravity (Surface irrigation), or using sprinkler irrigation.

Figure 4.11: Dam sheet/Gashora irrigation site

The area under irrigation in Gashora irrigation site is 129ha; and the irrigation is supplying over 2.76mm/day of irrigation intensity determined based on the quantity of water pumped in 3 days irrigate their lands in normal conditions. However, Nasho/Mpanga irrigation site, they use water from lake Nasho/Cyambwe, to irrigate an area estimated to 464ha, and irrigation in this site supplies 3.072mm/day as irrigation intensity per day. The water pumping from the lake is done using the pumps installed on the lake with discharge 193m^3/h, the project of irrigation is managed by MINAGRI under GFI project which offers the technical support to

the farmers to enhance the irrigation performance in this site. However, in Kagitumba irrigation site which covers an area of 900ha, the water used in this irrigation scheme is pumped from Umuvumba river and Akagera river *(Fig.4.12),* the irrigation intensity in this irrigation site contributes to 1.240mm/day as irrigation yield, within 3 days a week they irrigate their land in normal conditions. Water pumped from Umuvumba/Akagera River, directly used either centre pivot irrigation or drip irrigation.

Figure 4.12: Water pumping from Umuvumba river/Kagitumba irrigation site

4.5.2. Agriculture Development Analysis in Irrigation Sites Selected

The Agriculture in the selected irrigation is favoured by irrigation due to lack of sufficient rainfall in Eastern province of Rwanda. Currently, Eastern province is under water stress and water shortage, in 2016, Meteo Rwanda, recorded an average rainfall below 0.85mm, in the stations located in Eastern province (Meteo Rwanda, 2018). Therefore, the farmers interviewed during this study, who cultivate an average land between 500 and 50000 Ares, were estimated to 21.1% of all respondents while 63.7% of the total respondents cultivate an average area ranging from 51000 to 10000 Ares. Whereas 15.3% of the respondents cultivate an average land varies between 10100 and 30000 Ares, 0.4% of the respondents cultivate area which is above 301000 Ares. The cultivation practises the farmers use to cultivate their land are dominated by hoes and tractors, where by 83.9% of the respondents use the traditional hoes to dig their land while 16.1% of the respondents use the tractors. The GoR is encouraging the use of mechanised system in their agriculture practises to enhance technology use in Agriculture and to enhance the time saving. During PSTA III, the target to have mechanised land to accelerate the use of tractor was estimated to achieve 25% of all cultivable land in Rwanda, and in 2012, 13% of the Rwandan land was mechanised (MINAGRI,2013).

The major dominant crops in selected irrigation sites of Eastern Province include maize, rice and horticultural crops such as tomatoes, fruits and legumes (*Fig. 4.14 & Fig.4.15*). Hence 75.1 % irrigate maize crops whereas 23.4% of the farmers cultivate and irrigate beans, either climbing beans or bush beans; 0.9% of the farmers irrigate the horticultural crops in the selected irrigation sites of the Eastern Province of Rwanda. The GoR, during CIP program initiated from 2007, aimed to improve agriculture productivity focusing on high potential crops for the sake of ensuring food security and self-sufficiency. The major crops focused on, includes maize, wheat, beans, cassava, rice, Irish potatoes and horticultural crops (Arumugam, 2011). As matter of facts in Gashora irrigation sites, 13.85% of the respondents, irrigate maize crops, while 3.37% of the respondents cultivate and irrigate beans crops. However, 17.94% of the respondents from Nasho/Mpanga irrigation site irrigate maize crops; 11.19% irrigate the beans crops *(Fig.4.13)*, while 0.89% of the respondents irrigate the other crops including the horticultural crops in Nasho/Mpanga irrigation site. Whilst, for Kagitumba irrigation site, 43.34% of the respondents cultivate and irrigate maize crops, 0.53% of the respondents irrigate rice crops while 8.88% irrigate the beans crops.

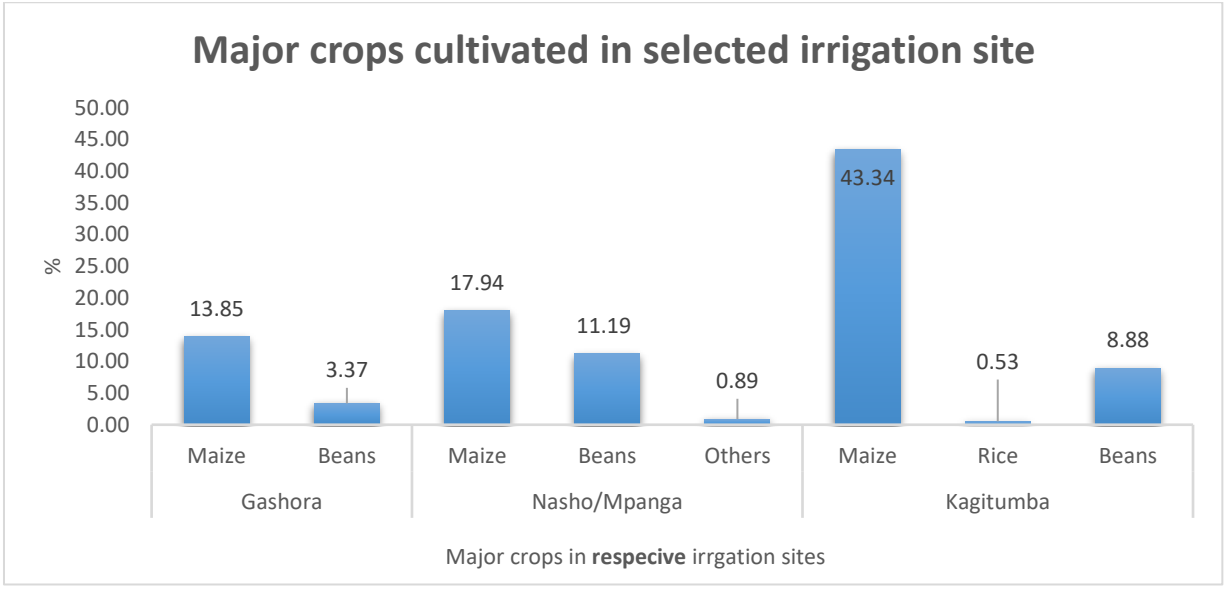

Figure 4.13: Major crops in respective irrigation sites selected

On average, most of the farmers sow, between 2kg and 100kg of maize seeds, depending on the land area. The farmers of Eastern province sow on average 25kg of seeds of maize crops per hectares of land while the quantity of seeds beans on average, is estimated to be 40kg. The estimated yield per unit of land cultivated most of the time depends on the availability of water and other inputs. During this study, we considered that other inputs as fertilisers, pesticides were considered safe and reliable to the production. Hence, for us we considered water inputs availability. Therefore, on average when there is enough water, per hectare of land of maize, a

minimum estimated yield per hectare of maize is 2.5tones while when there is a shortage of water; the farmers may harvest 500kg maximally. Referring to the Rwandan, agronomist diary of 2018, the production of maize per hectare in Rwanda is estimated to vary between 2 to 3 tons of dried grain of maize. While for the beans crops, the farmers of Eastern Province the sow on average between 30kg to 50kg depending on the size of beans seeds, and they harvest between 3 to 5 tons of beans when water are available and weather conditions are favourable on the hand, when there is water shortage, they may even do not get the quantity of seeds sowed. For the tomatoes and other fruit, and horticultural crops, the farmers of Eastern province in selected irrigation sites, they count the harvest based on the quantity of basket (Intebo), but it is not favourable due to the wastage along the value chain from the harvest up to the consumers. There is a need to approach them an agro-alimentary industry or improvement of transportation and harvest practises of the horticultural crops.

Figure 4.14: Horticultural crops under irrigation/Gashora irrigation sites

Figure 4. 15: Beans and Horticultural trees under irrigation/Nasho irrigation site

4.5.2. Analysis of Irrigation Performance in Eastern Province

Irrigation performance in Eastern province is quite moderate. The frequent existing type of irrigation, found in the selected irrigation sites of Eastern Province include, surface irrigation, sprinkler irrigation using centre pivot sprinkler irrigation or hose reel sprinkler irrigation and drip irrigation (*Fig. 13& 14*). Others uses the traditional way of irrigating their crops mostly do not reach their plots. Generally, 8.7% of the farmers of Eastern use surface irrigation whereas 72.3% of the farmers stated that they use sprinkler irrigation, either, centre pivot sprinkler or horse reel sprinkler irrigation. Whereas drip irrigation is used by 9.9% of the respondents, 9.1% use other type of irrigation such as traditional means or combination of drip and sprinkler irrigation. As matter of facts, in Gashora irrigation site, 6.75% of the respondents use surface irrigation, mostly due to the water stored in dam sheet and flow by gravity. While 4.09% of the respondents from Gashora irrigation site use the sprinkler, irrigation dominated by horse reel sprinklers; 3.02% of the respondents from Gashora irrigation site use drip irrigation and 3.37% use other type of irrigation *(fig.4.16).*

As matter of fact, for Nasho/ Mpanga irrigation site, 1.78% of all respondents use surface irrigation were the farmers from Nasho irrigation site; 25.40% use sprinkler irrigation (horse reel sprinkler), while 0.89% use the drip irrigation and 1.95% of the respondents combines both sprinkler irrigation and drip irrigation. Considering the rate of using surface irrigation with other irrigation sites selected, 0.18% of all respondents use surface irrigation in Kagitumba irrigation site, 42.81% of the farmers participated in this study who use sprinkler irrigation came from Kagitumba. The dominant type of sprinkler irrigation in this irrigation site, includes centre pivot sprinkler irrigation and on small-scale horse reel sprinkler irrigation. However, 6.04% of the respondents from Kagitumba use drip irrigation and 3.73% of the respondents combine both sprinkler and drip irrigation at the same time during their farming activities (*Fig. 4.16 and fig. 4.17*).

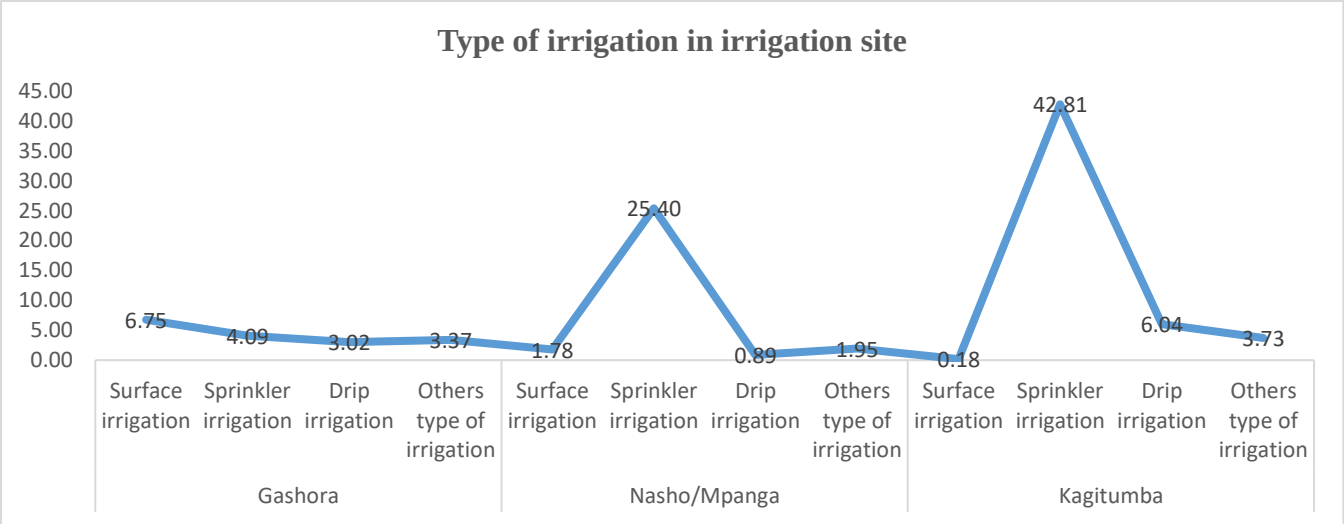

Figure *4.16*: Type of irrigation in respective irrigation sites

Figure 4.17: Center pivot irrigation type/Nasho irrigation site

Figure 4.18: Surface irrigation under Banana crops and Tomatoes/ Nasho/Mpanga irrigation site

Use of water resources in irrigation, most of the time, require competition among the users due to the different reasons related to their farming practises and amount of water needed to be extracted by each farmer. During this study, 30% of the farmers who participated in this study said that water that they get are enough to irrigate their land and crops while 70% of the respondents, enumerated that water they use in irrigation are not enough to irrigate their crops. As matter of facts, 42.8% of the respondents who came from Kagitumba irrigation site said that water for irrigation are not enough comparing to their counterpart. However, 9.9% of all respondents who said that water is enough. At Nasho/Mpanga irrigation site, 20.4 % of the respondents said that water is enough to irrigate their land. Oppositely in Gashora irrigation site, the farmers on large scale are sufficient with water they get where by 10.5% of the famers are satisfied with the quantity of water while 6.7% of all respondents do not *(Fig.4.19).* In Gashora irrigation site, the farmer is fully independent to pump water from the surrounding lakes comparing to the other irrigation site. Most of the farmers from Nasho/Mpanga and Kagitumba irrigation site depends on the infrastructures constructed by the different project Therefore, they share the available water, which make them not get enough water comparing o their fellows' farmers from Gashora irrigation site. Hence, a sustainable remedy to have sustainable water supply for irrigating the crops in the respective irrigation sites includes the establishment of the dam sheet that may help the farmers when the pumps are not operating and will help the water harvesting during rainy season.

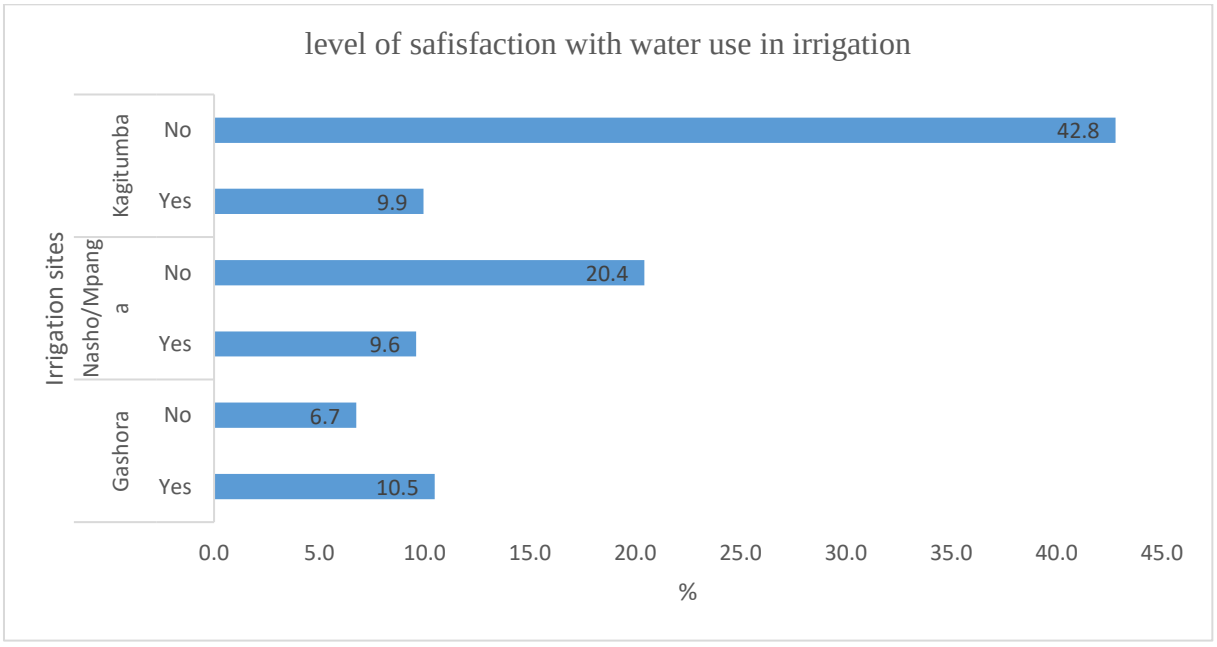

Figure 4.19: Level of satisfaction with available water resources for irrigation

The reasons, provided by the farmers why water is not enough to irrigate their lands while they use water from the lakes, includes drought; inappropriate water rationing calendar; cost of irrigation equipment and lack spare party of the existed infrastructure once they are damaged. Hence, 26.6% of the respondents said that the cost of the irrigation equipment once there are damaged is very high. Mostly in Nasho/Mpanga irrigation sites, some pipes are not available on the market, hence slows down the irrigation performance in this site, whereas 11.4% of the respondents, enumerated drought as one of the main causes of water insufficiency in their irrigation activities. In addition, 50.6% of the respondents pointed out water rationing calendar, as the major cause of the water insufficiency in irrigation. This is due to that some farmers change the round tour of the centre pivot, hence other do not get water on time. In addition, because they use direct water pumped from the lakes without tanks sometimes, when there is high water demand the water calendar is not followed as it is, and water consummation increases hence the pumps available do not serve them, as it is required.

Even though water is not enough to some extent the farmers of Eastern province recognise the time to irrigate their land, they do not strongly compete for the available water. Hence, 19% of the respondents said that they irrigate their crops periodically, most of the irrigation sites, we conducted in our study, they irrigate three times a week. While 26.8% of the farmers of Eastern Province, they irrigate their crops when the crops start to appear water stressed, and 53.8% irrigate their crops as long as the soil starts to appear dry, 0.4% irrigate their crops due to the different circumstances and combine both periodic and when he soils starts to appear drier (*Fig.4.20*). According to Brouwer, *et. a*l, 1989, the different methods suitable for the small farmers and low-income farmers to enhance the irrigation performance includes plant observation method, consisting of observing 'when' to irrigate the crops, through observing colour changes, curling of leaves and plant wilting. In addition, the other methods include estimation method consisting of estimating the water needed following the schedules depending on the climatic conditions. Also, for the advanced farmers may use simple calculation method, basing on the depth (mm) and determine the water needed for the irrigation during growing season.

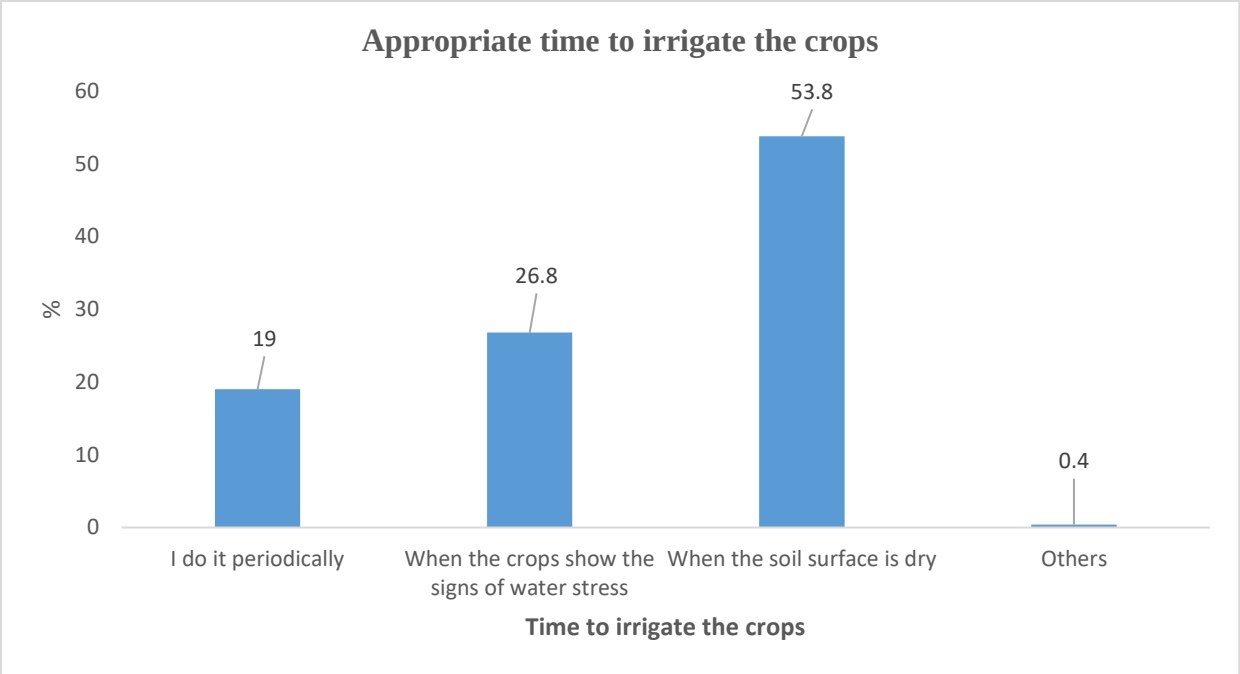

Figure 4.20: Appropriate time to irrigate the crops.

The main challenges the farmers, form the irrigation sites selected of Eastern province facing during their daily activities of irrigating, their land includes, water-rationing calendars which is not suitable enough and some farmers changing the rotation of centre pivot irrigation equipment; damaged irrigation infrastructure; Inefficiency of highly skilled irrigation engineers in their irrigation sites, and lack of training on irrigation infrastructures maintenance. Therefore, 29.7% of the respondents, encounter water rationing calendar as major source of irrigation challenges they face with, while, 30.4% enumerated some irrigation infrastructures damages, and delay replacement of the damaged infrastructures, mostly in Nasho/Mpanga irrigation site. The highly skilled technician also is need, who will enhance the raise of knowledge transfer on irrigation management. 8.9% of the respondents see lack of training as major challenges they face with in irrigation. Finally, 6% of the respondents enumerated other challenges including crops, which do not meet the available water supplied and disasters, frequently found in this region such as drought and flooding when there is rainy season (*Table.4.6*).

Table 4.6: Frequent challenges of irrigation in irrigation sites selected

The frequent irrigation challenges	**%**
Water allocation calendar	29.7%
The irrigation infrastructures well damaged	30.4%
Lack of technician	21.8%
High water uses fees charges	3.2%
Lack of training	8.9%
Others	6.0%
Total	**100%**

Looking on specific challenges, in the irrigation sites selected of Eastern Province, and its intensity on irrigation performance, for Gashora irrigation site, 3% of all respondents enumerated water allocation calendar as major challenge for irrigation. While 7.5% of the respondents from Gashora irrigation site, said that, the irrigation infrastructures have been damaged (fig4.21) due to disaster and delay of repairing and the unavailability of spare parties of the existed irrigation infrastructures. 3.4% of the respondents enumerated the lack of technicians in irrigation, 3.4% see lack of training on irrigation management as major challenges that slows down the irrigation. However, Nasho/Mpanga irrigation site, 2.8% of the respondents find irrigation calendar as major challenge, while 17.2% said that the irrigation infrastructures have been damaged (*Fig.4.22*), and it is difficult to find the spare parts to replace them on the local market. 0.9% of the respondents from Nasho /Mpanga irrigation site stated the high-water fees, which is not proportional to the harvest, they get and the input they invested in Agriculture as well the on-farm services cost. 3.7% of the respondents enumerated lack of training while 5.3% said other challenges including, lack of organic fertilisers to mix with inorganic fertilisers, and when they find it, the price is too high because they purchase it at Ndengo sector in Kayonza district. In addition, an extended drought, and some farmer who do not respect an irrigation calendars are the major challenges, which slows down an irrigation performance in the irrigation sites selected. For Kagitumba irrigation site, 4.8% of all respondents, said that water allocation calendar is the major challenge of irrigation development, due to that some farmers turn back the centre pivot rotation, others do not find water on right time. While 5.7% declared the infrastructures have been damaged, while 27.5% said they don't have high skills irrigation engineers and 2.3% said the water use fees are too high to afford comparing to the input and harvest. 1.8% does not have enough training on

irrigation management and water use management. 0.7% of the respondents enumerated other challenges such as pests, disaster and to some extent the hippos, which ruin their crops *(Fig.4.21).*

Figure 4.21: Irrigation infrastructures damaged (Gashora and Nasho/Mpanga irrigation sites)

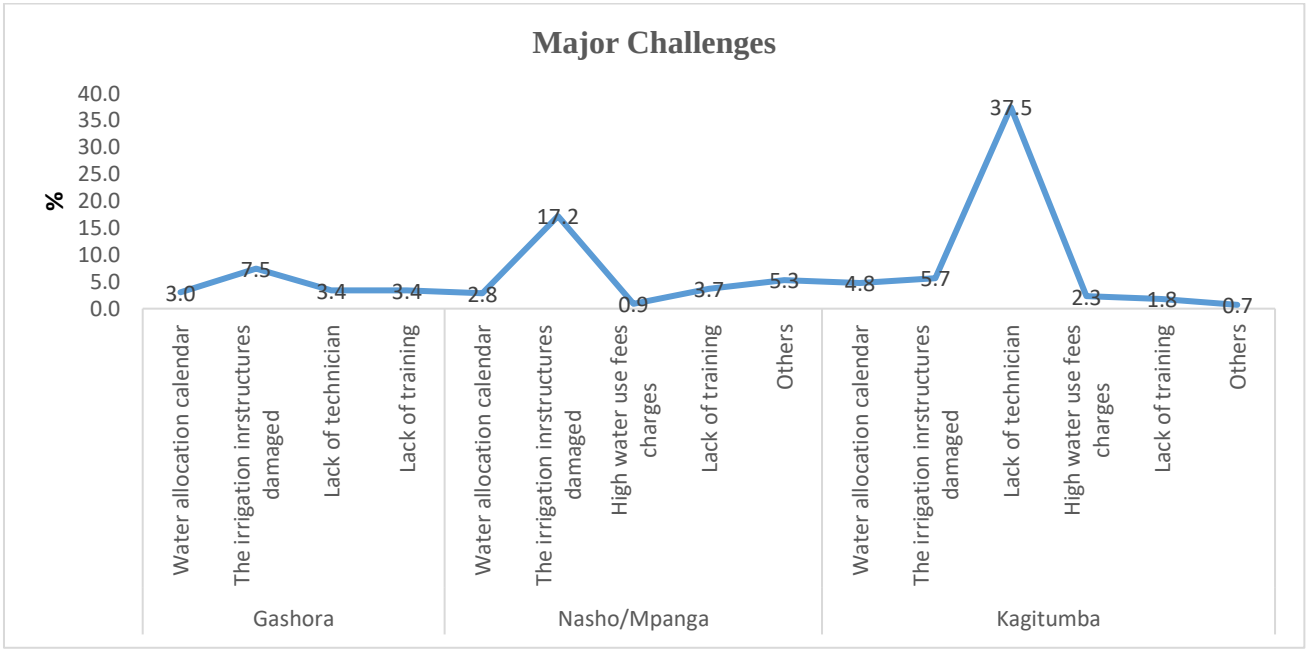

Figure 4.22: Major challenges in irrigation sites selected

Even though there are some challenges that hinder the outcome of the irrigation performance, in irrigation sites of Eastern province of Rwanda, the farmers are proposing some strategies that may help them to improve their irrigation practises. Hence, 43.9% of the respondents proposed an innovation of irrigation technics exist, mainly at Nasho/Mpanga irrigation site, they propose, to renew of the exited irrigation infrastructures from horse reel sprinkler system to canter pivot irrigation type. While 12.6% proposes to reduce, the water use fees, and the payment base on the harvest because sometimes they do not get enough return after harvesting. 20.4% of the respondents propose to increase the training on irrigation

development. However, 19.2% proposes the increase of subsidies in irrigation like the GoR does on fertilisers and seeds through Nkunganire. 3.9% proposes other strategies including, availing the irrigation machine on the local market.

4.6. Interview with Local Leader

During this study the local leaders in charge of Agriculture on sector level were also interviewed. Normally, sector agronomist is one of governmental officers who are near by the farmers and give them the support to improve their agriculture practises. Therefore, two sector agronomists of Mpanga sector and Gashora sector were interviewed. Hence, they enumerated different reasons the private sector involves in irrigation, such as when there is a need to build new infrastructure which requires huge money that may not be afforded by government budget, the private sector is required to intervene and sign contract which improve the agriculture. Currently in Gashora sector and Mpanga sector, the private sector involves in irrigation provide several positive impacts to the development of the sector, through jobs creation, training and facilitating the farmers to get farmers filed schools which enhance their farming activities and irrigation in general. In addition, the role of government to ensure the sustainability of the irrigation includes, positive collaboration with private sector invested their money, allocating subsidies in seeds and fertilisers through Nkunganire system and reducing the taxes on the importation of the irrigation machines an equipment. Generally, the government benefit from the investors in agriculture through the cooperation of building the infrastructures hence, their citizens get jobs as well as developing their agriculture farming activities; and the private sector involvement also helps to extended area under irrigation. Meantime, the private sector investing in irrigation are still low, the local leaders appeal, those who think that agriculture sector is regarded as risky sector due to the disaster, pest and diseases which can ruin the harvest and difficulties encountered to get loans from bank, to analyse this sector as other business. They enumerated different strategies like digitising Nkunganire System, innovate by RAB together BK TecHouse, which will facilitate the farmers to get the subsidies on the selected crops and fertilisers and it is planned also facilitate the farmers to get loans from the bank. In addition, the crops insurance also program was initiated to improve agriculture and be regard like other businesses; the government also, planned to build enough feeder roads to facilitate easy transport of the harvest as well building small agro-food processing at each irrigation site and Post-harvest store at each cell.

CHAPTER 5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study assessed the implications of water policy on irrigation performance, in Eastern province of Rwanda. The study focused on the Kagitumba irrigation site of Nyagatare district; Nasho/Mpanga irrigation site of Kirehe district and Gashora irrigation site of Bugesera district. The specific objective of this study was to identify the effect of water use permit on irrigation performance; Assessing the roles of public private participation on irrigation performance; Evaluating the impact of Water Users Association on irrigation performance. Therefore, this study concluded that the water use permit issue to the different project as the water resources policy stipulates, is much more important to monitor the use of water resources in irrigation. The irrigation sites which have water use permit are much more organised and producing comparing to the other which do not have. In addition, the public-sector implication in irrigation performance development in Eastern province are much more appreciated. Through the trainings offered at each agriculture season, but the private sector implications are still not sufficient, to deliver to the farmers some services and training. The implication of the public sector, are favoured by WUA and the cooperatives which facilitate the payment of water use fees and the training on irrigation performance and water management. But the measurement of water used by the farmers is not suitable to moderate and facilitating the monitoring of water withdraw. Meantime some challenges encountered by the farmers are related to high cost of irrigation machines and unavailability of their spare parties on local market; disaster; energy source which is enough and high cost of fuel this slows down irrigation performance.

5.2. Recommendation

- Building food processing at irrigation site, this will increase the value of the crops harvested especially vegetables and horticultural crops.
- Install water meter at pumping station and monitor the quantity of water abstracted, in order to know exactly the quantity of water used.
- Avail the spare party of the irrigation machines on local market
- To conduct a further study to examine the feasibility of runoff water harvesting in the irrigation sites selected, as major alternative source of water in irrigation.

5.3. Proposed Solutions

Water Use

Abstraction of water from the lakes, and rivers may rise high competition among the water users and aquatic water bodies. Therefore, as Eastern province experienced much drought, this study is proposing the measurement of water abstracted from the lakes and rivers hence, recorded the data daily, this will facilitate the prediction and restriction where it is possible the use water in order to sustain the aquatic life. In addition to this, the WUA, need to get training on construction of valley dams and water harvesting from the roofs of their houses, this water may come as alternative source, this will reduce water abstraction from the lakes. In other words, the farmers need to construct big water tanks which may facilitate them to store much water which may facilitate them to irrigate their crops when there is some damage of the pumps.

Agriculture Development

Agriculture, development in Eastern province need also to be renewed, specifically on beans growing, as the farmers, invested much money in it, they have to improve the breeds of the beans. Mostly, the farmers grow the bush beans, and this type normally produce small quantity of harvest comparing to the climbing beans. Therefore, I am suggesting, to grow the climbing beans, this will help the farmers to increase the quantity of beans harvested. Without forgetting that, the stakes to support the beans may become, scarce, this study proposes, the use of string stakes and the trunks of maize harvested to be able to grow the climbing beans. In addition, for the horticultural farmers, most of the time, their harvest can be perished easily, hence, at each irrigation site, have to be built a small food processing unit, which may facilitate the reduction of quality loss of fruits and horticulture crops. As result, I am appealing the private sector to be implied in the construction of this food processing unit, hence the farmers pay a lump sum money which may facilitate the sustainability plan of the infrastructure built.

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APPENDICES

Appendix 1: Research Authorisation

REPUBLIC OF RWANDA

RWANDA AGRICULTURE BOARD
(RAB)
Office of the Director General
Kigali-Rwanda

Kigali kuwa 04/05/2018
Réf: N° 01.11/854/018/PK/H.Q

To: BIZUHORAHO Theobard
PanAfrican University,
Tleemen-Algeria

Dear Sir,

Subject: Response to your letter

Reference is made to your letter of 18th March, 2018 requesting for Authorization to carry out a research in partial fulfilment of the requirements for the award of a Master of science in Water Sciences Policy track, at Pan African University.

I'm very pleased to inform you that your request is accepted. The responsible staffs under LIM Department/RAB are requested to facilitate during the entire period of your data collection. RAB will be glad to receive a copy of your findings upon completion.

Wishing You success!

Patrick KARANGWA (PhD)
Acting Director General of RAB

P.O.BOX: 5016 KIGALI Website:www.rab.gov.rw

Appendix 2: Farmers' questionnaire

Implications of Water-Policy on Irrigation performance in Eastern Province of Rwanda

The implication of water policy on irrigation, allows to identify the physical inputs, human needs and institution efficiency that play a key role in agriculture and water management. This study, intends to collect the information about the implications of water policy on irrigation performance in Eastern Province of Rwanda. The study aims at identifying the effect of water use permit; assessing the role of Public Private Participation and evaluating the Impact of WUAs on irrigation performance. Therefore, the data will be used to fulfil MSc thesis in Water Policy, from Pan African University, in partnership with Abou Bakar Belkaid University of Tlemcen. In addition, the results will help the researcher to inform the water resources and Irrigation decision makers with evidence based on the impact of water resources policy on Agriculture development. In this regard, any creditable information related, will not be revealed. The data will be used for the purpose of this study.

A. INSTRUCTION: Use √ symbol to indicate the appropriate response's box.

B. DEMOGRAPHIC DATA:

1. Respondent Name: _____ (Optional)

2. Tel _____

3. Gender: i. Female ☐; ;ii. Male ☐

4. Level of education:

i. No schooling ☐ ; iii. 12YBE ☐

ii. Primary Education ☐ ; iv. University ☐

C. IRRIGATION PERFORMANCE

5. Which is the source of water do you use in irrigation?

i. Surface Water ☐ ; ii. Ground water ☐

iii. Harvested water ☐ ; v. other specify _____

6. What is the area of your irrigation land?_____

7. What are the major crops do you plant?

i. Maize ☐ ; ii. Rice ☐ ; iii. Other specify_____

8. How many kg of seeds do you sow per hectare/plot?

i. Maize _____ ; ii. Rice _____ ; iii. Others specify _____

9. What are the major types of irrigation that you use for watering your crops?

i. Surface irrigation ☐; ii. Sprinkler irrigation ☐

iii. Drip irrigation ☐; iv. Others specif _____

10. Is the source of water, that you use, enough to irrigate your crops? i. Yes ☐; ii. No ☐

11. If **No (10)**, what are the major causes?

i. Our crops do not meet available water ☐ ; ii. Drought ☐

iii. Water rationing and allocation calendar ☐ ; iv. Others specify _____

12. How do you recognize the appropriate time to irrigate your land?

i. I do it periodically ☐ ; ii. When the crops show the signs of water stress ☐

iii. When the soil surface is dry ☐ , iv. Others specify _____

13. How much yield do you get, when you get enough water for irrigation?

i. Maize _____ ; ii. Rice _____ ; iii. Others specify _____

14. How much yield do you harvest, when there is water shortage?

i. Maize_____ ; ii. Rice _____ ; iii. Others specify _____

15. What are the possible challenges that you face in irrigation?

i. Water allocation calendar ☐ ii. Infrastructures were damaged ☐

;iii. Lack of technician ☐v. High water use fees charge☐; v. Lack of training ☐

vi. Others specify _____

16. What type of information/Strategy do you think could improve better the irrigation?

i. Innovation of irrigation equipment ☐ ii. Reduce the irrigation price ☐

iii. Training on irrigation scheduling ☐ iv. Increasing the irrigation incentives ☐

v. others specify _____

D. Role of water use permit on irrigation performance

17. Is your source of water registered? i. Yes ☐; ii. No☐

18. If, **Yes (17)**, Where did you get your water use permit?

i. WUA☐; ii. Cooperative ☐ ; iii. District☐; iv. Other specify_____

19. How long does it take, to get the water use permit?_____

20. How long does it take to be expired? _____

21. Do you pay for water use fees charges? i. Yes ☐; ii. No ☐

22. If **yes**(21), how much money do you pay per year? _____

23. What is the main criteria is based on fixing the water use fees charges?

i. Land size ☐; ii. Crop type ☐ ; iii.UDEHE Categories ☐; iv. Others specify_____

E. Public participation in irrigation performace

24. How often do you get the training on water management in Agriculture?

i. Once Year ☐ ; ii. Once a season ☐; iii. None ☐ iv. other specify _____

25.Who train you? i.Private sector ☐ ii.GoR instutions ☐ iv.other specify _____

26. If there are some irrigation technical problems(failure of pumps and valves..), who involves in repairing and maintenance?

i.WUA ☐ ; ii. Farmer ☐; iv.Irrigation technician ☐

; v. Other specify _____

27. How do you pay for the maintenance and opearations fees of irrigation canals, equipment and structure?

i.Per head ☐ ;ii. Per WUA ☐ ;; iii. Other specify _____

28. What are the cultivation practises do you use? i.Hoe ☐;ii.Tractors ☐ iii.Bulls ☐

29. How do you measure the performance of your irrigation scheme?

i.Field topography measurement ☐ ii. Soil moisture determination ☐

iii.Water distribution in field ☐ iv.Pressure and Discharge sprinkler ☐

30. Do you record the data of irrigation harvest and its performance? i. Yes ☐ ;ii. No ☐

31.If **yes**(30), when do you record the data of your irrigation performance in your field?

i.At the end season ☐ ;ii.From the beginning season ☐ ;iii.other specify _____

32. What is the role of Agricultural extension in irrigation performance ?

i.To educate the cultivation practises in the field ☐ ; ii.To educate cropping syestem ☐

iii.To educate recommended agronomic practises ☐ ; iv. To educate irrigation scheduling ☐

33. What are the major factors do you consider when you are planning the cropping patterns?

i. Local consumption potential ☐ ; ii. Market aspect ☐ ; iii. Food security ☐

iv. Agronomic aspect ☐ ; v.Labour requirements☐ ; vi.Others specify_____

34.What is the role of private sector and stakeholders in irrigation performance?

i.Water resources assessment ☐ ;ii.Technical support☐ ; iii.Financial support☐

iv. Designing and construction of irrigation infrastructure ☐ ; v. other specify _____

F.Water Users Associations(WUA) for enhancing irrigation performance.

35.Are you a member of any Water Users Association? i. Yes ☐ ; ii. No ☐

36. When did you join that WUA? _____ Year

37. How do you benefit from the WUA?

i. Easily getting water subsidy ☐ ; ii. Farm management training ☐;

iii. Selling the harvest ☐ ; iv. Credits services from WUA ☐ ; v. Other_____

38. What are the main challenges you encounter in your WUA?

i. Ability to pay water use fees ☐ ii. High cost of irrigation machine& repairing ☐
Inadequate water distribution in the plot ☐

; iv. Lack of communication with the seniors ☐ ; v. other specify _____

39. How do you wish your WUA could improve its functionality for achieving sustainable water use in irrigation? _____

Thank you!

Appendix 3: Water Users Association Interview

Implications of Water Policy on Irrigation Performance in Eastern Province of Rwanda

The implication of water policy on irrigation, allows to identify the physical inputs, human needs and institution efficiency that play a key role in agriculture and water management. This study, intends to collect the information about the implications of water policy on irrigation performance in Eastern Province of Rwanda. The study aims at identifying the effect of water use permit; assessing the role of Public Private Participation and evaluating the Impact of WUAs on irrigation performance. Therefore, the data will be used to fulfil MSc thesis in Water Policy, from Pan African University, in partnership with Abou Bakar Belkaid University of Tlemcen. In addition, the results will help the researcher to inform the water resources and Irrigation decision makers with evidence based on the impact of water resources policy on Agriculture development. In this regard, any creditable information related, will not be revealed. The data will be used for the purpose of this study

A. Instruction:

. Use √ symbol to indicate the appropriate response's box.

B. Demographic data:

1. Name: _____ (Optional)

2. Tel _____

3. Gender: i. Female ☐; ii. Male ☐

C. Water Users Association (WUA) identification

4. Name of Water Users Association _____

5. What is your leadership position in WUA? i. President ☐ ; ii. V/P ☐; iii. Other_____

6. In which year your WUA was created? _____

7. How many WUA members do you have? i. Female _____ ; ii. Male _____

D. **Water User Association functionality**

8. What are the main water users categories do you have?

9. What are the main entry requirements for joining your WUA?

10. What are the main activities of your WUAs?

11. Do you hold water use permit? i. Yes☐ ; ii. No☐

12. If yes, which type of water use permit do you hold?

13. What are the major sources of conflict do you encounter in your WUAs?

14 Which means of conflict management within the water actors?

15. Who set the water use fees charges?

16. Does, the current water use charges fees appropriate for your WUA members?

i. Yes ☐ ; ii. N ☐

17. If No,

i. No (Too much money applies) ☐ ; how much money do you wish to pay per month?_____

ii. No (Too little money applies) ☐ ; how much money do you wish to pay per month?_____

18. Which method do you use, for collecting the water use fees charges?

19. Which means do you use for making advocacy to the high Government institutions and private sectors in charge of Water Resources and Agriculture?

20. How do you manage the water use fees charge?

21. What are the major challenges does your WUA face most of the time?

22. What is your suggestion, would you propose to the water decision makers for enhancing the irrigation performance?

Thank you!

Appendix 4: Irrigation Development Governmental Official's Interview

Implications of Water-Policy on Irrigation Performance, in Eastern Province of Rwanda

The implication of water policy on irrigation, allows to identify the physical inputs, human needs and institution efficiency that play a key role in agriculture and water management. This study, intends to collect the information about the implications of water policy on irrigation performance in Eastern Province of Rwanda. The study aims at identifying the effect of water use permit; assessing the role of Public Private Participation and evaluating the Impact of WUAs on irrigation performance. Therefore, the data will be used to fulfil MSc thesis in Water Policy, from Pan African University, in partnership with Abou Bakar Belkaid University of Tlemcen. In addition, the results will help the researcher to inform the water resources and Irrigation decision makers with evidence based on the impact of water resources policy on Agriculture development. In this regard, any creditable information related, will not be revealed. The data will be used for the purpose of this study.

1. In which circumstances there is a need for private sector involvement in irrigation development?
2. What is the role of Government in sustainability of public/ private partnership in irrigation
3. How do the people and Government in general, benefit from the private /sector investment in Agriculture?
4. What are the strategies the government plan to attract more investor in irrigation development in Rwanda?

Thank you!

Appendix 5: Krejcie and Morgan Sample size determination table of known population

Table for Determining Sample Size of a Known Population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*

Source: Krejcie, et al, 1970