The Right Of Use And Economics Of Irrigation Water In Uganda: A Comparative Analysis Of Small Scale Irrigation Schemes In Eastern, Northern And Western Uganda

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ABSTRACT

This study was conducted on the right of use and economics of irrigation water for small-scale irrigation schemes in Eastern, Northern and Western parts of Uganda to examine the extent to which irrigation is accessible to farmers and the economic returns from irrigation water. The specific objectives were to examine the profitability of using irrigation water in Uganda, to assess the sustainability of small-scale irrigation schemes in Uganda, to identify the factors influencing productivity of irrigation water in Uganda, to identify the factors influencing farmers" willingness to pay for Irrigation water and to determine the implications of water user rights and costs on adoption of irrigation in Uganda. This study used a cross sectional research design in which data from respondents were collected at a single point at a time whereby both purposive and cross-sectional data collection approaches were adopted. A systematic random sampling procedure was used to select the desired sample size from the study area. Purposive and simple random sampling was employed for key informant personnel who are stakeholders Data were analyzed using both SPSS and STATA software. The results indicated that the net returns per year from two sites namely Bukatabira and Andibo SSISs are 121,306,920 and 34,730,684 shillings for tomato and watermelon respectively at Bukatabira SSIS while at Andibo SSIS the net returns are 50,416,800 and 200,802,000 shillings for tomato and water melon respectively. This means tomato is more profitable in Bukatabira SSIS than watermelon while watermelon is more profitable at Andibo SSIS than tomato. Sprinkler and drip irrigation were found to be more water-saving, cost effective and efficient compared to other methods of irrigation for example surface or furrow irrigation systems. The values of BCR clearly indicate that tomato crop is most suitable at Bukatabira SSIS while watermelon is most suitable at Andibo SSIS with the current production systems. The analysis also revealed that investment in five crops grown at Bumusse SSIS is not economically viable. Out of the eleven explanatory variables, four such as education level, off farm income, credit access and rainfall reliability were statistically and significant at 1% level to influence the farmers" willingness to pay for irrigation water in study area. The results also indicated that the water user rights and costs have positive implications on adoption of irrigation water in Uganda and significantly contributed to different factors such as price of water for irrigation, extension services, access to agricultural information, off farm production, cooperative membership, training opportunities, personal savings, contribution for operation and maintenance and high agricultural productivity.

1. INTRODUCTION

This study investigated the economic viability of Uganda‟s small scale irrigation schemes and the feasibility of water markets in Uganda.

In Uganda, unlike other East African countries specifically Kenya and Tanzania, the adoption and development of irrigation was first observed in Karamoja sub region in 1948 where a significant public investment was directed towards the construction of flood diversion structures and round bunds to enclose floods in the fields and ensure infiltration (Carruthers, 1970). In 1952 much more complicated irrigation system comprising of dams and channels was developed in Agoro in northern Uganda in 1952 (Adams and Anderson, 1988). However the most significant development in irrigation was seen with the construction of the Mubuku irrigation project on Lake George Flats that started in 1960 although by 1970, the scheme had not yet achieved its commercial viability.

The first Private scheme establishment was at Kakira sugar estate in Busoga in 1956 where 100 acres were irrigated using sprinkler and 50 acres using furrows although with time sprinkler irrigation proved more efficient due to the uneven topography thereby abandoning furrow irrigation method in 1958 (Carruthers, 1970).

1.1.2. The economic viability of Uganda's Small scale Irrigation Systems

Considering the last comprehensive National Agricultural Census conducted between 2008 and 2009 by Uganda National Bureau of Statistics (UBOS); the Uganda Census of Agriculture (UCA) Volume 3 reported that Irrigation was being practiced by only 0.9% of the approximately 3.600.000 Agricultural Households that responded implying that agriculture was predominantly rain-fed. Eastern region registered the highest number of Agricultural Households with 53.5% of all households surveyed.

Table 1: Number and Percentage of Agricultural Households that reported Presence of Irrigation on the holding by Region

Region	Ag HHs	percent
Central	5,492	17.5
Eastern	16,784	53.5
Northern	2,776	8.9
Western	6,305	20.1
Uganda	**31,357**	**100**

Source: National Agricultural Census 2008-2009; Uganda National Bureau of Statistics (UBOS); the Uganda Census of Agriculture (UCA) Volume 3.

The total land being irrigated was about 7,000 Hectares and the most dominant method of irrigation used was Localized irrigation that constituted 73.9% of the total irrigated land. Shallow wells were the most commonly used source of water for irrigation of the eight categories of irrigation water sources. Out of the 0.9% of households practicing Irrigation, only 0.11% were paying for agricultural water usage. The three Payment methods for Irrigation water identified were Water Fee per Hectare, Water Fee per Volume and Other form of payment (UCA, 2008/09).

Development of Large scale Irrigation Schemes in Uganda have been hindered by land acquisition snags, high capital investment that an individual farmer cannot afford and there is limited capacity for planning, designing and construction of Large scale Irrigation Schemes. In response to these challenges, government through ministries responsible for providing water for agricultural production are constructing localized Small-scale Irrigation Schemes to reduce government‟s financial burden of setting up large-scale schemes and farmers‟ burden of operational and maintenance. As such developments are on-going in the irrigation sector, answers to key questions needed to be found, questions such as: Are farmers able to pay for irrigation services with their production systems? Are farmers willing to pay for irrigation water?

This expresses the importance of having an idea of the value attached to irrigation water.

1.1.3The feasibility of water markets in Uganda

Globally, irrigation activities were seen to expand significantly in the 20th Century especially the post-World War II era (Schoengold and Zilberman, 2007). This was further accelerated by continued demand for food to take care of the continuously growi0ng populations and the increasing competition for water among valuable economic sectors combined with the implications of global climatic change on irrigation observed through changes in hydrology (Turral et. al). Due to this growing demand for quality irrigation water, user rights must be defined to accommodate the interest of crop producers while considering the economic value of the water.

The first Dublin guiding principle recognizes water as a finite and vulnerable resource while the fourth Dublin guiding Principle describes water as an economic good (GWP, 2018). In addition, FAO is aware of the importance of water in agricultural and food production. According to FAO, globally, irrigation continues to be the main water user despite the increases in water use by other sectors hence agriculture is responsible for about 70 percent of all freshwater withdrawals worldwide (FAO, 2018). This therefore calls for sustainable management of the water resource considering its vital socioeconomic importance.

1.1.4 Water rights in Uganda

According to the National Objectives and Directive Principles 13 and 21 of State Policy (1995), the state shall: "take all practical measures to promote a good water management system at all levels" and "protect important natural resources, including land, water, wetlands, minerals, oil, fauna and flora on behalf of the people of Uganda"

The Water Action Plan (1995) is a framework that outlines policy options and guidelines for the protection and development of Uganda's water resources as well as recommends a structure for their management. The Uganda Water Action Plan (WAP) adopted and operationalized the guiding principles for water resources management as they emanated from the Dublin-Rio de Janeiro (UNCED) process and Agenda 21's Chapter 18 on freshwater resources. The W AP adopted these guiding principles recognizing: (i) freshwater as a finite and vulnerable resource, essential to sustain life, development and the environment, (ii) management of water resources, at the lowest appropriate levels, (iii) the role of Government as an enabler and in a participatory, demand-driven approach to development, (iv) the recognition of water as a social and economic good, (v) the integration of water and land use management, (vi) the essential role of women in the provision, management and safe-guarding of water" (vii)-the important role of the private sector in water management.

The National Water Policy (1999) in respect to water for agricultural production is intended to promote the development and efficient use of water in Agriculture in order to increase productivity and mitigate effects of adverse climatic variations on rain-fed agriculture, with full participation, ownership and management responsibility of users.

The Water Act (1998), Cap. 152.; provides for the use, protection and management of water resources and water supply in Uganda. The water act lays out procedures for acquiring water permits for specific water usage of water resources in the country. A fixed charge or fee determined by Minister or Director in charge must be paid by the applicant of the water permit depending on the source and amount of water to be abstracted. The fixed fee or charge shall be in accordance with pricing policies established by the water action plan or other policy as may be determined by the government. The water permit holder has the legal rights to use water in accordance with the terms of reference stipulated. In the event that the holder of the permit fails to comply, the permit is cancelled with procedures stated in the act. Water permits have been issued for private commercial farmers, construction companies, industries, among other users.

The Water Statute (1995) provide for the use, protection and management of water resources. The objective of the Statute in relation to Agricultural productivity is to allow for the orderly development and use of water resources for watering of stock, irrigation and agriculture in ways which minimize harmful effect to the environment.

The National Environment Management Policy (1994) and Statute (1995) take account of the key policy objective on water resources conservation and management; to sustainably manage and develop 'the water resources in a coordinated and integrated manner so as to provide water of acceptable quality for all social and economic needs.

1.2. Statement of the Problem

Effects of global climate change on crop production is alarming; in the year 2010, drought accounted for 38% loss in beans production and 36% loss in maize production while in 2014, Uganda registered Uganda shillings 2.8 trillion loss of Gross Domestic Product (GDP) equivalent to 8% and 87% loss to agro-based industries (Mwaura et al 2014). Despite the low agricultural crop production being realized in most parts of Uganda as a result of relying on rainfed agriculture, farmers have shown laxity in adopting irrigation yet the country has a huge irrigation potential that is evident with numerous fresh surface water sources consisting of lakes, rivers and swamps covering over 15% of her total surface area; on the contrary the ratio of cultivated area under irrigation to the irrigation potential is only 0.5%.

Table 2: Area Irrigated according to Method of Irrigation

Region	Surface	percent	Sprinklers	percent	Localized	percent
Central	69	4.6			892	17.6
Eastern	1,283	84.1	127	37.0	3,021	59.7
Northern	151	9.9			454	9.0
Western	22	1.4	216	63.0	690	13.7
Uganda	**1,525**	**100.0**	**343**	**100.0**	**5,057**	**100.0**

Area (Ha) Irrigated according to Method of Irrigation. (Source: National Agricultural Census 2008-2009; Uganda National Bureau of Statistics (UBOS); the Uganda Census of Agriculture (UCA) Volume 3).

This has resulted into low crop production, low and unstable incomes and consumption of farmer households, food insecurity and vulnerability to weather and climate events.

Uganda‟s Vision 2040 drafted primarily to achieve a transformed Ugandan society from a peasant to a modern and prosperous country within 30 years is emphasizing commercialization of agriculture by encouraging adoption and use of cost effective technologies such as drip irrigation indicated in the National Irrigation Policy to maximize production and achieve efficiency and long-term environmental sustainability, social and economic benefits for Ugandans from water. On the other hand, this water is only free for citizens who occupy or are residents on lands where there is water and they must use this water for domestic use, fighting fire or irrigating a subsistence garden only and not for any commercial purpose (The Water Act, Cap. 152.). The Act requires farmers interested in small scale irrigation systems to quantify and pay for irrigation water amounts sufficient for production.

To better understand this gap in adoption of irrigation, this study intended to answer the following questions: To what extent has water rights and costs hindered the farmers from actively undertaking irrigation? Does the revenue from small scale irrigated agriculture outweigh the overall cost of production by farmers? To what extent are the established irrigation schemes/facilities sustainable? These were answered by undertaking a comparative analysis of existing irrigation projects in Eastern, Northern and Western Uganda that have demonstrated differences in the level of adoption in order to assist authorities responsible for small-scale irrigation water pricing and establishment of small-scale irrigation schemes to better plan and implement irrigation projects.

1.3.Research Objectives

1.3.1 Main objective

The main objective of this study was to examine the right of use and economics of irrigation water using a comparative analysis of small scale irrigation systems in Eastern, Northern and Western Uganda.

1.3.2 Specific objectives

More specific objectives of the study were to:

1. Examine the profitability of using irrigation water in Uganda.
2. Examine the sustainability of small-scale irrigation schemes in Uganda.
3. Investigate factors influencing productivity of irrigation water in Uganda.
4. Determine farmers" willingness to pay for Irrigation water in Uganda.
5. Assess the implications of water user rights and costs on adoption of irrigation in Uganda.

1.3.3 Research Questions

1. Is using irrigation water profitable in Uganda?
2. Are small-scale irrigation schemes sustainable in Uganda?
3. What factors influence agricultural productivity in Uganda?
4. How much are Ugandan farmers willing to pay for irrigation water?
5. To what extent has water use rights and costs hindered adoption of irrigation in Uganda?

1.4. Scope of the study

1.4. Content Scope

This study was carried out on small scale irrigation schemes constructed by Ministry of Water and Environment specifically Water for Production department through its regional centers East, North and West. 16 SSIS that possessed differences in land sizes, types of irrigation, types of enterprises and water sources were chosen for study.

1.4.2. Time scope

The study was conducted during the rainy season in most parts of the country; this was due to the timing of the study but the data collected were showing results of revenue generated from farming activities carried out in the dry season.

2. LITERATURE REVIEW

This chapter comprises of three sections; section 1 gives the global, continental and regional scenarios of irrigation water use rights, section 2 provides key economic definitions, concepts, issues and definitions, section 3 highlights on different techniques used in estimating irrigation water productivity and value.

2.1. Irrigation water rights

Water right is the legal right to abstract or divert and use or store a quantified amount of water from a natural source or the legal right to use water in a natural source. Water right is different from the "right to water" - a presumed human right which is demanded to be existent in one way or the other as a right in itself or as a supplementary aspect of the "right to food" created by article 11 of the International Covenant on Economic, Social and Cultural Rights which stipulates that everyone has a right to an adequate standard of living for himself and his family including adequate food, clothing and housing. "Right to water" was developed in General Comment 15.

Property rights can be defined as "the claims, entitlements and related obligations among people regarding the use and disposition of a scarce resource" (Furubotn and Pejovich 1972). Bromley (1992:4) points out that "Rights have no meaning without correlated duties on aspiring users to refrain from use." This means that property rights are not a relationship between a person and a thing, but are social relationships between people with relation to some object (the property). Particularly in the case of water, rights also have corresponding duties that apply to the rights holder usually to use the water and dispose of wastes in a certain manner, and often to provide money, labor, or other resources to maintain the water supply.

Water rights being one of the many forms of property rights need to be secured. Property rights are important since in most treatments of property rights, these types of rights are contrasted with open access situations in which anyone has unrestricted use of the resource. There are no specific rights assigned to anyone and no one can be excluded from using the resource. It is the lack of rules in open access that is seen as contributing to the "tragedy of the commons," wherein resources degrade because of lack of control over their use or incentives for investing in its provision (Bromley 1992). Hence effective property rights need to be secured for the following reasons;

Efficiency: Property rights are required to provide incentives to invest in a resource. For water, this repeatedly means developing and maintaining water infrastructure such as wells and or irrigation canal.

Environmental protection: Property rights provide incentive to protect the resource, and without property rights that are enforced, resources often become degraded.

Equity: Distribution of the resource in terms of equality of access, particularly for meeting basic needs, or in terms of distribution of rights in proportion to investment that people make or both. Establishing effective property rights is costly, in cases where a resource is abundant, there is little incentive or need to define rights over it, but with increasing demands and scarcity, there is pressure to define rights (Alchian and Demsetz, 1973).

As with other types of property rights, water rights can be broadly classified as public, common, or private property, according to who holds the rights, and particularly, the decision-making rights of allocation, which lie at the heart of water rights (Pradhan, Rajendra&Meinzen-Dick, Ruth. 2003; Paul 2003).

Water legislation offers a variety of exemptions for activities that would otherwise call for a water right. This may be done by reference to the quantity of water used, the nature of activity, or both.

In Saskatchewan Province (Canada) the exemption comes from the dimension of the plot to be irrigated.

In Spain for example, such uses are termed as “common uses” and these include the use for drinking, bathing, livestock watering and other domestic purposes.

In Wales and England an exemption for water withdrawals up to 20 cubic metres per day was suggested yet this lacked a pronounced theoretical account for exempting such uses from recognized water rights systems. The legislature makes judgment by taking into account the increased financial and administrative liability of making such uses be part of the formal framework, their value to different users and their overall effect on the water resources balance.

In many parts of the world, water is allocated using a “queuing” system (Easter & William,

1986). Two commonest types of queuing systems are prior appropriation system and riparian rights system. Prior appropriation system is centered on the principle of “first in time, first in right”. Priority in is given to the first person to abstract or divert water for beneficial use. Riparian rights system gives property-owners with land adjacent to the water source rights to use that water. (Tiwari et al., 2000).

There are economic restrictions to the public acquisition of water rights in a trading system when cultural and social objectives are required. The small farmers are time and again victimized as they encounter complications in obtaining shares and trading them. In such circumstances, regulatory procedures to safeguard the smallholders' rights may be required. (Howe 1996). In the western states of United States of America, the “prior appropriation” principle applies. Water rights are still created by operation of law; although mostly created on the basis of legal instruments issued by the state agencies responsible for water resources management. Such instruments are variously termed in legislation as “consents”, “concessions”, “authorizations”, “licenses” and “permissions”.

These water rights are established on the notion of the hydrologic cycle; water in its natural state is in constant motion, therefore water rights cannot be given or controlled in isolation to other activities involving watercourses. This makes the flow of water along a water course to be an important component of a water right therefore the need for maintaining a minimum flow of water in the river or canal system for sustaining downstream users to avoid exploitative situations especially where large landowners could dominate the water rights and in periods of drought.

In Mexico, water users are granted rights for water use and use of irrigation infrastructures through Water Users‟ Associations (WUAs). Water users needed to be provided with certainty in user rights by forming a Public Registry of Water Rights and allow transmission of the rights amongst users of the same basin or amongst those who use water from the same source or aquifer (Klozen, 1998).

In Chile‟s tradable water rights systems, a right-holder can transfer that water to others through sale or lease.

In New Zealand, the National Water Act provides for fixing quota system for water abstraction for irrigation purposes. For instance, within the Riet River and the tributary; the Modder River downstream of the Krugersdrift dam, the Act outlines the necessity for restricting up to 35% of the full quantity of water delivered from the Krugersdrift dam (National Water Resources Department, New Zealand).

In Ukraine water is a public asset where the state institutions have the right over them. The Water Code of Ukraine controls the normative structure of water rights. The procedure for getting water rights is complex, costly and bureaucratic. 12 different documents matched by different institutions have to be presented by water users prior to getting a license (Pavlov, 2004). This is extremely difficult for small farmers to manage since each document has to be paid for. Therefore farmers form associations to use one „water right" license in a bid to minimise costs. Water rights are issued for periods up to 25 years according to the Water Code but in practice the period is however only 1 to 3 years. In this kind of situation farmers fail to make long-term strategies and investments in irrigation systems.

In Indonesia, no particular model of water resources distribution is entirely applied in the country. Traditional law controls in certain locations and statutory law prevails in others. Natural resources are governed by the State in public trust for the people according to Article 33 of the Basic Constitution. Water allocation precedence starts with drinking water, followed by agriculture, and lastly energy according to Law No. 11 (1974). Indonesian Water Law of February 2004 makes a distinction between basic or non-commercial usage rights and commercial exploitation; this law also highlights unusual consideration on the water rights for 'traditional communities'.

In China specifically Tejinin province, quota system for water allocation is well-defined and apportioned based on crop water requirements per unit of agriculture area. The agreement of rational irrigation quota for crops allotted for the eight river basins and regions in the province are centered on estimates of effective rainfall, run-off, potential water deficits and crop water requirements.

The diversity of water law is further increased in many places in Africa because each of these types of law especially state, customary, and religious may themselves be plural. In most African customary water law, water is considered as a community property and private ownership of water is not recognized (WFP, 2001).
Rights are often grouped into two broad categories: use rights of access and withdrawal, and decision-making rights to regulate and control water uses and users, including the rights to exclude others, manage the resource, or alienate it by transferring it to others (Schlager and Ostrom 1992).

While the exact definitions of these rights vary from place to place, there are several common elements in water law in Africa:

1. The state generally claims some kind of ultimate "ownership" rights over water, which may not be felt at all at the local level, or it may require that individuals or groups who want to use or develop a water source need to get some kind of permission from the state.

2. There are widespread notions that anyone is entitled to water for "primary uses," which are usually interpreted as basic domestic needs, as well as household gardens, but may include other productive livelihood needs. Islamic law has formalized this as a "right to thirst" for people and animals.

3. Although there are individual use rights in Africa, private water allocation rights are not widespread. There are some sources such as wells or small springs which are considered private, in which the right holder has the right to allocate water from that source.

In Egypt, there is no charge for irrigation water in the Nile Valley and Delta (Hamdy et al., 1995; Attia, 1997). Farmers on traditional, below-grade tertiary canals (mesqas) must lift water about 1 to 2 metres at their expense, but the water is free, and no funds are collected for operating and maintaining the main delivery system (Ward, 1993; Nassar et al., 1996). There are no restrictions on the volume of water entering drainage canals (Ward, 1993) and farmers are not charged the variable cost of providing drainage services (Okonjo-Iweala&Fuleihan, 1993).

In Nigeria, „the Water Resources Decree of 1993 vests in the Federal Government the right to the use and control of all surface and groundwater and all water in any water-course affecting more than one State, for the purpose of promoting the planning, development and use of the country‟s water resources; coordinating the distribution, use and management of water resources; and ensuring the application of appropriate standards for the investigation, use, control, protection, management kind administration of water resources‟ (Kuruk, P., 2005). Under section 2 of the Water Resources Decree, any person may (i) take water without charge for his domestic purpose or for watering his livestock from any water course to which the public has free access; or (ii) may use water for the purpose of fishing or for navigation to the extent that such use is not inconsistent with any other law for the time being in force; or (iii) who, has a statutory or customary right of occupancy to any land, may take and use water from the underground water source or if abutting on the bank of any water course, from that water course, without charge for domestic purposes, for watering livestock and for personal irrigation schemes. The authority of the Minister for Water Resources to control groundwater use includes the power to define the time, places and manner in which water may be taken or used; to fix the amount that may be taken in times of shortage; to prohibit the taking or use of water for health reasons; to regulate the construction and operation of boreholes; and finally to revoke a right to use or take water in the public interest. In the discharge of his statutory duties, the Ministry is required to make proper provision for adequate supplies of suitable water for domestic, and non-domestic use; the watering of animals, irrigation, agricultural purposes as well as the generation of hydro-electric energy for navigation, fisheries and recreation.

In Ethiopia, water rules came into action recently, but prior to this the people were using water customarily and even as of 1987 it was still being observed in many parts of the country (Ewnetu 1987). The Ministry of Water Resources formulated a water policy having the irrigation component both at Federal and Regional level, basing on the Agricultural Development Led Industrialization Policy (ADLI) of the country (MoWR: 1999). The overall objective of the policy was to develop irrigated agriculture for production of food and raw materials for agro industries. As of the year 2002, Ethiopia did not yet have a single body of rules relating to the use rights of and management of water resources (Yacob 2002). This was also later reported in the year 2004 (Lemma 2004). Additional studies conducted by FAO in 2005 reaffirmed that there is no extensive legislation covering the use of water in Ethiopia although there are decrees that water is a national asset and that it can be controlled only by the central government (FAO, 2005).

In South Africa during the apartheid era, state water law was based on the English common law principle, which gave use and control rights over water to those who owned the overlying land. The new government reformed water rights through the National Water Act (Act 36 0f 1998). This Act declared that the state is the guardian of all water resources in South Africa, but it also incorporated the African customary view on water rights by declaring water to be a public resource that belongs to the whole nation and needs to be available for common use by all South African citizens. All water required for basic human needs like drinking is guaranteed as a right (RSA 1998; Perret 2002). Under this act, people cannot own water but can be granted water use rights through a licensing system, which require users to pay for it. The money generated from water use charges is used for water service and management costs (Farolfi 2004,Tewari 2002)

In Zimbabwe"s water reform of 1990s, it was declared all the water to be the property of state. People can get water rights through acquiring water permits, which gives them legal license to use but not own water. Water permits are issued in consideration of the needs of the applicant and the expected benefits of the proposed water use (Latham 2000, Mtisi and Nicol, 2003).

In Mozambique, the Water Act of 1991 regards water as a public good. People cannot have private ownership of water sources but can obtain rights to use water by acquiring a water license (Vaz and Pereira, 2000). Water licenses are granted for a period of 5 years and are renewable. The use of water for primary needs like small irrigation, domestic use, watering the livestock, is free.

In Botswana, people do not need to acquire water rights if they are using the water for domestic purposes or for watering livestock. However, people are required to obtain water rights if using the water for irrigation or commercial purposes.

According to the Ugandan National Irrigation Policy, a lot of complexities exist in land user rights. These are in the form of land access, security of land rights, dammed water and wetland use limitations are the most common unsolved issues. Exclusive water user rights for irrigation or hydropower dams have been a limitation in reaping benefits of integrated water resources management and use could have led to a rapid irrigated agricultural development. Therefore these national water and land user rights together with riparian water sharing agreements have affected the desirability for investment in irrigated agricultural development.

2.2Key economic definitions, concepts and issues

Willingness to pay:Willingness to pay for irrigation water is defined as the maximum amount of money a farmer is willing to pay for water used in irrigating a farm. The method of determining a farmers" willingness to pay for irrigation water is detailed in the questionnaire. Willingness to pay survey results are presented graphically to show the values" distribution for a range of collected responses.

Expressed willingness to pay:Maximum amount that a farmer expresses that he or she is willing to pay for irrigation service, typically registered in monetary units per season/year, in response to a specific question

Economic benefit:Increased benefit that a farmer could receive from a proposed project compared to his or her present situation. In the case of an irrigation project, it indicates the attributed benefit of the irrigation water service in monetary units, versus the current rain fed agricultural production.

Economic analysis:Shows the economic feasibility of a project, from the perspective of the farmer as well as that of the country.

Financial analysis:Illustrates whether the project will be profitable or not, from the viewpoint of the water utility that will implement and operate the irrigation system.

Economic benefit:Increased benefit that a farmer could receive from a proposed project compared to his or her present situation.

Demographic study: The study of the project"s target population (farmers) to identify and determine distinct features that would affect project feasibility.

Demand study:In the context of an irrigation project, this study determines the demand for an irrigation service in terms of number of users, size of plots/farms and market availability. A future demand projection for an irrigation project should be considered.

3. RESEARCH METHODOLOGY

3.1. Introduction

The net economic contribution of irrigation water to the value of agricultural production is termed as productivity. The cost of provision and the net value of irrigation water is of great importance to the farmers and the proprietors of the irrigation schemes. Income distribution theory emphasizes that each factor of production should receive a share of production income equivalent to the contribution made by each factor, therefore the value of a resource used in production should be within the farmers" ability to pay (Bronfenbrenner, 2007)). For instance, effecting cost recovery plans for irrigation projects greatly depends on the realistic estimates of the productivity of irrigation water which gives vital evidence on the ability of farmers to pay for irrigation services hence sustainability. This chapter provides the methodology used in the study.

3.2. Research design

In this study, a social survey was conducted whereby a cross-sectional research design was used in which data from respondents were collected at a single point at a time; both purposive and cross-sectional data collection approach were adopted. The population of interest constituted of farmers growing vegetables in SSISs. A systematic random sampling procedure was then used to select the desired sample size from the study area. The area of study was purposively chosen because the area is among the few areas where SSISs are found.

3.3.Study population

The respondents were farmers in capacities of individual/model farmers and farmer groups who have been actively engaged in farming activities in SSISs for a minimum period of 6 months. The farmers comprised of male and female youths, adults and elders. Farmer group sizes ranged between 10 and 330 members

3.4.Sampling Procedure and Sample Size

The multistage sampling technique was employed in this study. The first stage was the purposive selection of small-scale irrigation schemes in Eastern, Northern and Western Uganda where MWE has established WfPRCs that are in charge of these SSISs. In the second stage, respondents were randomly selected to make a desired sample size. Data was collected with the use of structured questionnaires to obtain information on farmers‟ socio-economic variables, farm size (ha), cost of inputs, output and value of output for the previous farming seasons.

Table 3: Category and number of respondents sampled and interviewed

Category of respondents	Numbers interviewed	Sampling Techniques
Individual farmers using small-scale irrigation systems	46	Simple Random
Farmers groups using small-scale irrigation systems	64	Simple Random
Scheme management committees	16	Purposive
Scheme agronomists	16	Purposive
Irrigation engineers	15	Purposive
District agricultural officers	1	Purposive
District water officer	1	Purposive
District commercial officer	1	Purposive
Irrigation engineers at MWE	10	Purposive
Sociologists at MWE	11	Purposive
Farmers who have fallen out of the schemes	2	Snowball
Farmers who haven‟t joined the schemes	1	Simple Random

3.5.Source of data collection

Forty six (46) model/individual farmers and sixty four (64) farmer groups from sixteen SSISs were selected for study to represent the diverse characteristics of these Small scale Irrigation Schemes in Uganda. To create a wider information base, the schemes selected were from more than one region and district. The schemes selected showed diversity in types of irrigation systems (pressurized, gravity); sources of irrigation water supply (wells, rivers and streams, lakes and swamps); types of crops grown (watermelon, tomato, cabbage, eggplant, green pepper, okra and onion); farming systems (commercial, subsistence, or both); scheme farming systems (individual/model farmers and farmer groups); land user rights (free, owned and rented) and cost of renting irrigated farming plots (ranging from 50000-200000 per plot) among other parameters.

Surveys were conducted in the sixteen functional irrigation schemes (sites). The purposes of these surveys were to evaluate the social, economic and technical statuses at individual plot and scheme levels, these helped in computing economic statistics. Individual farmers were interviewed in each of the selected schemes; focused group discussions were conducted for scheme management committees and key informant interviews for irrigation engineers, sociologists and agronomists attached to the selected sites to obtain vital and general information about each of the schemes. Well-structured questionnaires were used to interview the farmers. The information captured in the individual farmer questionnaire included household characteristics, plot sizes, enterprises chosen, agricultural inputs used, monetary returns from farming, irrigation water management, cropping systems, other sources of income, and sources of credit, market access and challenges being faced in the scheme. The farmer group questionnaire had group size, sex distribution, enterprises chosen, returns from farming and group registration as the main areas of interest.

3.5.1Primary data

3.5.1.1Questionnaires

These were employed to capture data from two farmer sections; individual/model farmers and farmer groups. The individual/model farmer questionnaire was more comprehensive compared to the one of the farmer group.

3.5.1.2Interviews

These were conducted for key informant persons such as scheme agronomists, scheme sociologists, district agricultural officer, district water officer, district commercial officer, Environmental officers and Irrigation Engineers at MWE.

3.5.1.3Focused group discussions

These were conducted for scheme management committee members to ascertain the mode of operation of their various schemes and also for farmer groups" representatives.

3.5.1.4Observations

Key observations were made on the components of the irrigation schemes, water meter readings, type of crops grown, topography and the general environment.

3.5.1.5Photography

This provided empirical evidence/information obtained in the field for interpretation by the researcher and consumption by the general public.

3.5.2Secondary data

Secondary data obtained was from unpublished data sources that were collected from individuals and public offices.

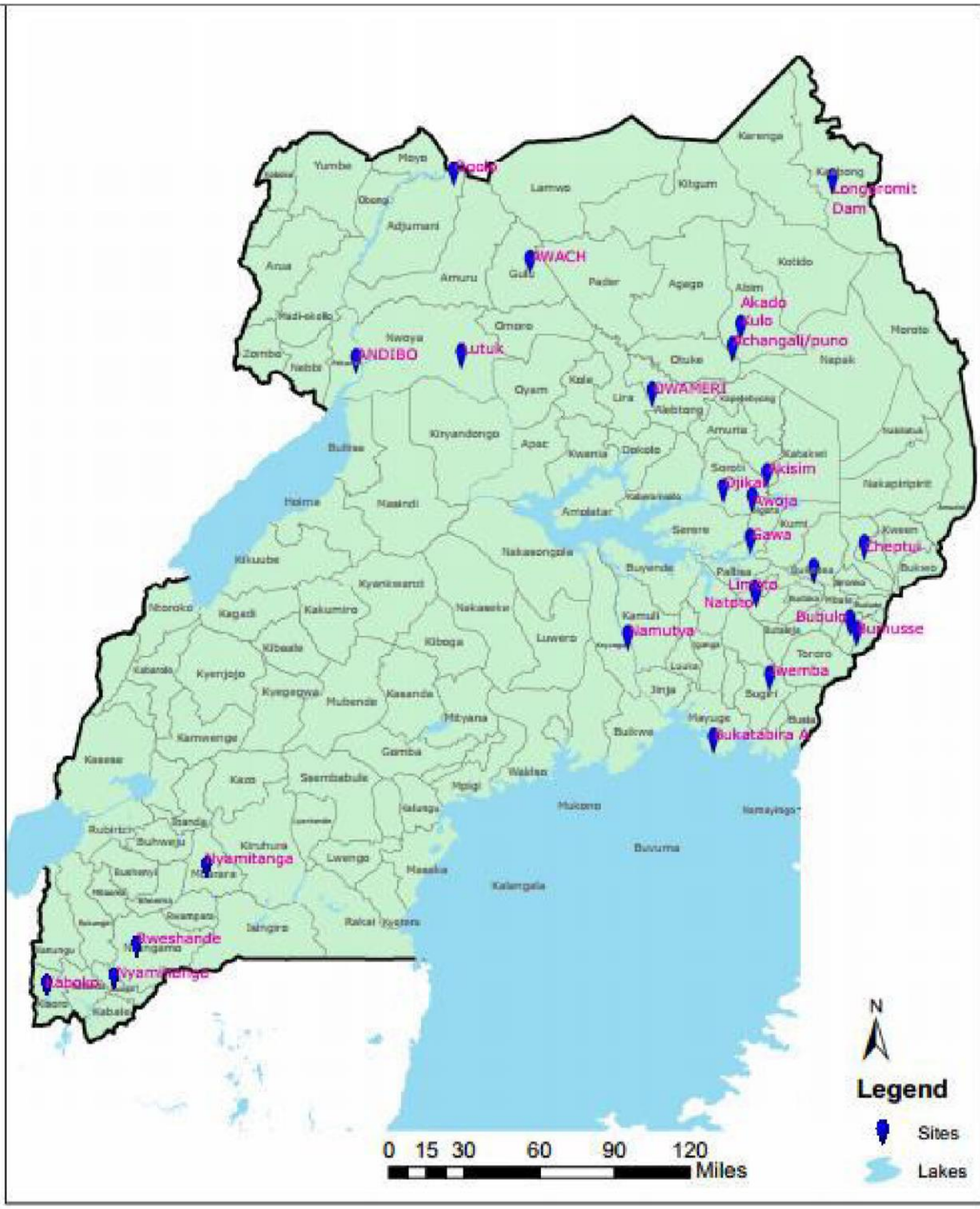

Figure 1: Map of Uganda showing selected SSISs

3.6Data processing and analysis

Data collected were analyzed using descriptive statistics, gross margin analysis and quantitative methods. Descriptive statistics such as mean, frequency, percentage count and standard deviation were used to analyze socio-economic characteristics of respondents in the study area.

Gross margin was used to analyze the profitability level of SSISs. For this analysis; the net profit was obtained by:

Net Profit = (Gross returns – Cost of production) ……………...……………………………… (i)

For this analysis the initial cost of the project was not considered.

Net Present Value was used to analyze the sustainability and viability of SSISs; this is given by the following expression:

$$NPV = \left(\sum_{t=1}^{n} \frac{Net\ Cash\ Inflow_t}{1+r^{\ t}}\right) - Initial\ Investment \text{ ………...…………………………….. (ii)}$$

Where; NPV = Net Present Value t = time in years r = R/100

R = interest or discount rate

N = number of periods or years

Or;

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{1+r^{\ 2}} + \frac{C_3}{1+r^{\ 3}} + \frac{C_t}{1+r^{\ t}} \text{ …………………………………………...…… (iii)}$$

Where; $-C_0$ = Initial investment

C = Cash flow

r = Discount rate

t = Time

Ordinary Least Square (OLS) regression analysis was carried out to determine the factors influencing productivity of crops grown in schemes and factors influencing farmers‟ willing to pay water for irrigation as well as the implications of water rights and costs on the adoption of water irrigation system in the study area. In order to draw conclusion, data collected from the primary source and the analysis of quantitative data were done with the aid of two softwares namely SPSS version 20 and STATA version 13.0.

3.7Model Specification

The production function analysis was used in four functional forms from which the lead equation was chosen based on the values of the coefficient of multiple determination (R^2) as well as the signs and significance of the regression parameters. This was stated explicitly as;

Y=*f*(X1, X2, X3, X4………………………………………………………, u) ………...….. (iv)

Where;

Y = Total output of crop grown (Kg)

X1 = Land size (ha)

X2 = Labour source (man/hour)

X3 = Family size (number)

X4 = Gender (1=male, 0=female)

X5 = Age (years)

X6 = Education level (years)

X7 = Fertilizers (kg)

X8 = Irrigation system (1=yes, 0=no)

X9 = Volume of water (m^3)

X10 = off farm income (1=yes, 2=0)

X11 = Price of produce (1=high, 0=low)

X12 = Distance to Market (km)

X13 = Agricultural credit (1=yes, 0=no)

X14 = Farming experience (years)

X15 = Extension Service (1=yes, 0=no)

X16 = Cooperative membership (1=yes, 0=no)

U = Error term

Profitability was estimated using gross margin analysis, which is the difference between total revenue (TR) and the total variable cost (TVC). This is illustrated as;

GM=TR-TVC
Where;

GM =Gross margin

TR = Total Revenue =P.Q (P=Price, Q=Quantity) TVC **=** Total Variable Cost

3.8. Model justification

Different models have been proposed in econometrics for estimating adoption processes. The most common include the linear probability, Tobit, Probit and Logit regression. The application of regression methods depends largely on the measurement scale of the outcome variables and the validity of the model assumptions. The outcome variables include continuous scale, binary measure or ordered category. In this study to determine the relationship between independent and dependent variables, two models namely Probit and Tobit regression analysis have been commonly used. Probit and Tobit models are mostly used when dependant variable is categorical and the continuous variable is either continuous or categorical.

Probit regression is used to model the association between response variables and a set of explanatory variables. It can be used where the researcher wish to study effect of explanatory variables on all levels of the ordered categorical outcome. Therefore, this study adopted the method due to the said purpose of the researcher. Tobit model gives a quantitative measure of the extent of adoption. These two model models give the effect of the various factors on the use as well as the predicted probabilities of the use.

The Probit model is often used in adoption studies that aim at identifying factors underlying adoption. These models (Tobit and Probit regression model) are more powerful, convenient and flexible and are often chosen if the predictor variables are a mix of continuous and categorical variables, which is the case in this study.

3.9Ethical Considerations

The researcher made efforts to adhere to ethical standards. Permission to carry out the study was obtained from the University. Further permission was obtained from Ministry of Water and Environment and the various WFPRC managers before going to the field for data collection (see annex 1). The researcher was ethically sound hence protected the participants from any physical and psychological harm and treat respondents with respect and dignity.

Another critical issue was that respondents were granted informed consent before they participated in the study. Therefore, prior to the research, the researcher clarified to the farmers the nature of the study. Participation in the study was therefore voluntary and based on informed consent

The authors quoted in the study were acknowledged

Findings were presented in a generalized manner

3.10Limitations

Communication barrier: Most of the data collection was done in rural communities. Language barrier was a huge problem since; majority of the farmers in the rural areas do not comprehend English. Additionally, there are many tribes in Uganda with discrete languages which the researcher is not conversant with. To overcome this challenge, the researcher hired two research assistants who are university students and knew the major languages spoken in western, eastern and northern parts of Uganda; they translated the languages during interviews and while administering questionnaires.

The researcher faced a challenge of long distances traveled to locate SSISs in all regions of Uganda. Some SSISs were located as far as 600km from Kampala; having poor road networks (hard-to-reach areas) with no public means of transport available. To overcome this challenge, a great deal of transport facilitation was required which was not available at the time of data collection. Therefore, the researcher had to improvise from other sources.

Unfriendly weather affected and delayed the research. The research was carried out in the rainy season in most parts of Uganda, this made it hard to move to the field due to bad roads, and sometimes the targeted population were inaccessible since most of them would be occupied in farms outside the irrigation schemes

The researcher had not receive the research grant by the time the surveys were being conducted; being a research that was dependent on primary data and the fact that the survey required the largest share of the budget; the survey was halted for some time as the researcher was mobilizing resources; this also med to delays in commencement of the research process since there was hope of receiving the research grant.

Tribal conflict was another factor that hindered the researcher. Data collection in Karamojasubregion was hindered by the tribal conflict between the Karamojong and Iteso tribes. This made data collection in Napak district impossible and as a result resources planned for that side was not properly utilized

Due to the difficulty in acquiring permit and permission; the data obtained belonged to SSISs designed and implemented MWE only

Individual/model farmer data was obtained only from Eastern region

4RESULTS AND DISCUSSIONS

4.1Demographic Characteristics of Respondents

This part presents the demographic characteristics of the study population. The responses were analyzed using descriptive and inferential statistics as presented in table 4.

Table 4: Demographic Characteristics of Respondents

S/n	Variables	Frequency	Percentage (%)
1	**Gender**		
	Male	35	76.09
	Female	11	23.91
	Total	**46**	**100**
2	**Age**		
	> 30	3	6.52
	30-40	16	34.78
	41-50	12	26.09
	51 and above	15	32.61
	Total	**46**	**100**
3	**Education level**		
	adult education	1	2.17
	Attended O-level	9	19.56
	Attended primary	17	36.95
	Completed O-level	5	10.88
	Completed primary	5	10.88
	Degree	1	2.17
	Diploma	5	10.88
	Institution	1	2.17

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	Master's	1	2.17
	Not attended school	1	2.17
	Total	**46**	**100**
4	**Marital status**		
	Single	1	2.18
	Married	41	89.13
	Widowed	4	8.69
	Total	**46**	**100**
5	**Family size**		
	5 and less	5	10.87
	Between 6 and 8	15	32.61
	Between 9 and 12	18	39.13
	13 and above	8	17.39
	Total	**46**	**100**

According to the data shown in table 4; out of the 46 respondents who participated in the study, the majority (76.09%) were males while (23.91%) were females. This finding could be an indication that most of the farmers using agricultural best practices and technology were males. The low number of women involved in SSI farming activities may hinder the productivity, profitability and sustainability of SSISs in the study area.

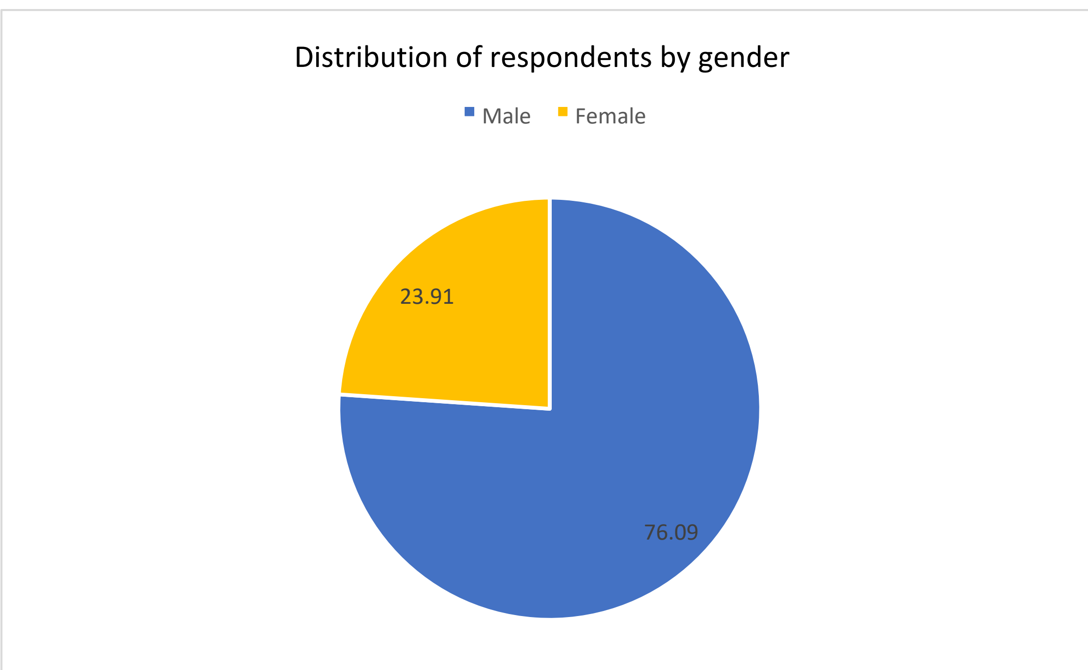

Figure 2: Distribution of respondents by gender

It is evident from the data shown in table 4 that the majority of the farmers (34.78%) were aged between 30-40 years, followed by the farmers aged 51 years and above represented by (32.61%), then the class ranging between 41-50 years (26.09%) while the least class was of 30 years and below with 6.52%. The findings reveal that respondents comprises of farmers who are young and middle aged. These are the age groups that understand innovation and contribute significantly because they are still productive. Therefore, farmers in the study area are well versed with modern farming technologies and this can influence positively the success of this economic activity.

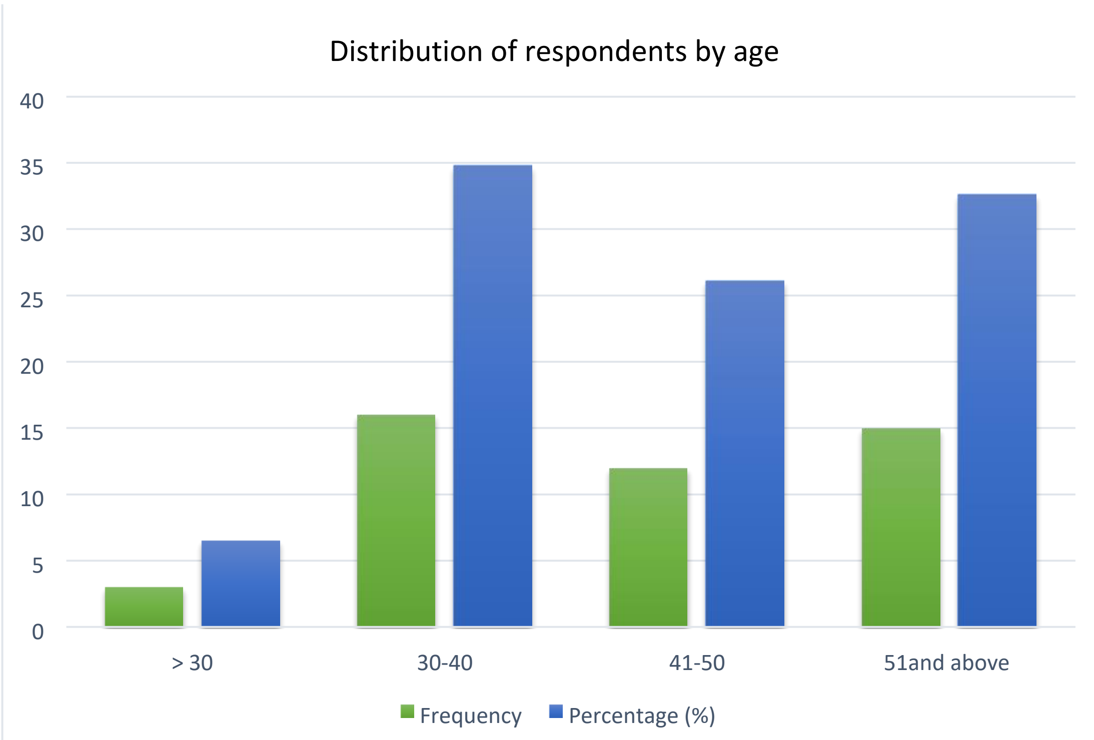

Figure 3: Distribution of respondents by age

The results in table 4 also indicated that, majority (36.95%) of the farmers have attended primary level of education followed by those that attended O-Level (19.56%), the respondents who completed primary and secondary are 10.88% and 10.88% respectively. The farmers who did not attended school represent (2.17%). Generally, the results pointed out that the majority of farmers have attained basic education. This means that the majority of farmers in the study area can easily understand various methods, innovations and new technologies in farming systems; this can greatly influence positively on productivity, profitability and sustainability of irrigation infrastructures.

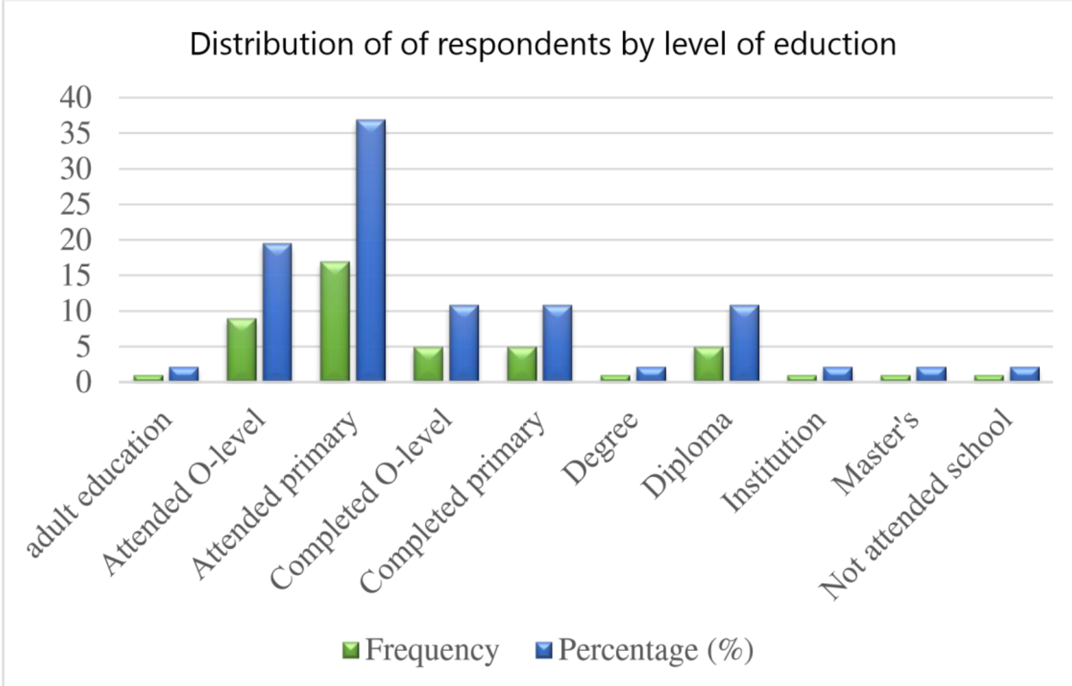

Figure 4: Distribution of respondents by level of education

The results in able 4 showed that majority (89.13%) of the farmers were married followed by widowed class with (8.69%) and the least class was that of single farmers represented by 2.18%. This is possible because many times young and unmarried people usually do not engage in the agricultural sector; another reason is that the old and elderly people are the main owners of land and have information and experience in agriculture. The restrictive factor for the young and widowed class is the limited access to agricultural bank credit and land.

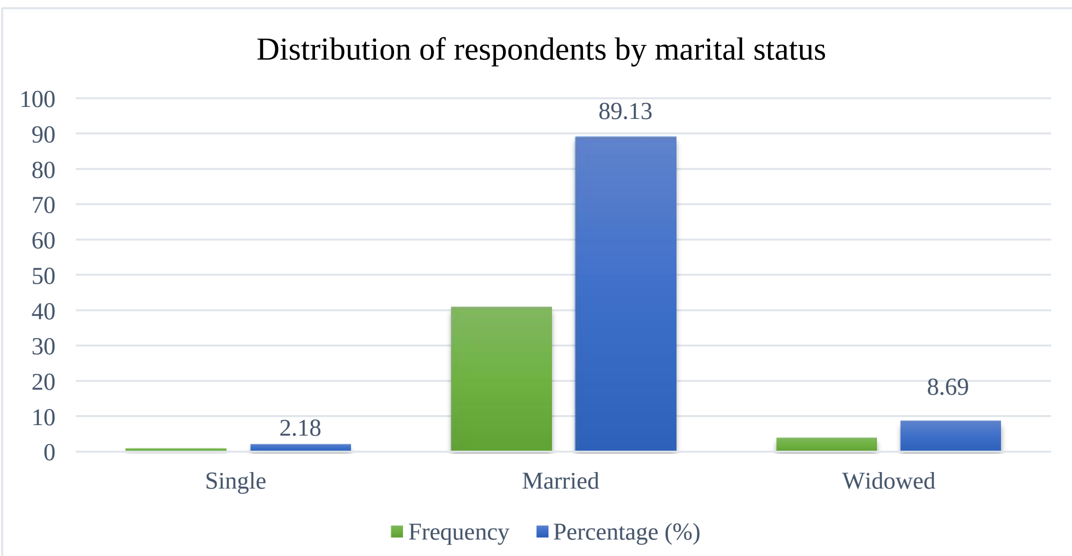

Figure 5: Distribution of respondents by marital status

The results in able 4 also revealed that majority of the farmers (39.13%) had family members ranging between 9-12 followed by the class ranging between 6-8 members (32.61) then, the class ranging from 13 and above (17.39) while the least class is of five and less members represented by (10.87%).This result indicated that most of the farmers use family labor in many of their agricultural best practices such as planting, weeding, pest and diseases control and mulching. In other words, the higher the number of household members, the larger the labor force which many times is the limiting factor for productivity, profitability and sustainability of irrigation water in study area and other developing countries.

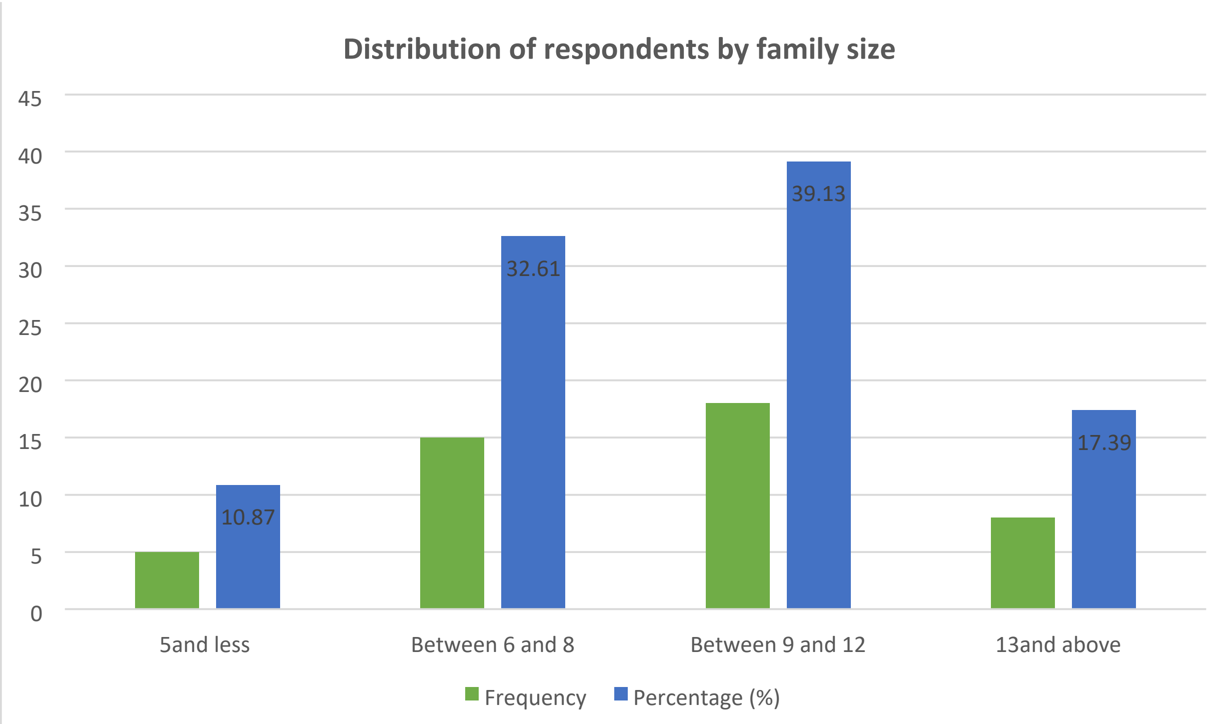

Figure 6: Distribution of respondents by family size

4.2Regression analysis results to determine the profitability of using irrigation water

4.2.1Profitability analysis Bumusse SSIS

The overall maximum production (gross margin) for the crops grown at Bumusse SSIS was found to be on tomato crop with a gross margin of 14099000 shillings while the highest net income generated per size of plot cultivated was found to be on watermelon crop as presented in table 5.

The discounted NPV for four out of the five crops grown at Bumusse SSIS with positive net income per year were -404374335, -565114335, -508930335 and -526414335 shillings for tomato, green pepper, cabbage and watermelon respectively. With these results, it was seen that all crops did not do well at Bumusse SSIS with the current production patterns exhibited by different crops hence the negative NPVs. This means that the overall production system should be revised in order to achieve returns on investment and make contributions to food security, household incomes and nutrition.

Table 5: Profitability analysis of Bumusse SSIS

Crop	Acreage Planted	Gross Margin per Season/Shs.	Total Production cost per Season/Shs.	Net Farm Income per Season/Shs.	Net Farm Income per Year/Shs.
Tomato	5.5	14099000	11275000	2824000	8472000
Onion	4	4244450	5124000	(879550)	(2638650)

Cabbage	1	2211400	1130000	1081400	3244200
Green pepper	1	1363000	1218000	145000	435000
Water melon	0.5	1400000	610000	790000	2370000

Since the NPVs are less than zero, the adaptation approach of the project can be rejected. A lower and or negative NPV indicates inefficiency in production and economic approach. **Table 6: A comparative status of NPV, BCR, ARR, and PBP of four crops grown at**

Bumusse SSIS

Particulars	**Tomatoes**	**Green pepper**	**Cabbage**	**Watermelon**
NPV (Shs.)	-404,374,335	-565,114,335	-508,930,335	-526,414,335
BCR	0.29	0.01	0.11	0.08
PBP (years)	67.7	1319.1	176.8	242.1
ARR (%)	1.47	0.56	0.07	0.41

From the results summarized in table 6, the BCR for the crops grown were found to be 0.29 for tomato, 0.01 for green pepper, 0.11 for cabbage and 0.08 for watermelon while investment in onion did not yield any positive returns. The ratios for the four crops were less than one (1); this showed that investment in these crops was not economically viable with the prevailing conditions on the scheme. If factors such as soil conditions (fertility), pest and disease control and farmers commitment are improved leaving other factors such as quality farm inputs and water availability constant, then the yields per unit of land will improve.

According to the results from the study, if only one enterprise (crop) is chosen for the entire scheme, the project costs could be fully recovered in 31 years from tomato, 110 years from green pepper, 14.7 years from cabbage and 10 years from watermelon. This means that water melon is more profitable if grown on the entire scheme land followed by cabbage then tomato and lastly green pepper. The results also showed that the Average Rate of Return for the project were 1.47 for tomato, 0.56 for green pepper, 0.07 for cabbage and 0.41 for watermelon.

4.2.2Profitability analysis for watermelon and tomato crops in Andibo and Bukatabira SSISs

The schemes are similar in the sense that both schemes have irrigable land equal to seven (7) acres and the highest values in gross margin were realized in watermelon and tomato crops. The cost of production was calculated based on the production cost at Bumusse SSIS shown in appendix 3.

The analysis results in table 7 indicated that the net returns per year from the two SSISs are 121,306,920 and 34,730,684 shillings for tomato and watermelon respectively at Bukatabira SSIS while at Andibo SSIS the returns are 50,416,800 and 200,802,000 shillings for tomato and water melon respectively. With these results, it is evident that tomato does well at Bukatabira SSIS while watermelon does well at Andibo SSIS. By comparing crops net farm income per site, tomato generated 3.5 times net return per year than watermelon at Bukatabira SSIS while at Andibo SSIS, watermelon generate 4 times net return per year than tomato. This means that tomato is more profitable at Bukatabira SSIS and watermelon is more profitable at Andibo SSIS. Looking at the highest production per crop per plot (0.5 acres) for the two (2) schemes, 2,225,400 and 8,880,000 shillings was generated from tomato and watermelon respectively at Andibo SSIS while 1,698,000 and 5,869,000 shillings was generated from watermelon and tomato respectively at Bukatabira SSIS (see appendix C). This implies that if maximum production per plot is maintained and scaled out to the entire scheme specifically for tomato at Bukatabira SSIS and watermelon at Andibo SSIS; these will significantly contribute to food security, household incomes and nutrition in the study area.

Table 7: Economics Analysis of Profitability at Bukatabira and Andibo SSISs

Crop.	**Area (acres) grown**	**Gross return per season (shillings)**	**Gross return for 7 acres per season (shillings)**	**Gross return for 7 acres per year (shillings)**	**Productio n cost per year for 7 acres (shillings)**	**Net return per year**
Bukatabira						
Tomato	2.5	19566300	54785640	164356920	43,050,000	121,306,920
Water melon	1.9	5460300	20116895	60350684	25,620,000	34,730,684
Andibo						
Tomato	0.5	2225400	31,155,600	93466800	43,050,000	50,416,800
Water melon	1.5	16173000	75,474,000	226422000	25,620,000	200,802,000

From the scheme data collected, the number of farmers differed from one site to another. In line with gender, at Bukatabira SSIS, the number of males equals the number of females. This means that men and women supplement each other in the agriculture sector and this should be the best approach for increasing household income as well as ensuring food security and household nutrition. At Andibo SSIS, out of the 85 farmers at the scheme 65.8% were men while 34.2% were female. This revealed that men dominate the agriculture sector since men are predominantly household heads unlike women. According to the net farm income earned by each farmer, at Bukatabira SSIS one farmers should gain 1,732,956 shillings from tomato compared to 496,153 shillings from watermelon. At Andibo SSIS one farmer should gain 593,139 shillings from tomato compared to 2,362,376.5 shillings from watermelon. Generally, farmers in Andibo SSIS earned much more than farmers at Bukatabira SSIS in both crops despite being more in numbers due to the maximized production from each crop per unit area.

In the same frame of total number of farmers per scheme, most of the schemes have high number of farmers hence the net margin per farmer is so low which is a demotivating factor to participating farmers (see appendix C); for instance in Owameri SSIS where there are 330 registered farmers in a group benefiting from 12,547,500 shillings gross return from a season"s production (see appendix 4)

4.3Sustainability of small-scale irrigation schemes in Uganda

4.3.1Economic analysis of sustainability of small-scale irrigation schemes in Uganda

Net present value analysis should be used in any study supporting government decisions to initiate, renew, or expand projects or programs that would result in a series of measurable benefits or costs extending from one to more years into the future. This study was done considering that the design period (lifespan) of the SSISs, which is 20 years. This analysis is done on two (2) SSISs namely Andibo and Bukatabira located in the Northern and Eastern parts of Uganda respectively.

The values of NPV, BCR, PBP and ARR are depicted in table 8. It is evident that investment in irrigation water was remunerative. Net Present Value (NPV) of future returns was discounted using the initial investment cost and the net returns generated from harvests. The discounted NPV at Bukatabira SSIS was 1,905,395,295 for tomato and 173,870,575 shillings for watermelon crops while at Andibo SSIS, the NPV were 358,336,000 and 3,366,040,000 shillings for tomato and watermelon crops respectively. The high NPV of 1,905,395,295 shillings and BCR of 4.6 for tomato at Bukatabira SSIS and NPV of 3,366,040,000 shillings and BCR of 6.2 for watermelon at Andibo SSIS indicated that it was worth investing in irrigation water. BCR clearly indicates that tomato crop is the most efficient at Bukatabira SSIS while watermelon is most efficient at Andibo SSIS.

Considering the initial costs of investment and the net annual returns generated, the project will have a payback period of 4.3 and 14.9 years when tomato and watermelon crops respectively are encouraged at Bukatabira SSIS and a payback period of 3.2 and 12.9 years when watermelon and tomato crops respectively are encouraged at Andibo SSIS. This means that, the higher the net farm income generated per year, the shorter the time taken to break even (PBP). This is evident at Andibo site where a higher net farm income was generated particularly from watermelon. At both sites, there are high values of NPV because of the high returns from production of tomato and watermelon. This therefore indicated that investments in tomato and watermelon at Bukatabira and Andibo SSISs respectively were economically viable and sustainable using irrigation water; hence the initial investment costs will fully be recovered before the 20 year project design period elapsing irrespective of the crop grown and the scheme.

The average rate of return expresses the profits arising from a project as a percentage of the initial capital cost. To determine the discounted Average Rate of Return (ARR), the values were discounted considering the difference between the initial project cost and the discounted returns from harvests of each crop. The ARR values at Bukatabira SSIS were 23.3% and 6.7% for tomato and watermelon respectively while at Andibo SSIS the ARR values were 30.8% and 7.7% for watermelon and tomato respectively. The values realized were greater than one (1) percent for both crops at the two sites. By principle, the project with the highest ARR value is considered as the best and that particular option is taken up first by an investor. For this study, all the two crops should be encouraged because the NPV, BCR, ARR, and PBP are very significant at both sites for the anticipated success of the project.

Table 8: Economic Analysis of sustainability of small-scale irrigation scheme

Particulars	**Bukatabira**		**Andibo**	
	Tomatoes	**Watermelon**	**Tomatoes**	**Watermelon**
NPV (Shs.)	1,905,395,295	173,870,575	358,336,000	3,366,040,000
BCR	4.6	1.3	1.5	6.2
PBP	4.3	14.9	12.9	3.2
ARR (%)	23.3	6.7	7.7	30.8

4.3.2Tobit regression analysis of sustainability of small-scale irrigation schemes

The sustainability of SSISs in Uganda especially in study area depends on several factors. Some of factors are affordable system, reliable water supply, enough water availability, access to investment funds, labor availability, availability of extension services, security, quality of inputs, conducive land policy, and benefit on farmer‟s investments. Table 9 summarizes the main factors affecting the sustainability of small-scale irrigation schemes in Uganda.

Table 9: Tobit regression analysis of sustainability of small-scale irrigation schemes

Variables	Coefficient	Std. Err.	P>t
Affordable system	6.453	2.133	0.001
Reliable water supply	-2.636	0.919	0.007
Enough water availability	0.697	0.248	0.015
Access to investment funds	0.401	0.546	0.0081
Labor availability	1.940	0.602	0.000
Availability of extension services	0.516	0.575	0.049
Security	0.983	0.410	0.087
Quality of inputs	0.021	0.117	0.000
Conducive land and water policy	0.388	1.512	0.197
Benefit on farmer"s investments	0.289	4.685	0.000
Constant	-1,058	0.528	0.002
Number of obs = 46	Prob> chi^2 =		0.0000
Log likelihood = -951.91224	R^2 =		0.815

In the study area, sustainability of small-scale irrigation was used as the dependent variable while factors contributing to sustainability of SSI were used as independent variables in the Tobit regression model. This was used to identify the factors that contribute to sustainability of smallscale irrigation after employing a field survey in the study area. 46 observations in our data set were used in the analysis of this study, with a p-value of 0.0000 and R^2 of 0.815. This tells us that our model as a whole fitted significantly at 100%. The results indicated that many factors such as affordable system, labor availability, Security, enough water availability, availability of extension services, access to investment funds, conducive land and water policy and benefit on farmer investments have significantly contributed tothe sustainability of small-scale irrigation in the study area at 1% level.

These factors therefore affect productivity of irrigation water. This positive influence suggests that when one factor increases, the sustainability of the irrigation schemes in study area also increases. This means that a one-unit increases in quality of inputs should increase the sustainability of small-scale irrigation schemes by 0.021%. It is usually expected that a unit increase in the Security of infrastructures should increase sustainability of small-scale irrigation by 0. 983%. This also implies that a 1% increase in affordable system, reliable water supply, enough water availability, access to investment funds, and labor availability should increase the sustainability of small-scale irrigation schemes at 1% significant level. The more the government focuses on these factors, the higher the sustainability of irrigation schemes.

4.4Factors influencing productivity of irrigation water in Uganda.

The factors influencing productivity of irrigation water were determined through OLS using STATA software version 13.0. The results of OLS regression are presented in table 10.Productivity of irrigation water is influenced by several factors in study area. In the study, social and economic variables such as family size, education level, fertilizers, irrigation system, farming experience, volume of water, extension service, off farm income, gender, and cooperative membership have positively influenced productivity. Factors namely family size, education level, fertilizers, type of irrigation system, farming experience are statistically significant at 1% level to influence productivity while volume of water, extension service, off farm income were positively influenced at 5% level while gender, cooperative membership were positively influenced at 10% level. Five factors such as labor source, age, market price of produce, distance to market, agricultural credit, negatively influenced productivity in study area. One factor namely land/plot size did not have any influence on productivity. Table 10 shows that the model fits the data reasonably well (p-value < 0.0001 and R^2 of 0.96). This means that 96% of the variation in the dependent variable is explained by the explanatory variables.

The results show that among the variables, factors namely family size, education level, fertilizers, type of irrigation system and farming experience have high positive significant influence on productivity (p values <0.01) whereas labor source, age, price of produce, distance to market, agricultural credit have high negative significant influence on the productivity of irrigation water (p <0.01). It is expected that a unit increase in family size would lead to a 1.3unit increment in productivity in the study area while holding other factors constant. A 1% increase in extension service should increase productivity by 1.4%. This is because more contact with the extension workers enhances sharing of information regarding the market trends, farm inputs and accessibility of water for irrigation. In other words service contact is enhanced by attending stakeholder (farmer) meetings from where the farmers are met by the extension workers (agronomists). Farmers who fail to participate in such meetings/trainings often have little information and thus improper usage of agricultural inputs causing low productivity of irrigation water

A 1-year increase in farming experience should increase productivity by 0.32%. This is because the more years a farmer takes in farming, the higher the knowledge and experience in different agricultural practices hence, high reduction of production challenges for example irrigation system failures and crop pests and diseases. Factors such as age, price of produce, distance to market, agricultural credit, negatively influenced productivity. It is expected that a 1-kilometer increase in distance to the market reduces productivity by 0.14%. This shows that accessibility to market is a key factor in determining the level of uptake of SSI and agricultural productivity. For a unit reduction in price of produce, there is a 0.3% reduction in agricultural productivity in the study area holding other factors constant.

Table 10: Factors influencing productivity of irrigation water in Uganda

Variables	Coefficient	Standard Errors	P-value
Land size/plot	0.649	0.319	0.684
Labor source	-0.447	0.305	0.057
Family size	1.295	0.211	0.000
Gender	0.178	0.055	0.086
Age	-0.621	0.176	0.073
Education level	0.162	0.232	0.005
Fertilizers	0.191	0.077	0.001
Type of irrigation system	0.774	0.267	0.000
Volume of water used	0.999	0.09	0.013
Off farm income	0.749	0.361	0.052
Market price of produce	-0.298	0.583	0.000
Distance to Market	-0.138	0.137	0.077
Access to agricultural credit	-0.697	0.213	0.000
Farming experience	0.319	0.304	0.000
Extension Service	1.421	0.113	0.035
Cooperative membership	0.224	0.306	0.081
Constant	0.774	1.402	0.000

Number of obs = 46	R^2	= 0.9606 F(16, 39)
= 44.22	Adj R^2 = 0.9389	

4.5Factors Influencing Farmers' Willingness to Pay for Irrigation Water

The results of the regression are presented in table 11. The results indicate that 73.72% of the variation in the dependent variable (Farmers‟ Willingness to Pay for Irrigation Water)is explained by the explanatory variables. The overall significance and fitness of the model is indicated by the F value, which in this case is 83.35 and is significant at 1% level, indicating that the explanatory variables reliably and statistically predict the dependent variable.

Out of the eleven explanatory variables, four such as rate of rainfall, education level, off farm income and access to credit were statistically significant at 1% level to influence the farmers‟ willingness to pay for irrigation water in study area. This implies that 1% increase in credit access by farmers increases the farmers‟ willingness to pay for irrigation water by 0.074%. The results also indicated that the off farm income was statistically significant to influence farmers‟ willingness to pay for irrigation water at 1% level. This explains that households that earned offfarm income were willing to pay more compared to those that do not earn off-farm income.

As expected, access to credit also positively and significantly influenced farmers‟ willingness to pay for irrigation water. This could be due to the possibility that part of the accessed credit offered was used to pay for irrigation water, among other inputs thereby increasing agricultural production and eventually productivity of irrigation water. Education level on best management of irrigation water and application system positively influenced farmers‟ willingness to pay for irrigation water; farmers with high education level understand more agricultural best practices and better management and use of irrigation water system. This class of educated farmers were found to be more willing to pay more compared to those who are not educated hence are not willing to pay for irrigation water.

Five factors such as age, household size, land size, rate of rain fall, and cost of inputs cost were found to have a negative relationship with farmers‟ willingness to pay for irrigation water. For example rate of rainfall was found to be negative and statistically significant at 1% level to influence farmers‟ willingness to pay for irrigation water. This implies that 1% increase in rate of rainfall should reduce the farmers‟ willingness to pay for irrigation water by 0.97%. While a 1%, increase in household size should reduce the farmers‟ willingness to pay for irrigation water by 0.013%; this may result from the extra cost of taking care of the additional person in the household.

Table 11: Factors Influencing Farmers' Willingness to Pay for Irrigation Water

Variables	Coefficient	Standard Errors	P value
Age	-0.076	0.024	0.014
Gender	0.036	0.044	0.414

Household size	-0.013	0.009	0.066
Education level	0.056	0.037	0.009
Off farm income	0.119	0.082	0.002
Access to credit	0.074	0.043	0.000
Land size	-0.694	0.206	0.071
Rate of rain fall	-0.967	0.296	0.000
Money gained from harvest	0.391	0.676	0.067
Money paid per season	0.035	0.028	1.923
Cost of Inputs	-0.766	0.322	0.921
Constant	1.802	0.508	0.000
Number of observations = 46 Prob>F = 0.0000 F (11,34) = 83.35 R^2 = 0.7372			

4.6Implications of water user rights and costs on adoption of irrigation in Uganda

The results in table 12 indicated that the water user rights and costs have positive implications on adoption of irrigation water in Uganda and has got significant influence on other factors such as price of irrigation water, extension services, access to agricultural information, off farm production, cooperative membership, training opportunities, personal savings, contribution for operation and maintenance and high agricultural productivity. This implies that 1% increase in water user rights and costs through off farm production should increase adoption of irrigation in Uganda by 0.34%. It implies also that one unit increase in water user rights and costs through Cooperative membership should increase adoption of irrigation in Uganda by 0, 93%. It implies also that 1% increase in water user rights and costs through access to agricultural information, and extension services should increase adoption of irrigation in Uganda by 0.23 and 1.46% respectively.

Table 12: Tobit estimate of implications of water user rights and costs on adoption of irrigation in Uganda

Variables	**Coefficient**	**Standard Error**	**P>|t|**
Volume of water supplied	-0.245	7.743	0.109
Price of water for irrigation	0.728	0.220	0.000
Extension services	1.461	2.925	0.008
Training opportunities	1.527	4.571	0.020
Access to agricultural information	0.230	0.748	0.000
Off farm production	0.338	0.555	0.000
Contribution rate on maintenance	0.497	1.000	0.059
Personal savings	0.412	0.493	0.011
Cooperative membership	0.932	0.682	0.000
Soil fertility test	-0.694	3.735	0.481
High agricultural productivity	1.325	2.077	0.078
Constant	1.031	0.831	0.000
Number of obs.	46		

LR chi2(11)	114.33
Prob> chi^2	0.00
Pseudo R^2	0.09
Log likelihood	-1267.24

5. CONLUSION AND RECOMMENDATIONS

5.1. Conclusion

The results from the 46 respondents who participated in this research study indicated that the majority (76.09%) were males while (23.91%) were female. The findings could be an indication that most of the farmers using agricultural best practices and technology were males. The low number of women involved in SSI farming activities may hinder the productivity, profitability and sustainability of SSISs in the study area.

Also, majority of the farmers (34.78%) were aged between 30-40 years, followed by the farmers aged of 51 years and above represented by (32.61%), then the class ranging between 41-50 years (26.09%) while the least class was of 30 years and below with 6.52%. The findings reveal that respondents comprises of farmers who are young and middle aged. These are the age groups that understand innovation and contribute significantly because they are still productive. Therefore, farmers in the study area are well versed with modern farming technologies, which can influence positively the success of SSI projects.

The results also indicated that majority (36.95%) of the farmers have attended primary level of education followed by those that attended O-Level (19.56%), the respondents who completed primary and secondary are 10.88% and 10.88% respectively. The farmers who did not attended school represent (2.17%). This means that majority of the farmers in study area can easily understand various methods, innovations and new technologies in farming systems; this can greatly influence positively on productivity, profitability and sustainability of irrigation infrastructures.

The results in table 4 also showed that majority (89.13%) of the farmers were married followed by widowed class with (8.69%) and the least class was that of single farmers represented by 2.18%; the same results also revealed that majority of the farmers (39.13%) have family members ranging between 9-12 followed by the class ranging between 6-8 members (32.61) then, the class ranging from 13 and above (17.39) while the least class is of five and less members represented by (10. 87%).This result indicates that most of the married farmers use family labor in many of the agricultural best practices such as planting, weeding, pest and diseases control and mulching. In other words, the higher the number of households members, the larger the labor force which many times is the limiting factor for productivity, profitability and sustainability of irrigation water; the restrictive factor for the young and widowed class is the limited access to agricultural bank credit and land.

The net benefit per year and the values of NPV, BCR, ARR and PBP clearly indicate that the investment in five crops at Bumusse is not economically viable.

The results indicated that the net returns per year from two SSISs namely Bukatabira and Andibo are 121,306,920 and 34,730,684 shillings for tomato and watermelon respectively at Bukatabira SSIS while at Andibo the returns are 50,416,800 and 200,802,000 shillings for tomato and water melon respectively. With these results, it is evident that tomato does well at

Bukatabira SSIS while watermelon does well at Andibo SSIS. By comparing net returns per crop per site, tomato generated 3.5 times than watermelon at Bukatabira SSIS while at Andibo SSIS watermelon generate 4 times than tomato. According to the net farm income earned by each farmer, at Bukatabira SSIS one farmers should earn 1,732,956 shillings from tomato compared to 496,153 shillings from watermelon while at Andibo SSIS one farmer should earn 593,139 shillings from tomato compared to 2,362,376.5 shillings from watermelon. Generally, farmers in Andibo SSIS earned much more than farmers at Bukatabira SSIS in both crops despite being more in numbers due to the maximized production from each crop per unit area of land.

The high NPV of 1,905,395,295 shillings and BCR of 4.6 for tomato at Bukatabira SSIS and NPV of 3,366,040,000 shillings and BCR of 6.2 for watermelon at Andibo SSIS indicated that it was worth investing in irrigation water. The ARR values for Bukatabira SSIS were 23.3% and 6.7% for tomato and watermelon respectively while at Andibo SSIS the ARR values were 30.8% and 7.7% for watermelon and tomato respectively. The projects will have a payback period of 4.3 and 14.9 years when tomato and watermelon crops respectively are encouraged at Bukatabira SSIS and a payback period of 3.2 and 12.9 years when watermelon and tomato crops respectively are encouraged at Andibo SSIS. These high values of ARR and short PBP are an indication that the projects are sustainable.

Factors such as affordable system, labor availability, quality of inputs used, benefit on farmer investments and access to investment funds have significantly contributed tothe sustainability of SSISs in the study area.

Factors such as family size, education level, fertilizers, type of irrigation system and farming experience have high positive significant influence on productivity whereas labor source, age, price of produce, distance to market, agricultural credit have high negative significant influence on the productivity of irrigation water

Rate of rainfall, education level, off farm income and access to credit have a positive influence the farmers‟ willingness to pay for irrigation water in study area while age, household size, land size, rate of rain fall, and cost of inputs cost were found to have a negative relationship with farmers‟ willingness to pay for irrigation water. .

Water user rights and costs have positive implications on adoption of SSI in Uganda and has got significant influence on other factors such as price of irrigation water, extension services, access

to agricultural information, off farm production, cooperative membership, training opportunities, personal savings, contribution for operation and maintenance and high agricultural productivity.

The field findings from Puno SSIS on the two (2) harvests so far made indicated that the second harvest made tripled the first harvest; there was a 204.5% overall increase in gross return from different enterprises in the second harvest as compared to the first. This is an indication that the farmers are adopting better methods of farming with the guidance of the agronomist on the best crop varieties as well as the market forces depending on seasonality factors. Another factor for this increase is the fact that group farming has been discouraged hence individual/model farming approach; this has eased farmer follow-ups, farming plot monitoring and management. This result therefore is an indication that the project is improving with time and all efforts should be gathered until the expected production per unit of land is obtained.

Table 13: Enterprises and gross returns for first and second harvests at PUNO SSIS

		Gross Returns (Shs.)	
S/n.	**Enterprise**	**First Harvest**	**Second Harvest**
1	Egg plants	2049300	7123300
2	Onions	297100	1194000
3	Cabbage	1002000	630000
4	Water melons	420000	1437000
5	Tomatoes	75000	1501500
TOTAL		3903400	11885800

5.2. Recommendations

5.2.1.To government

- According to the data from the 46 respondents that participated in this research study, the majority were males in study area. Here female farmers should be encouraged and supported to participate in agricultural activities in order to increase and improve their incomes.
- According to the values of NPV, ARR, BCR and PBP in the study area, production of tomato should be encouraged at Bukatabira SSI where it is most cost effective to produce while watermelon is should be encourage at Andibo SSI.
- The production system at Bumusse SSI should be revised to realize the return on investment within the project design period
- Affordable SSI systems, quality farm inputs and investment funds should be easily accessible to prospective farmers.
- The factors that influence the farmers‟ willingness to pay for irrigation water in study area should be encouraged in order to have enough water for irrigation as well as to increase agricultural productivity in scheme area.
- Government should ensure that SSISs set up are supported to achieve maximum production before commissioning to farmers (beneficiaries)
- Government should ensure the availability of affordable irrigation systems, investment funds and quality farm inputs for farmers to realize benefits on investments
- Government should ensure that there is available and stable market for agricultural products
- Government should make affordable the price of irrigation water
- Government should ensure adequate extension services and agricultural information access

- Government should ensure an enabling environment for formation and operation of farmer cooperatives.

5.2.2To Scheme Management Committees

- SSISs should focus on crops with greater production advantages

- The number of farmers per scheme should be sustainable in relation to benefit per farmer

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