ECONOMIC VALUATION OF IRRIGATION WATER IN SMALLHOLDER FARMING SYSTEM IN RWANDA: THE CASE OF KIBAYA - CYUNUZI SCHEME

BY

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ABSTRACT

Rwanda is in a current shift of management of state controlled irrigation schemes to farmers through the Irrigation Management Transfer (IMT) programme. However, such water management decisions require conceptually correct and empirically accurate estimates of the economic value of water. This study was carried out to determine the economic value of irrigation water in a smallholder irrigation scheme of Kibaya – Cyunuzi. Data was collected from 110 respondents within the scheme. The data was analyzed using descriptive and quantitative methods. The Residual Computation Method was used to compute the economic value of irrigation water for paddy rice – the main crop cultivated in the scheme. The Contingent Valuation Method was employed to elicit the farmers' willingness to pay for irrigation water and its related infrastructure. Socio-technical analysis helped to capture the process of water control and management through Water Users Associations. Results showed that the average economic value of water in irrigated paddy was low (5.33 Rwf/m^3), mainly due to poor management of water. Water productivity was also low (0.08 kg/m^3) due to an insufficient supply of water to the scheme. The CVM analysis showed that on average, the respondents were willing to pay 8000 Rwf per ha per annum for irrigation water. IMT impact assessment showed that WUAs are the realms of interaction for different stakeholders involved in water management. The problems farmers were facing in improving water productivity in the scheme were identified but the solutions require joint effort among the stakeholders. Policy decisions related to water sector investments, allocation and management could be better guided if the key dimensions of water i.e. water availability and use, are properly taken into account in valuation.

DECLARATION

I, Sandrine Urujeni, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

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CVM	-	Contingent Valuation Method
EDPRS	-	Economic Development and Poverty Reduction Strategy
FAO	-	Food and Agriculture Organization of the United Nations
Ha	-	Hectare
IMT	-	Irrigation Management Transfer
IMTA	-	Irrigation Management Transfer Agreement
IWMI	-	International Water Management Institute
KWAMP	-	Kirehe Watershed Management Project
MINAGRI	-	Ministry of Agriculture and Animal Resources
REMA	-	Rwanda Environment Management Authority
RIM	-	Residual Imputation Method
RWF	-	Rwandan Franc
SPSS	-	Statistical Package for Social Sciences
TVP	-	Total Value Product
VMP	-	Value Marginal Product
WMO	-	World Members Organization
WUA	-	Water Users Association
WTP	-	Willingness to Pay

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The world is currently facing severe and growing challenges in meeting the rapidly growing demand for water resources. Globally, the average amount of water per person has been dropping substantially from about 43 000 cubic meters per person per year in 1850 to about 9000 cubic meters per person per year in 1990 (Gleick, 1996). This trend results from the rapid population growth, which does not match with an equivalent growth in the development of new water sources.

Water has unique characteristics that determine both its allocation and use as a resource in agriculture. Over the years, many researchers have examined the valuation of water as an instrument for improving water allocation, reducing water consumption and management of the irrigation systems (Maetsu, 2001). This is because irrigation is a vital component of agricultural production in many developing countries

The Fourth Principle of the 1992 Dublin Statements defines water as an economic good. Such a definition is aimed at achieving efficient and equitable use, and encourages conservation and protection of water sources. The Fourth Dublin Principle denotes a landmark shift in emphasis to the economic dimensions of water use in general, and irrigation in particular (WMO, 2007).

Irrigated agriculture, which consumes about 50 % to 70 % of global water resources, constitutes a driving force of both food productivity and agricultural income (Kadigi, 2006). As an immediate determinant of the climate and the socio-economic structure, water is not only an essential input for profit-making agriculture, but also inevitable for the economic viability and social coherence of various rural areas.

According to Hussain *et al.* (2007), the value attached to water varies across time and space among different stakeholders at various scales (farmer, system manager, basin planner and national policy maker).

Thus, the need to develop flexible institutions to maximize water's beneficial use in the face of growing demands for scarce and variable water supplies is the most compelling issue for economic development for the people who live in dry places. In principle, more water, better timed water, a more suitable place, and better quality water for a particular use are usually available at higher prices. Thus, sufficient time is required for building storage, conveyance and or treatment capacity (Ward *et al.*, 2002).

The agricultural sector in Rwanda is dominated by smallholder farmers with average farm size of less than one ha. However, smallholder farmers have been performing poorly mainly due to overdependence on rain fed agriculture, with their production often at the mercy of highly unreliable rainfalls (Ministry of Agriculture and Animal Resources, 2007). In Rwanda, small-scale irrigation is seen as an important rural development factor that contributes to a sustainable use of water, creates employment opportunities, generates income and enhances food security. In this respect, huge investments have been made in the sector, and this includes rehabilitating the existing irrigation schemes. In perspective of this, the Government of Rwanda has initiated a reform programme which aims at revitalizing the management of smallholder irrigation schemes from Government control to smallholder farmers. The reform, which is referred to here, requires that an Irrigation Management Transfer Agreement (IMTA), which involves a cost recovery and institutional change be adopted (KWAMP, 2008). The Rwandan government has decided to introduce institutional reforms in the water sector and transferred thc responsibility for operation and maintenance (O&M) of irrigation systems to water users. Thus, the creation of Water Users Associations (WUAs) became a key element of irrigation management transfer (IMT).

Despite that water is needed for meeting basic human needs and for ecological reserve, it is no longer a free commodity and therefore every user is expected to pay for water use so that the rule of efficiency can be applied. In fact, irrigation water is an asset and its availability increases or reduces household capacity to produce income in combination with other assets. Since, the smallholder irrigation sector is no exception to this rule. There is therefore the need for the estimation of water productivity and value in the sector (Yokwe, 2004).

1.2 Problem Statement and Justification

Public investment in irrigation schemes still remains a high cost constraint on government budgets since it includes massive rehabilitation works (Vermillion and Sagardoy, 1999). In a cost cutting plan, the Government of Rwanda is in a current shift to streamline the management of the irrigation schemes from state controlled to farmer managed through a reform programme called Irrigation Management Transfer (IMT). The IMT model and its generic requirements through the WUA concept necessitate farmers to pay for irrigation water to cater for operation and maintenance of the irrigation schemes. Such water resources management policy decisions, however, need to be informed by prudent research. According to Ward and Michelsen (2002) and Hellegers and Perry (2006), conceptually correct and empirically accurate estimates of the economic value of water are essential for making rational water management and allocation decisions.

Most of the previous studies in Rwanda have focused their analysis on bio-physical aspects of irrigation water management. A considerable portion of this work has related to climatic, soil and crop factors and their influence on irrigation water management (Ngoga, 2008) with substantial analysis of social implications in lieu of management of irrigation water (Murengerantwari *et al.*, 2008). However, much less attention has been paid to measuring the economic value of irrigation water; including the evaluation of smallholder farmers' willingness to pay for water in the irrigation scheme and its determinants. This is particularly important if irrigation fees paid by smallholders are to reflect the marginal value of irrigation water.

Knowledge of this value is necessary when making, for instance, investment decisions concerning water resources development, policy decisions on sustainable water use and water allocations, or when determining the socio-economic impacts of water management decisions (Hussain *et al.*, 2007). Specifically for the agricultural sector, this knowledge is important to design fair, informed and rational pricing systems, providing incentives to irrigators upon using water sparingly and efficiently and allowing recovering operation and maintenance costs (Lange, 2007; Perret and Geyser, 2007). However, there is a current gap in knowledge at least in the context of smallholder irrigation schemes in Rwanda.

The proposed research therefore made the first step in this direction to examine the value of irrigation water in smallholder farming systems and potential implications of changes in water management on this water use to fill this existing knowledge gap using Kibaya - Cyunuzi Irrigation Scheme as a case study.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of this study was to determine the economic value and management of water in smallholder irrigation system of Kibaya-Cyunuzi scheme in Rwanda.

1.3.2 Specific objectives

a) To estimate the economic value of water in smallholder irrigation system in Kibaya-Cyunuzi scheme.

b) To investigate smallholder farmers' willingness to pay for irrigation water in Kibaya-Cyunuzi scheme.

c) To identify the impact of Irrigation Management Transfer through water users associations with regards to water allocation and management in the scheme.

1.4 Hypotheses

a) The value of water in Kibaya-Cyunuzi scheme is low.

b) Farmers are willing to pay high for irrigation water in smallholder farming system.

c) IMT using WUAs has a positive impact on water allocation and management in the Kibaya-Cyunuzi scheme.

CHAPTER TWO

2.0 LITERATURE REVIEW

Water resources provide important benefits to human kind, both commodity and environmental values. However, because of the increasing scarcity of water for both its commodity and environmental benefits and scarcity of resources required to develop water, economic valuation plays an increasingly important role in public decision on water projects, reallocation proposal and other water policies (Young, 1996). This chapter reviews literature related to economic value of irrigation water and water management as well as previous studies done in valuation of agricultural water.

2.1 Approaches to Resource Valuation

The term value of a good or resource, in any sense, implies two fundamental concepts namely, scarcity and benefit. All goods are scarce and generate benefits in one way or another.

Economic value is one of the many possible parameters of measuring benefits. In economics, the term value refers to monetary measure or hangs in economic welfare. Economic valuation refers to a quantification of goods and services provided by a resource, whether or not market prices are available for these goods and services. The strict economic definition of a value of a resource is the amount a rational user is willing to pay for it (Ward and Michelsen, 2002).

For any resource, prices are interpreted as expressions of willingness to pay (WTP) by consumers. While this is obvious for marketed goods and services, where the market price represents the willingness to pay at the margin, it is equally applicable to non-market goods and services where WTP is a theoretical criterion of determining prices generally referred to as shadow prices.

Under the approaches for valuing benefits and costs of natural resources for which no markets exist or are highly imperfect, several valuation methods and techniques have been developed based on economic theory and applied economic principles. Some of these methods could potentially be adopted for valuing water (Hussain *et al.*, 2007).

According to Hussain *et al.* (2007), the major approaches for resource valuation may be classified into the following categories:

a) *Conventional market-based approaches*: where goods are traded in the market and prices exist for inputs and/or outputs. Prices (or adjusted prices) can be used as expressions of willingness to pay and the benefits and costs can be valued using market prices.

b) *Alternative/replacement cost approaches*: These approaches can be applied to situations where market prices for some inputs or outputs do not exist or where direct estimations of demand and supply functions becomes difficult due to lack of data. Replacement cost approaches are based on the notion that maximum willingness to pay for any good or service is not greater than the cost of producing that good or service with alternative means of production or technology. The cost of producing that good or service is compared with the cost of least-cost alternative means of producing that good and the difference represents the net economic benefit. The minimum replacement cost can be used as an estimate of the value of benefits of the good or service in question.

c) *Observed indirect or implicit or revealed preference approaches,* where market prices do not exist. These approaches can be used to infer willingness to pay based on actual expenditure choices made by consumers, revealing their preferences. They are based on actual consumer behavior where Willingness to pay for a good or service is estimated indirectly.

d) *Stated preference approaches*: These approaches are applicable to situations where people's preferences or willingness to pay cannot be inferred directly or indirectly from the actual behavior in the market. People's willingness is obtained through hypothetical markets where people are asked to express their willingness to pay or preferences for a good or service in question through surveys.

2.1.1 The economic value of water

The economic value of water is reflected through the many uses to which the water can be put in satisfying people's needs. Water can have a very high economic value because it is scarce and because it is capable of being applied to many different uses (Ward and Michelsen, 2002). Whenever water is available in unlimited supply, it is free in the economic sense. Scarce water takes an economic value because many users compete for accessing it. In a market system, economic value of water, defined by its price, serve as a guide in allocating water among alternative uses, potentially directing the water and its complementary resources into uses which yield the greatest total economic return (Ward, 2002).

The principle of maximizing the total economic value of resources such as water is an essential concept in modern natural resource economics. Rational decisions supporting water resource development, allocation, and use also require measuring the value of water in alternative uses (Ward and Michelsen, 2002).

2.1.2 Dimensions of the value of water

The value of water has many dimensions. Hussain *et al.* (2007) classify these dimensions into four basic categories namely, Use dimension, Time dimension, Space dimension, and Impact dimension. Each of these dimensions is explained below.

Use dimension: the value of water depends on the pattern of water use. Among consumptive uses, the value of water would be higher where multiple cropping is practiced. Cropping is diversified with high-value crops and high-value multiple enterprises (such as livestock and fish farming) compared to single low-value crops or enterprises. Similarly, the value of water would be higher where the water is also used for non-consumptive multiple purposes and for non-farm rural enterprises.

Time dimension: the value of water is also influenced by time, the time period during which the impacts are realized. In general, the longer the time period the greater the value (or disvalue) of water is likely to be. This is because most of the secondary impacts are realized over a long period (For example, on the positive side, irrigation induced expansion in economic activities and asset creation in agriculture occurs over a long period of time. On the negative side, land degradation resulting from irrigation also occurs over an extended period). Therefore, short-term values will be different from long-term values. In particular, in the water scarce environments, one would expect that the value of water would increase in the long run due to technological advancements leading to an increase in productivity and a gradual shift over time towards high value crops and other farm enterprises.

Space dimension: the value of water can vary significantly across various spatial scales—farm, system, basin and macro/national levels. In general, the higher the spatial scale the higher the water value (or disvalue). These variations may be due to a number of factors such as the effects of externalities (indirect or secondary benefits and costs) at the higher level, the effects of scale on the water accounting and the value of the denominator, and the distribution of value adding activities.

At the farm level, the optimal value of water will be achieved when the marginal value product (i.e., the addition made to the total value of product by using an extra unit of water at the margin) is equal to the marginal cost of water. In this case, farmer's marginal private benefit and marginal private cost would be equal. However, at the higher level (basin or macro level) the optimal value of water will be achieved when the marginal social benefit is equal to the marginal social cost, which accounts for beneficial or adverse externality effects. Where beneficial externality effects significantly exceed adverse externality effects, the value of water will be much greater at a higher geographical scale than at farm level, and vice versa.

Impact dimension: the value of water would also depend on the magnitude and nature of direct or primary and indirect or secondary impacts (benefits or lack of benefits) which in turn would depend on the nature and intensity of socioeconomic activities in both agricultural and related non-agricultural sectors. The impact dimension is related to the other three dimensions discussed above. In general, the impacts of agricultural water would be higher, in the long run, at higher spatial scales and under multi-enterprise practices and in multiple water-use situations.

2.1.3 Factors influencing the value of agricultural water

There are a range of factors that influence the abovementioned four dimensions of water value. These may be classified according to spatial scales and which include micro, meso, and macro level scales. Each of these factors is explained below:

a) Micro/local level factors: Resource-related local level factors

Water availability and supply influences the value of agricultural where water is scarce, and vice versa. It is also influenced by the reliability of water source, water quality (such as highly saline water), and return flows of water. However, if water is not used and not degraded, it maintains its value.

Climatic conditions, crop growth stages and water infrastructure condition and its management as well influence the value of agricultural water (e.g., rainfall during water-shortage versus water surplus seasons). This will vary across and within growing seasons and will depend upon crop water requirements.

Primary and secondary (or indirect) uses of water will be high under multiple use contexts, including non-consumptive uses. Beside, land tenure, land distribution and land quality could also influence the value of water.

b) Meso/intermediate level factors

Water institutions and management factors also influence the value of water. For example, improved management may lead to water reallocation to high-value uses (high-value crops and farm enterprises) or to locations where water-related benefits are relatively higher. Production-market linkages at the regional level would also indirectly influence the value of water.

c) Macro level factors

Factors that would influence the value of water comprise investment and water policies, laws and regulations. Policies for non-water inputs, outputs and services such as input subsidy/tax policies, price/market/ trade policies and other policies that affect agricultural productivity are also included.

2.1.4 Valuing agricultural water use

The valuation of water in irrigated agriculture can be approached in a variety of ways depending upon data availability and other constraints. Water valuation can be complex. Data are often not available and expensive to collect. In smallholder sector the volume of water consumption is usually not measured. Water values are usually very site-specific and benefits transfer (a method of applying values obtained from one study site to other site) is not well developed for many aspects of water (Hassan and Lange, 2004).

The value of irrigation water therefore can be addressed from a number of perspectives:

a) How much yield or gross margin (GM) a unit of irrigation might give; b) how much money are farmers ready to pay to acquire water; c) how much does it cost to supply a unit of water; d) how these estimated values can be compared with what farmers actually pay? In view of these questions, the strength and limitations of the following methods are discussed, taking into account the above mentioned constraints attached to smallholder irrigation sector.

a) The Residual Imputation Method

Residual Imputation Method (RIM) is a very frequently used approach to apply in water valuation, particularly for irrigation water. In this method, the total value of output is allocated among each of the resources used in the production process. If appropriate prices can be assigned to all resources but one, the remainder of total value of product is imputed to the remaining input (Young, 1996).

The prices of all resources are equated to returns at the margin (value of marginal product). Profit-maximizing producers are assumed to add productive inputs up to the point where the value of marginal products is equal to the costs of the additional inputs. If there are other inputs which are not priced, not competitively priced or not employed to the point where their price equals their value of marginal product, then the residual imputation method will generate inaccurate estimates of water values (Manyats *et al.*, 2007).

The total annual crop revenue less non-water input costs is a residual, the maximum amount the farmer could pay for water and still cover costs of production. It thus represents the on-site value of water. This monetary amount, divided by the total quantity of water used on the crop, determines a maximum average willingness to pay for water for that crop (The economic value of irrigation water). Depending on whether or not fixed costs are included, such values will be long-term or short-term average values respectively (Hassan, 2007).

This method of calculating values is rarely used, but it is an interesting method in that it allows the separation of normal profits from the value of the water. Regular farm enterprise budgeting procedures merely identify the maximum expense possible for water, reducing profits to zero unless they are explicitly included as an input cost of production (Wichelns, 2002).

b) Contingent Valuation Method

There are cases in which it is not possible to derive value measures from observing individual choices through a market. Ojeda *et al.* (2008), call the methods developed to measure environmental values in such cases, *hypothetical methods.* In this approach, respondents are offered a hypothetical market, in which they are asked to express WTP for existing or potential environmental conditions not registered in any real market.

The most common form of questioning on hypothetical futures is called the contingent valuation method (CVM). It involves directly asking individuals what they would be willing to pay for particular goods or services contingent on some hypothetical change in the future state of the world. The monetary values obtained in this way are said to be contingent upon the nature of the constructed market and the commodity described in the survey development.

Many analysts have applied the CVM to water-related issues as Lankford and Franks (2000) revealed. A limitation on ascertaining the marginal value of water may occur, because the questions asked do not relate to incremental changes in water supply or quality, but to the value of the site or policy itself. However, Young (2005) argued that, questions regarding different amounts of water for fishing, boating or streamside recreation, illustrated with photographs of alternative situations, have elicited useful estimates of the marginal value of stream flow.

In CVMs, random or stratified samples of individuals selected from the general population are given information about a particular problem, and are presented with a hypothetical occurrence such as a disaster and a policy action that ensures against this disaster. Under CVM survey format, the respondent is offered two alternatives or scenarios often set in the context of a referendum, one of which is the status quo scenario and the other, an alternative scenario that has a greater cost than the status quo and the respondent is invited to state his or her preference (Carson and Groves 2007). To obtain the actual value placed by individual households on environmental amenity, monetary values are randomly assigned to different respondents.

The resulting data are then analyzed statistically and extrapolated to the population that the sample represents. These studies are conducted as face-to-face interviews, telephone interviews or mail surveys. The face-to-face is the most expensive survey administration format, but it is considered the best, especially if visual material needs to be presented. Non-response bias is always a concern in all sampling frames, because on average people who do not respond have different values to people who do respond.

c) Mathematical Programming Method

Mathematical Programming Method (MPM) is a good method for determining water demand functions in agricultural systems with more than one crop. It is mainly based on the use of models for assigning areas, water and other production factors to different crops. As in the case of the residual method, from which it derives, it is crucial that all possible costs be taken into account (Young, 2005).

In addition, a production function representing the response of the crop to the amount of water applied must be known. Leontief-type techniques can be used to represent this function by omission. Mathematical Programming Method is rarely applicable, especially since there are practically no agronomic production functions that establish relationships between the amount of water used and the yields of most ligneous crops (Lemly *et al.*, 2000).

d) Hedonic Price Analysis

The hedonic pricing analysis is applicable when data can be inferred from markets, which can then be used to measure willingness to pay for water supply or environmental quality differences. In their earliest applications these techniques were meant to capture the WTP measures associated with variations in property values, resulting from the presence or absence of specific environmental attributes that can be recognized by purchasers (Chiara and Peter, 2008).

A variation of the approach in comparing the effects of an environmental attribute involves comparing the price of a single piece of property at successive sales. By correcting for other factors that might influence the value of the subject property (the number of rooms in a house, the quality of the neighborhood, etc.), economists are able to isolate the implicit price of some amenity or package of amenities which has changed over time. From a sample of closely-similar marketed goods, an implicit price is found which reflects the value of the different characteristics of these goods. The contribution of various characteristics is identified statistically (Ojeda *at al.,* 2008).

Chiara and Peter (2008) argue that, a hedonic price function can then be formulated which expresses the price of the marketed item in terms of all these characteristics. The partial derivative of the hedonic price function with respect to the characteristic of interest yields a measure of the marginal value of that characteristic. The hedonic technique depends on observable data resulting from the actual behaviour of individuals. Market data on property sales and characteristics are available from real estate services and municipal sources and can be readily linked to other secondary data sources.

The hedonic technique is as yet relatively rarely applied to measuring values of water or water quality. A large enough sample of transactions may be difficult to obtain. If water resources are already in public ownership, market transactions may not be available. Buyers and sellers must be able to recognize the actual physical differences in the level of the characteristics to be valued, which may be difficult when water supply and quality are highly variable. Besides, when estimating the benefits of both environmental and recreational improvements, property values may reflect only a part of the total. It is likely that people other than property owners for instance; day visitors who travel to the area from elsewhere also gain. As Chiara and Peter (2008) suggested, with such limitations, it is difficult to generate statistically reliable and economically plausible results using the hedonic technique.

2.2 Water Management

Water management can be looked at under four thematic areas, first, the global changes in irrigation schemes management; secondly, the potential impacts of IMT; third, the basic status of Rwanda's irrigation water management as area to be studied; and fourthly, the features of associations of water users. Each of these themes is explained below.

2.2.1 Global changes in irrigation schemes management

Worldwide, irrigation schemes are now faced with decentralization and privatization policies, aiming at increased local participation, and at relieving the Governments from the burden of financial and technical support (IWMI, 2003). During the past three decades, a large number of formerly State-owned and public sector managed schemes have been transferred to users (through the so-called Irrigation Management Transfer -IMT), which are now expected to bear at least the expenses incurred by operation and maintenance (Vermillion, 1997).

Over the past three decades, governments in both developed and less developed countries have transferred public companies and other state enterprises to the private sector. While originally concentrated in the manufacturing and transportation sectors, privatization has now extended to almost all sectors of the economy, including the provision of water services such as potable water and irrigation (Johnson, 2002 as cited by Ntsonto, 2005).

Increasingly, countries are embarked on a process of transferring the management of irrigation systems from government agencies to Water Users Associations (Perret, 2002). This process, which is called Irrigation Management Transfer (IMT), includes state withdrawal, promotion of the participation of water users, development of local management institutions, transfer of ownership and management. The broad objective of IMT has been increasing irrigation performance and reducing demands on the public budget. IMT seems to improve economic conditions by reducing the role of the state agents trough privatization and empowerment of local communities (Kamara *et al.*, 2001).

The Kibaya –Cyunuzi scheme has been managed by government. Since 2006, the scheme has proven to be so inefficient that the farmers have decided to take over the management of the scheme. The underlying principle of this arrangement was to encourage farmers and local communities to take responsibility for the management of local resources.

2.2.2 The potential impacts of IMT

The primary stakeholders, farmers, irrigation agencies, and the government should be considered in Irrigation Management Transfer. Using the experience from Mexico and Turkey as examples, Groenfeldt and Sun (personal communication, 2009) suggest the following potential impacts:

Table 1: Impact of IMT on diverse perspectives

Positive Impacts	Negative Impacts
A. Farmer Perspective	
✓ Sense of ownership	✓ Higher costs
✓ Increased transparency of processes	✓ More time and effort required to manage
✓ Greater accessibility to system personnel	✓ Less disaster assistance
✓ Improved maintenance	✓ No assured rehabilitation assistance
✓ Improved irrigation service	✓ Less secure water right
✓ Reduced conflict among users	
✓ Increased agricultural productivity	
B. Government Perspective	
➢ Reduced O&M costs to government	➢ Less direct control over cropping patterns
➢ Greater farmers' satisfaction	➢ Need to reduce staff levels
➢ Reduced civil service staffing levels	
➢ Reduced costs to the economy (greater economic efficiency)	

Source: Groenfeldt and Sun (2009)

2.2.3 Basic status of Rwanda's irrigation water management

In Rwanda, special institutions have been set up mainly in canal system in most of the irrigation schemes. A council or management committee composed by representatives from special management institutions, collective organizations and water users is in charge of studying and deciding on the important issues in the management of irrigated areas. These institutions are responsible for maintenance, water allocation, calculation and collection of water bills and the comprehensive operation and management of water and soil resources (KWAMP, 2008).

Recently, the above-mentioned management structure played a big role in promoting the country's agricultural and rural economic development. However, because the scope of water users' participation in management is very limited, the state-level institutions show little concern over the maintenance of projects. In addition, the water price in the irrigated areas is too low, and collection of water bills is very difficult (REMA, 2009).

In light of the above-mentioned problems, reforms in various localities, which include improvement of management structure, adoption of water price reforms and implementation of contract of responsibility system have been undertaken. Water users have been encouraged to be more participatory in the management of their irrigation systems.

2.2.4 Features of associations of water users

Concretely speaking, the associations of water users set up in various localities have the following features (Liu, 2007).

a) The associations are not established by administrative divisions, but by water bodies, which are favorable to the unified development and utilization of water resources.

b) The organizations are non-governmental. In-service government officials are not allowed to work part time in the associations in order to reduce administrative intervention.

c) The associations are established democratically. The convention of representatives of water users is the source of power for the association while the water use group is the policy making body and the executive committee is the secretariat.

d) The affairs of the association are decided democratically, managed according the rules and bound by the law.

e) The functions of the association are all-dimensional. It manages the water, canals, maintenance, and collection of bills. Its institutional setup is standing and therefore operates sustainably.

f) Its internal disputes are conciliated by the government and water administrative department or arbitrated by the judiciary.

2.3 Empirical Studies on Irrigation Water Valuation and Management

Water has unique characteristics that determine both its allocation and use as a resource in agriculture; water is a vital component in production especially in the Irrigation sector. Over the years, many researchers have examined the valuation of water as an instrument for improving water allocation in irrigation systems (Karthikeyan *et al.*, 2009).

Faux and Perry (1999), estimated irrigation water value using hedonic price in Malheur County, Oregon, found that, the value of irrigation water in this place is estimated at US $9 for an acre-foot on the least productive land irrigated, and up to US$ 44 per acre-foot on the most productive land.

Renwick (2001) has valued water in irrigated paddy cultivation and reservoir fisheries in Sri Lanka. The author used a Residual Imputation Method (RIM) and found the estimated total annual value of water in irrigated paddy production to be US$ 3.1 million; also the study demonstrated significant potential, financial and economic gains to irrigated agriculture from improvement of water management practices.

Ward and Michelsen (2002) reviewed several issues on concepts and policy applications that must be considered in deriving accurate estimates of the economic value of water. These include establishing common denominators for water values in quantity, time, location and quality; identifying the point of view from which values are measured; distinguishing the period of adjustment over which values are estimated; and accounting for the difference between total, average, and incremental values of water. Using drought policy analysis of the Rio Grande Basin, Ward and Michelsen (2002) concluded that, the economic value of water comes from the many uses to which water can be put in satisfying people's needs. Furthermore several economic and hydrologic factors affect the value of water.

Kadigi *et al.* (2004) assessed the value of water in irrigated paddy and hydroelectric power (HEP) generation in the Great Ruaha (GR) Catchment in Tanzania using the Change in Net Income method. The average values of water for irrigated paddy were estimated at USD 0.01 and 0.04 per m^3 for abstracted and consumed water respectively. For HEP, the values were relatively higher USD 0.06-0.21 per m^3 for gross and consumed water respectively.

Hussain *et al.* (2007) provided an overview of the issues in valuing agricultural water and identified a range of factors and determinants of the agricultural water value in their study of measuring and enhancing the value of agricultural water in irrigated river bassin. The indicators deloped are applied using primary and secondary data from Indus basin Pakistan, to demonstrate how water value varies across scales and time. The study suggested that there is no single value of water, the value of water differs temporally and spatially. Four key dimensions in estimating water value have to be considered namely, time,space , use and impacts.

Speelman *et al.* (2008) applied RIM to calculate water value for small-scale irrigation schemes in the North West Province of South Africa. The study found an average water value of US$ 188/m^3, in line with the expectations for vegetable crops. Furthermore, the crop choice and the irrigation scheme design and institutional setting were shown to significantly influence the water value, whilst individual characteristics of farmers proved to be less important.

On the side of agricultural water management, Abdullaev and Mollinga (2010) examined water management by applying a framework for socio-technical analysis in some selected Water Users' Associations (WUAs) in northwest Uzbekistan's Khorezm region. The study showed that the WUAs are becoming arenas of interaction for different interest groups involved in water management. The socio-technical analysis of Khorezm's water management highlights growing social differences at grass root level in the study of WUAs. The process of social differentiation is in its early phases, but is still able to express itself fully due to the strict state control of agriculture and social life in general.

In Rwanda, insight into the value of water has not been a subject to study, yet fiew studies have been conducted in irrigation water management. Mati *et al.* (2008), identified Agricultural Water Management Interventions with Proven Returns to Investment to smallholder farmers by using different technologies, that is, gravity fed-irrigation found in low land. Household variables have been considered to influence those technologies. One of their findings shows that rice production on gravity fed-irrigation increased by 39% and 13 % in utilization of valley bottoms. Murengerantwali *et al.* (2008) studied social aspect of irrigation management in Migina marshland, the outcome of this study shows that the stakeholders must not be ignored when designing new infrastructures and choosing irrigation technologies.

2.4 Literature Gap

This chapter has discussed the strengths and limitations of the various valuation techniques and some empirical examples. Taking into account the current features and constraints attached to smallholder irrigation sector, examining the value of irrigation water in smallholder farming system and potential implication of change in water management on these water uses are still raising an issue to research on. However, drawing from this discussion, as Hussain *et al.* (2007) argue, it is appropriate to use the concept of value of water in assessing benefits of irrigation water.

In Rwanda few published works are available that lay out socio-economic information that can be used to support water decisions. For these reasons, examination of economic factors that determine the value of water is needed to contribute to the allocation and management of irrigation water according to the crops water requirements. In addition, knowledge about irrigation water values can reduce conflicts among water users due to proper water allocation and management, after that, provides indications on the reliability of the investments in the sector.

On a case study basis, only two methods were chosen. Residual Valuation Method given that it can be based on the premise that water is paid after all other inputs in the production process of smallholder irrigation scheme are paid off. The value of water is thus computed by subtracting total cost from total revenue and then dividing the residual value or gross margin by the quantity of water used. And Contingent Valuation Method: since this method does not rely on market data, it would be useful in estimating value of water in smallholder irrigation system. The problem is that smallholder irrigation farmers do not consider the value of water as a relevant unit. They express WTP using units that make sense with regard to their cropping systems. Thus the need to apply this method to investigate the farmers' WTP by linking gross margin gained from irrigation water used and accounting cost (Operation and maintenance costs).

CHAPTER THREE

3.0 METHODOLOGY

Empirical estimates of the value of irrigation water provide important evidence on the farmers' ability to pay and effective management in implementing cost recovery programs for development projects, and for long-term sustainability purposes. This chapter presents a brief description of case study area and methods of data collection and analysis.

3.1 Conceptual Framework

The following conceptual framework is proposed to assess water value and Management in smallholder irrigation context. In this framework, the water value is calculated at a total gross margin of output. Farmers' characteristics (age, gender, and education), farm size, irrigation water availability, invested capital, membership to WUA, access to credit, and contribution of supplementary crops on farmers' income from farming in the scheme determine the farmer's willingness to pay for irrigation water, and affect water value.

In addition to that, the economic value of irrigation water gives a clue to appropriate water allocation and management which was evaluated using a socio-technical analysis borrowed from Mollinga (2003) for describing two interlinked parts of water management systems: one is infrastructure and the second is human factor in managing water. Socio-technical analysis is based on the linkage among physical, organizational and socio-economic dimensions. These are interlinked processes in water control.

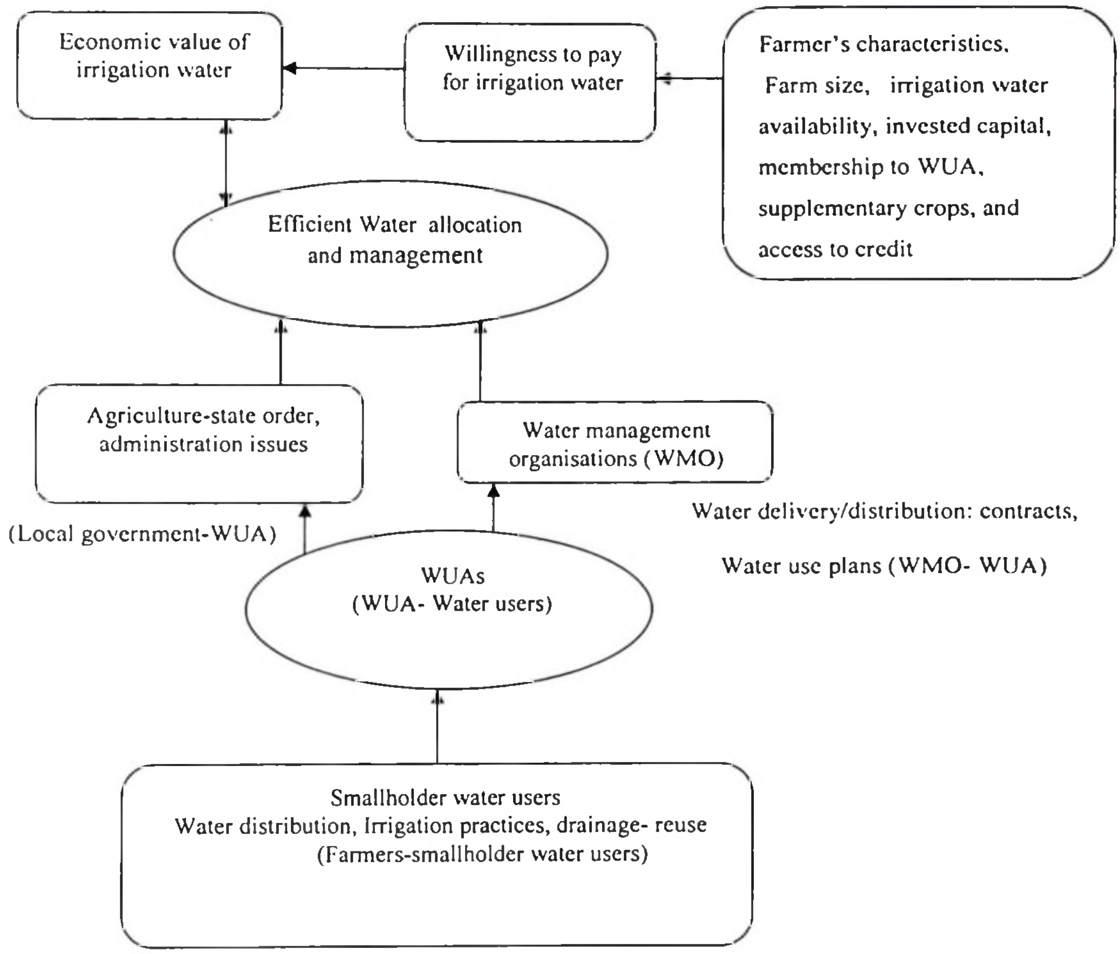

Figure 1: The conceptual framework of the study

To capture the processes of water control, it is very important to select specific locales or sites where the capacity to process and act can be observed concretely. One of these locales is the establishment of organizations such as Water Users' Associations (WUAs). Four specific interfaces can be identified at WUA level: local government-WUA, water management organizations (WMO)-WUA, WUA-water users (farmers), and water users (farmers)-water users.

3.2 Location and Description of the Study Area

Kibaya-Cyunuzi is a small scale Irrigation Scheme located in Kirehe district in the western province in Rwanda. It is a swamp that forms a Kibaya-Cyunuzi marshland complex, as cited in Organic Law N° 04/2005 of 08/04/2005 determining the modalities of marshlands Protection as fragile ecosystems in Rwanda. The swamp has permanent water source (Kabilizi river), where water abstraction is by gravity. The scheme command area is 196.5 ha. The farmers in the area practice two overlapping seasons per year and the main crop grown is Paddy rice and vegetables in season C. The scheme has one source of water, Kabilizi River.

The swamp rice scheme has been selected because it has got a chance of being developed by Rural Sector Support Project of the Ministry of Agriculture and Animal Resources (MINAGRI); and the WUA model, which has been initiated, plays an important role in increasing efficiency in the use of water.

3.3 Research Design and Sampling

This study adopted a cross-sectional data which allowed data to be collected at a single point in time without repetition from the target population. The primary data for this study were collected from farm households selected from two zones (Kibaya and Cyunuzi) under Kibaya-Cyunuzi Irrigation Scheme. The study targeted farmers farming in the scheme seasons A and B 2010. It also interviewed leaders, technical personnel in the scheme, leaders of WUA, personnel responsible from the district as well as from development projects in that area. Given the diversity and nature of the sampled population, the data obtained from all these stakeholders were assumed to be reliable and consistent. Farmers in that scheme are grouped in a farmers' Cooperative (COOPROKI) from each zone.

They constituted a sampling frame from which, 110 farming households were randomly selected.

3.4 Data Collection Requirement

To achieve the objectives, the study used both primary and secondary data.

3.4.1 Primary data

Primary data were collected using a semi structured and pre tested questionnaire. Questionnaires have been administered to farmers whom were randomly selected but representing both zones in the scheme. Scheme leaders, Water User' Group and farmers gave the history of the scheme and the development achieved. They also provided the information on water management organization, operation and maintenance of irrigation systems, irrigated rice and production costs, and revenue. The gathering of such information was done through focus group discussions and questionnaire administered to the sampled farmers.

3.4.2 Secondary data

Secondary data were collected from the relevant sources, including Sokoine National Agricultural Library (SNAL), district agricultural and irrigation zone offices and from the Ministry of Agriculture. A review of relevant government published reports has also been used in data collection. Secondary data required for this study also included climatic data (rainfall from weather station) which is one of the sources used in calculation of crop water requirement, and hydrological data in the scheme in order to determine irrigation water value.

3.5 Data Analysis

The information collected was coded using the computer for the analysis. The data were analyzed using statistical package computer software namely the statistical package for social sciences (SPSS). Generally, the study utilized both statistical and descriptive analysis, including means, frequencies and cross tabulations to identify farmers' conditions, contribution rates to the operation and maintenance activities. A residual imputation method was employed to evaluate the economic value and management of water in the scheme. In relation to water management, a socio-technical analysis has been adopted.

3.6 Determination of Water Value

Neoclassical economic theory predicts that in a competitive market, the economic value of a good corresponds to its market price, which reflects individuals' willingness to pay for that good. For water, however, due to the limited role played by markets, valuation techniques must be used Young (1996), cited by Speelman *et al.* (2008).

Several methods for estimating the value of water have been developed. They can be grouped according to whether they rely on observed market behavior and data to infer economic value "indirect techniques", or alternatively use survey methods to obtain valuation information directly from water users "direct techniques" (Agudelo, 2001). In general, the most scientifically accepted methods are those based on actual market behaviour and information (Hussain *et al.*, 2007).

In the case of Rwanda, there are no water markets from which values for irrigation water can be derived. Furthermore, since subsistence farmers exploiting marshland in the study area are paying water fees in addition to other fees, the establishment of a relationship between price and demand from actual behaviour to generate demand function is not a straightforward matter.

However, the study has used inductive methods to investigate the economic value attributed to water and its management in a Small Holder Irrigation Scheme. Two approaches that were employed, these include the Residual Imputation Method (RIM) (see Lange, 2007), and WTP by means of Contingent Valuation Method (CVM) to estimate water values for the studied small irrigation scheme.

3.6.1 Residual Imputation Method (RIM)

To evaluate water value by crop type, the Residual Imputation Method (RIM) was adapted to measure the return to water out of the gross margin obtained from all the production input employed. Before applying RIM, the analysis of the value of water in crop production started with modeling of crop water requirement using FAO's CROPWAT model (8.0 version). This is a computer programme used to calculate crop water requirement, irrigation water requirement, the irrigation scheduling, and yield reduction due to water shortage of a given region from climatic and crop data. The analysis in this study was limited to crop water requirement.

Considering the production function process in which the crop output Y is produced under irrigation by the following factors; Capital (K), Labour (L), water (W) used and other non-water inputs (Z).

Note that water is used as an intermediate good (input to produce another good) in irrigation.

The production function is:

$$Y = \int(K, L, W, Z) \qquad (1)$$

Assuming constant prices under competitive factor and product market;

$$TVP_Y = (VMP_K \times Q_K) + (VMP_L \times Q_L) + (VMP_W \times Q_W) + (VMP_Z \times Q_Z) \qquad (2)$$

Where: TVP = Total value of product, Y

VMP = Value marginal product of resource *K, L, W, Z*

Q = the quantity of resource

Assuming VMP$_i$ = P$_i$, that is, value marginal products equal the prices of resources and then by substitution and rearrangement of the equation, it follows that:

$$P_W = \{TVP_Y - [(P_K \times Q_K) + (P_L \times Q_L) + (P_Z \times Q_Z)]\} / Q_W \qquad (3)$$

Note: QW was estimated from CROPWAT programme

This gives out the value of the shadow price of water (P$_w$), which is basically the Economic Value of Water. The residual method has been widely used to derive economic values of water, especially in irrigated agriculture (Young, 1996; Renwick, 2001; Kadigi *et al.* 2004; Yokwe, 2005).

In fact, the assumptions of the RIM are not overly restrictive, but care is required to assure that conditions of production under study are reasonable approximations of the conceptual model. The main issues can be divided into two types (Young, 1996; Lange and Hassan, 2007): issues relating to the specification of the production function, and those relating to the market and policy environment (i.e. the pricing of outputs and non-residual inputs). If inputs to production are omitted or underestimated, then the RIM will generate inaccurate estimates.

To overcome the first problem, all relevant inputs should be included in the model. The second problem can be solved by determining shadow prices for the inputs that are not correctly priced. Because of this sensitivity to the specification of the production function and the assumptions about market and policy environment, the residual imputation method is only suitable when the residual input contributes a large fraction of the output value. However, this is the case for irrigated agriculture in water scarce regions (Speelman *et al.*, 2008).

3.6.2 Willingness to pay for irrigation water

Willingness to Pay (WTP) is an economic concept, which aims at determining the amount of money a consumer is willing to pay for the supply of a given good. The consumers' WTP is becoming increasingly popular and is one of the standard approaches that is used by market researchers and economists to place a value on goods or services for which no market-based pricing mechanism exist (Khawaja *et al.* 2001). Experience shows that very high level of WTP for water is observed in developing countries (Briscoe *et al.*, 1995).

The CVM was used to elicit information on household willingness to pay for irrigation water. The contingent valuation method (CVM) is a direct method of assessing WTP. It is a survey-based stated preference valuation technique used to value non market environmental amenities. In the last two decades, Contingent valuation method has gained popularity and has become a major tool for valuing environmental amenities. According to Hassan and Lange (2004), this approach does not rely on market data, but asks individuals about the value they place on something, that is, by asking them how much they would be willing to pay for water. Questions can be asked in a variety of ways, using both open-ended and closed-ended formats. In the open-ended format, respondents are asked to state their maximum willingness to pay for the environmental improvement. With the closed-ended format, also referred to as discrete choice, respondents are asked whether or not they would be willing to pay for environmental improvement, or whether they would vote yes or no for a specific policy at a given cost.

Since the key advantage of CVM does not rely on market data, it is useful in estimating the marginal value of water in Smallholder Irrigation System (SHIS). Karthikeyan *et al.* (2009) applied this method to value the WTP for irrigation water in tank irrigation systems in South India. According to the survey results by Calatrava and Sayadi (2005), who studied the evaluation of water and willingness to pay analysis with respect to tropical fruit production in Southeastern Spain, growers paid an average price of €0.14 m^{-3} for their water; the lowest price paid was €0.054 m^{-3} and the highest was €0.192 m^{-3}.

The current study has used open-ended format, where respondents were asked their maximum willingness to pay for irrigation water. Then after factors that affect that WTP have been analyzed.

3.6.3 Factors affecting farmers' willingness to pay for irrigation water

In analyzing factors influencing farmers' willingness to pay for irrigation water in the scheme, multiple regression model was adopted. The factors examined included: farmers' characteristics (age, education levels and gender), farm size, irrigation water availability, capital invested, access to credits, membership to water users association and contribution of supplementary crops. The multiple regression model is represented as follows:

$$Y_i = \beta_0 + \beta_1 AGE + \beta_2 EDU + \beta_3 GENDER + \beta_4 FS + \beta_5 IWA + \beta_6 CAP + \beta_7 AC + \beta_8 MWUA + \beta_9 SCr + \epsilon_i$$

Where:

Y_i	=	Average income of farmers
β_0	=	Intercept
$\beta_1, \beta_2 \ldots \beta_9$	=	Coefficients
AGE	=	Age of the respondents
EDU	=	Education level of the respondents
GENDER	=	Gender (sex of the respondents)
FS	=	The plot size cultivated by the household in the scheme for the seasons A and B 2010
IWA	=	Irrigation water availability
CAP	=	Capital
MWUA	=	Membership to WUA
AC	=	Access to credits
SCr	=	Contribution of supplementary crops
ϵ_i	=	Disturbance term

Regression equations generated by ordinary least square are associated with a number of problems depending on the type of the data used, the nature and form of the regression model employed in the analysis. The common problems encountered in the regression analyses include multicollinearity, heteroskedasticity and autocorrelation (Gujarati, 1998). This study used cross-sectional data; such data are likely to have multicollinearity and heteroscedasticity. The problem with heteroscedasticity is that ordinary least squares estimators while still linear and unbiased can no longer provide minimum variance. This makes the least square estimators unreliable; that is, the variance will be large leading to small t-values. The small t-value associated with large variance leads to a situation whereby the explanatory variable' parameters are rejected more frequently than necessary.

To contend with this situation in the study, a natural logarithm transformation of the dependent variable data was adopted because changing the functional form of the model can treat heteroskedasticity problem (Gujarati, 1998).

Another problem associated with multiple regressions is the presence of the multicollinearity. This problem is caused by the existence of the linear relationships among the explanatory variables. The symptoms suggesting the existence of the multicollinearity include: the existence of a very high coefficient of determination (R^2), illogical signs of the parameters included in the model, and F- ratios being highly significant whilst most of the individual t-ratios are insignificant. The data in this study show no serious sign of the existence of multicollinearity.

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CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

This chapter presents and discusses the results on economic value of irrigation water, farmers' willingness to pay for irrigation water and its related explanatory factors. In addition, irrigation water allocation and management in the scheme is discussed. At the end of this chapter farmers' opinions and problems face in the scheme are also presented.

4.1 Socio-economic Characteristics of Respondents

Socioeconomic characteristics bear essential attribute to socioeconomic and farming practices adopted by farmers. Studying these characteristics is thus important in order to understand the general behaviour and attitude of the people in the study area. The socio-economic characteristics discussed in this section include, sex, marital status, education level, farm size, and household size

4.1.1 Sex of respondents

The socio-economic profile of the sample respondents revealed that 75.4% were males and 24.6% were females; this shows that the participation of males in agriculture is higher than that of females. This trend is in contrast with the countrywide profile where agriculture provides work for 80% of the total economically active population where 60% of agricultural workers are female (EDPRS, 2008). It can be said therefore that female participation in irrigation farming is relatively low in the study area.

Table 2: Distribution of respondents by sex in the study area (%)

Sex	Kibaya (n=55)	Cyunuzi (n=55)	Total
Male	36.3	39.1	75.4
Female	13.7	10.9	24.6
Total	50	50	100

4.1.2 Marital status of the household

From the results in Table 3, majority (i.e. 71.8%) of the respondents were married while 3.65% were single and 21.8 % of the household heads were widows. This shows that young people are less involved in agricultural activities and managing water resources in the study area. Marital status influences decision making at the household level, including the use of water in irrigated agriculture and management of water sources and environmental resources. Understanding the distribution of marital status of household heads is important in assessing management and utilization of water for irrigation. Therefore it is important to have a good percentage of young people encouraged to join farming activities under the irrigation schemes.

Table 3: Distributions of head of household by marital status (%)

Marital status	Kibaya	Cyunuzi	Total
Married	31.8	40	71.8
Single	3.6	0	3.65
Divorced	0.9	1.9	2.8
Widowed	13.7	8.1	21.8
Total	50	50	100

4.1.3 Education level of household heads

From the results in Table 4, the majority of respondents 72.6% had attained primary education. The higher the education levels the higher the knowledge on wise use of irrigation water. In the study area, there are only a few people with no formal education (illiterates). The situation indicates that, the studied community of farmers has enough education to follow basic knowledge and farming skills if provided. However providing farmers with proper farming knowledge and techniques would still improve their economic status irrespective of their education level, this is because the farmers have requisite practical knowledge and skills which can be use.

Table 4: Distribution of household heads by education level in the study area (%)

Education level	Kibaya	Cyunuzi
None	10.9	3.7
No completed primary	6.4	9
Primary	38.1	34.5
Post primary	3.7	2.8
No completed secondary	0.9	0
Total	55	55

4.1.4 Households size and age of respondents

From the results in Table 5, the average household size seems to be high (5.60), this figure exceeds the national average household size in Rwanda which is between 3 and 5 people (EDPRS, 2008). As Kessy (1998) observed, development pressures over resources are caused by, among other things, increasing human population.

Table 5: Households size and age of respondents

Variable	Minimum	Maximum	Mean
Age of respondent	23	60	37.96
Household size	1	10	5.60

4.1.5 Average farm size of household

Paddy is a major crop grown in Kibaya-Cyunuzi scheme. According to Integrated Rwanda rice commodity chain (2010), paddy production has been given high priority by the Government, especially in the valley bottom marshlands, where the crop has a high production potential. Here rice is potentially capable of yielding over seven metric tons per hectare for each of two crops per year, as long as water is available. This is far greater than the returns from any other crop that can be planted in the marshlands. Vegetables are often cultivated in the plots where water is insufficient and there are not prioritised in the valley bottom marshlands as paddy that's why its minimum value is 0.

Table 6 : Land allocation to crops found in the scheme

Variable	Mean(acre)	Minimum(acre)	Maximum(acre)
Paddy	0.2	0.0	0.8
Vegetables	0.0	0.0	0.3

4.1.6 Land ownership in the scheme

Kibaya-cyunuzi irrigation zone officer and farmers, in responding to questions related to land ownership and transfer in the scheme, according to the draft law determining the use and management of marshlands in Rwanda (2009), there is a common rule and/or regulation that marshland resource, which means all biological resources within a specific marsh including vegetation, wildlife resources, marshland produce and associated ecosystems are under a registration of land lease agreement provided by the Ministry. For this reason in many cases, there is no land re-allocation, but individually owned plots do exist under the supervision of farmers' cooperatives. The present tenure arrangement does not provide much opportunity and incentive for uninterested farmers to sell out and for interested and capable ones to expand their holdings. This may prevent the achievement of full productive potential of the irrigated land.

4.2 Economic Value of Irrigation Water

The costs of production for paddy without the cost for irrigation were calculated. These costs of production were deducted from gross returns of the crop. These residual revenues were further divided by the amount of water applied (m^3) to get the economic value of water for irrigation for a particular crop. The amount of water used was estimated from FAO's CROPWAT programme (8.0 version). This is a computer programme used to calculate crop water requirement. Therefore, the economic value of water for irrigation has been estimated for the crop cultivated in the study area according to their costs from the crop water requirement.

The revenue earned by the farmers for each crop was calculated by multiplying the production by the market prices. On the input side, the costs of fertilizers and pesticides were taken into account. These were considered as relevant inputs in the production process. For these inputs and the outputs, market prices are thus considered to equal the shadow price. Price correction, as proposed by Lange and Hassan (2005), is necessary to fulfill the assumptions of the RIM.

Table 7: Irrigation water value in paddy within Kibaya-Cyunuzi scheme

Parameters	Value
Average revenue from irrigated paddy per Ha (Rwf)	1 093 792
Average cost for non water inputs in irrigated paddy per Ha (Rwf)	790 380
Average residual revenue attributable to water (Rwf)	303 412
Estimated water requirement (m^3)	58 011.87
Estimated average value of irrigation water (Rwf/m^3)	5.23
Average paddy yield (Kg/ha)	5 200
Estimated average water productivity kg/m^3	0.08

The government of Rwanda has given high priority to production of paddy in the country's marshlands (Integrated Rwanda rice commodity chain, 2009), it is because of this that paddy has become one of the main crops in Kibaya-Cyunuzi scheme.

However, the value of water was calculated for paddy crop only because this crop was identified as the main crop in the scheme whereas vegetable crop is in the area which is not reached by water in the scheme. According to the scheme officer, the scheme has one part whereby water doesn't reach; however the scheme's future plan is to cover the whole area under the scheme.

As shown in Table 4.6, the average value of irrigation water was calculated to 5.23 Rwf (US$ 0.009) per m^3 of water. This value is relatively low compared to the value of water estimated at US$ 0.1 by Kadigi *et al.* (2004) in the study on the value of irrigated paddy in the Great Ruaha, Tanzania; as well as comparing with an average water value of US$ 0.188/m^3 calculated using the RIM by Speelman *et al.* (2010), for small-scale irrigation schemes in the North West Province of South Africa. Furthermore, the crop choice, the irrigation scheme design and institutional setting were shown to significantly influence the water value.

One obvious identified reason of economic value of water being low was that Kibaya-Cyunuzi scheme experienced serious water shortage last season due to drought and thus, a big part of the area in the scheme is without sufficient water. However, the results of the current study concur with the recommendation given by Hussain *et al.* (2007), whereby diversifying cropping pattern towards high value multiple cropping by switching from high water consuming (low value crops) to low water consuming (high value crops) is considered among the means for improving the socioeconomic value of water at micro local level Although, Kibaya-Cyunuzi scheme has a mono-crop cultivation of paddy. The average productivity of irrigation water (paddy produced per drop) was very low in the scheme. According to the study results, the average water productivity is 0.08 kg/m^3.

As it is not easy to specify the main cause of low water productivity; poor plot leveling, leading to poor water control, poor plot bunds and lack of water control structures in the canals, such as, water gates and proper water distribution boxes seem to be some of the major factors for low water productivity. Farmers feel that access to seed and water are the two most limiting factors in increasing productivity of their paddy crop.

When these results are compared with those obtained in the study by Kadigi *et al.* (2004) in Usangu basin in 2004, which is 0.18kg/m^3 and, when comparing with the average for the Sub Sahara African countries, which is about 0.25 kg/m^3; it is clear that the average water productivity from the studied irrigation scheme is very low. It is important therefore, that the Rwandan agriculture policy focuses means of increasing productivity of water.

4.3 Profit Margins and Returns to Labor in Paddy Production

Results in Table 8 show paddy as having a low profit margin in the scheme, and this does not match with the labor requirements neither does it match with the returns. Paddy in the case study has less attractive returns of 1 035/ man day. As it has been revealed in other studies in Rwanda, considering the complexity of rice value chain, the smallholder rice farming in Rwanda is constrained and characterized by unsustainable agricultural practices such as mono cropping, inefficient inputs, inferior seeds, improper control of pests and diseases, and inappropriate soil and water management. It is obvious that these problems are the prohibiting factors to farmers in raising the productivity of paddy in Kibaya-Cyunuzi scheme.

Table 8: Profit margins and returns to labor in paddy production

Type crop	Yield T/ha	Average Price Rwf	Gross Income Rwf	Production costs Rwf	Profit Margin Rwf	Man days	Return to labour Rwf/mandays
Paddy	5.2	171.5	891800	790380	101420	98	1035

4.4 Willingness to Pay for Irrigation Water

The WTP value in our study has been reviewed for irrigation water, operation and maintenance of irrigation infrastructure; since this value is perceived by farmers as combined, there is no value attributable to irrigation water only. The supporters in water provision even the scheme management committee has decided to combine the payment of irrigation water and its related infrastructures in what they call *redevance*. All farmers in the scheme (100%) are aware of that contribution; they know very well its importance and they are willing to pay. The only issue for discussion is the amount they are willing to pay depending on various factors. This is the reason why in this case, farmers' willingness to pay has been investigated using only open ended questions. The mean WTP obtained from the open-ended question was 400 Rwf per plot (0.05 ha) equivalent to 8000 Rwf per ha per annum (US$ 13.3 per ha per annum).

4.5 Factors Affecting Farmers' Willingness to Pay for Irrigation Water

To test the effect of various factors, which were hypothesized to determine farmers' willingness to pay for irrigation water, regression equation was employed. This equation was aimed at examining the influence of farmers' characteristics (age, gender, and education), farm size, irrigation water availability, invested capital, membership to WUA, access to credit, and contribution of supplementary crops on farmers' income from farming in the scheme. The equation examined the effect of the mentioned factors to dependent variable, that is, "farmers' willingness to pay for irrigation water" in the scheme.

Table 9 gives the summary of independent variables used in the regression analysis showing the form and units that the variable takes.

Table 9: Summary of the independent variable used in regression analysis

Variable estimated	Description
AGE	Age of the respondents in years
EDU	Education level of the respondents (1 = None, 2 =No completed primary, 3 = Primary education, 4 =Post primary, 5= Secondary education, 6 = Higher education).
GENDER	The sex of the respondent (Dummy variable where: 1 = Male, 0 = Female)
FS	Farm size cultivated by the respondent for 2010 seasons A and B (ha)
IWA	Irrigation water availability where 0 = Not enough, 1 = Partially enough, 2 = Quite enough.
MWUA	Membership to WUA (Dummy variable where: 0 = member, 1 = no member).
AC	Access to credits (Dummy variable where: 0 = No, 1 = Yes.)
CPT	Capital invested in farming in 2010 season in Rwf.
SCr	Contribution of supplementary crops in percentages.

4.5.1 Expected signs from the variables' coefficients

AGE: Age of the Household Head. It was assumed that elder farmers had experience on farming specifically on irrigated farming and therefore they were expected to perform better than younger farmers. This variable was expressed in terms of the number of years; thus the variable was expected to carry a positive sign.

EDU: Education level of the household head.

Education level is expected to have a positive influence on farmers' willingness to pay because the higher the levels of education for the household head the higher his/her ability to understand.

GENDER: Sex of the household head

The percentage of men involved in farming in the scheme was found to be higher than that of females. It was therefore anticipated that gender could influence farmers' willingness to pay.

FS: Farm size.

The variable of farm size under paddy/rice cultivation was expected to have a significant positive influence on farmers' willingness to pay such that the larger the plot/farm sizes the higher the farmers' willingness to contribute to irrigation water.

IWA: Irrigation water availability

It was expected that the availability of irrigation water would increase crop yield, which would in turn increase income and stimulate farmer's WTP because water is considered to be the main input in irrigation. Therefore irrigation water availability and farmers' WTP are expected to be positively related.

CAP: Capital invested in farming in the scheme

Achievement of appropriate and timely farming operations as well as well-timed purchases and application of farm inputs depend on the availability of capital. Therefore, it was expected that capital would influence WTP positively, such that the greater the capital invested in farming the higher the incomes and WTP.

AC: Access to credits

It was expected that access to credit would give farmers an opportunity to increase their capital and income and hence influence positively their WTP for water.

MWUA: Membership to WUA

It was supposed that members of WUA would be more willingly to pay for irrigation water than would be non members.

SCr: Contribution of supplementary crops

The percentage contribution of supplementary crops was examined. It was expected that supplementary crops generate substantial amount of income to supplement the total farming income hence WTP for water. Therefore, this parameter was expected to have a positive influence.

4.5.2 Multiple regression results and analysis

The results in Table 10 show that, as expected, all coefficients were positively related to the dependent variable, and that jointly the estimated variables as indicated by the F- value ($F = 56.2$) were statistically significant ($p>0.05$). Similarly, the majority of the individual parameters attached to the estimated variables were also statistically significant ($p>0.05$).

a) The results revealed that farmers' characteristics estimated, that is, age and gender were all statistically insignificant. The results therefore suggest that age and gender of the respondents had no notable effect on farmers' WTP. On the other hand, they indicated positive relationship to the independent variable, but their effects are not significantly notable. The insignificancy of these farmers' characteristics was due to the fact that all farmers, irrespective of their ages and sex have an opportunity to farm in the scheme. Furthermore, farmers in these schemes received training on proper irrigation farming techniques. Therefore, the implementation and adoption seem to be easy. These results concur with those found by Speelman *et al.* (2008), which show that individual characteristics are less important in influencing the value of water.

b) The positive relationship between the average plots size cultivated and the WTP is attributed to the fact that in average, farmers in the scheme own or cultivate relatively small plots. Another fact is that most farmers use family labour before opting for other sources of labour; in this respect, water as an input is highly valued.

c) The positive relationship between the availability of irrigation water and WTP can be attributed to the fact that plots receive different quantities of water depending on where the plot is located in the scheme and whether or not the canals that channel the water are broken. There were lots of differences among farmers on the access to water; these differences were attributed to the various reasons; one part of the scheme is said to be not well rehabilitated, and has an incomplete irrigation structure, as a result some plots do not receive sufficient water. Irrigation infrastructures especially canals in most cases are not regularly cleaned, hence they block the water from running making farm plots at the far end receive very little water as compared to the plots near the source.Poor level of the plots also makes the crops get insufficient water.

d) The insignificance of the parameter attached to the capital invested is attributed to the fact that since farmers do not cultivate large farm, most of these farmers keep enough capital; thus, capital is not a limitation for increasing their WTP.

e) Membership to farmers' WTP that exists in the studied scheme is only of two possibilities, that is, member and non member. It was anticipated that to be a member influence farmer's WTP positively. WUA's members use their knowledge and expertise to maintain a public infrastructure the results therefore suggest that membership to WUA significantly influence farmers' willingness to pay. This can be attributed to the fact that members are well organized and they have in their organization a provision on the protection of water resources and on the prevention of water and water resources from being wasted.

Table 10: Multiple regression analysis results

Variable	Estimated coefficients	Std. Error	T-ratio
Constant	8.719	0.320	35.055*
Age of the respondent	0.000	0.006	0.123
Education level of the respondents	0.021	0.046	0.019
Gender (Sex of the respondent)	0.037	0.076	0.762
The plot size cultivated by the respondents in the scheme	0.321	0.056	2.820*
Irrigation water availlability	0.588	0.048	9.468*
Membership to WUA	0.345	0.086	2.894*
Access to credit facilities	0.323	0.089	2.380*
Capital invested in farming in the season 2010	0.120	0.015	1.400
Contribution of supplementary crops	0.001	0.000	3.207*

(Dependent Variable: Logarithm of the farmers' WTP)

R^2 = 76.4% F-value = 54.6* * = Significant at 5%

It can be noted from the results in Table 10, that all coefficients as expected were positively related to the dependent variable (Farmers' WTP for irrigation water), and that jointly the estimated variables as indicated by the F-value (54.6) were statistically significant ($p > 0.05$).

It is also noted that the coefficient of determination (R^2) is 76.4%, meaning that all of the independent variables together account for 76.4% of the total variation in the farmers' WTP for irrigation water. On the other hand, the results show that 23.6% of the variations in the farmers' WTP are attributed to other factors not included in the model.

4.6 Water Allocation and Management in the Scheme

Water management in our case study is reviewed at scheme level. The way farmers manage the water which is allocated to them is crucial for optimal crop production. The farmers use the water according to their own perceived needs and in most cases they do not want to be told what to do with the water supplied to them. Farmers are very much aware of their right of the share of water supply according to their zones in the scheme. However, at the plot level, farmers are not monitored (by the scheme, technical personnel and/or other farmers), to see how effectively they use the water. The absence of a monitoring mechanism is a weakness in water management, and which consequently raises questions on sustainability of the scheme. Attention has to be paid at a plot level because poor water management results into reduced crop productivity.

At the scheme level, the issue of equity in water allocation is important in order to avoid conflict among water users. To avoid inequalities, the irrigation management committee has divided farmers in the scheme into different zones and each zone is organised and has a well established schedule for water distribution.

The scheme is led jointly by a water users association (WUA) and a Farmers' cooperative. The WUA, which is in charge of water management, holds a water permit and signed an irrigation management transfer (IMT) with the Ministry of Agriculture. The farmers' cooperative holds the land lease and marshland management agreements and is in charge of supporting crop production. The cooperative signs yearly performance contracts with the district so that farmers act as an engine of economic growth.

WUA of Kibaya-Cyunuzi scheme is composed of three interfaces; the local government – WUA, WMO-WUA and Farmers-WUA. Under the local government – WUA interface, the WUA works together with a government representative at the district level (Kirehe District Agriculture Officer). Under the WMO - WUA interface- the water management related NGOs (e.g. RSSP - Rural Sector Support Project and KWAMP - Kirehe Water shade Management Project) assist WUA members through mainly training in water management. These non government institutions assist Kibaya-Cyunuzi WUA to extend irrigation structures throughout the scheme. Lastly, under the farmers – WUA interface, WUA members try to help and sensitize the rest of the farmers in the scheme about water management. These WUAs' interfaces in Kibaya - Cyunuzi scheme show the impact of institutional change via Irrigation Management Transfer. This is where farmers are provided with skills and become empowered by the various stakeholders in managing their own irrigation scheme leading to the improvement of water allocation and management.

Kibaya - Cyunuzi's WUA has managed to improve water allocation and management by assigning responsibilities to its members using three approaches; water management, agriculture and works teams. The WUA members in the water management team are tasked to prepare the schedules of water delivery and to monitor and prevent misuse and wastage of water. The WUA agriculture team is charged with preparation of crop plan, inspection of water utilization and to educate farmers on good agronomical practices. The Works team is charged with the improvement and repair of the irrigation system for efficient use of available water

Despite these efforts, the WUAs are still facing some challenges like the failure to adhere to the water delivery schedules, tampering with the irrigation systems, failure to adopt proper irrigation methods and irregular payment of the water tax and ground rent especially by other water users within the scheme who are non - members of WUAs.

4.7 Farmers' Involvement in Operation and Maintenance of the Scheme

Basing on the importance of Operation and Maintenance (O&M) activities of irrigation infrastructures in the scheme, there has been an institutional change (Irrigation Management Transfer) through the establishment of water users association in the scheme that made farmers responsible for their water control (allocation and management).

The study examined how farmers are involved in these activities, since O&M and agricultural productivity have a cause and effect relationship, that is, the sustenance of one depends on the good performance of the other (Samakande *et al.*, 2007). In irrigation, agricultural productivity increases with the increase of water productivity, hence, water value. Therefore, O&M activities are considered as some of the means by which economic water value, allocation and maintenance can be increased.

On responding to the question, how does the scheme involve farmers in the operation and maintenance activities; the irrigation officer in the scheme, the district agricultural officer, the scheme leader and farmers themselves said that farmers were involved in diverse ways; this particularly because the maintenance of the rice scheme depends on the free labour input of its members.

a) The scheme is sensitized and has formed an active Water use association in which operation and maintenance activities are included,
b) Scheduling all O&M activities at the beginning of each season on zonal basis

c) Organisation of communal works that involve farmers in various activities to maintain irrigation infrastructures in the scheme.

Obviously, smallholder farmers cannot do all of the activities manually, this is because some of these activities require special materials, and skills. Therefore, financial resources in ensuring smooth running operation and maintenance activities are unavoidable. To meet these requirements water fee including O&M fees are indispensable. Despite that water fee is crucial, the results show that on average the collection rate of such fees is just 72.3% (according to the scheme office) which, according to the leaders, is not enough. This is because the envisaged collection target is 100% which is intended to be achieved though sensitizing more farmers and enforce the methods and modalities of fee collection.

The timing as to when to collect water fee is very important because in most cases farmers do not have enough income for them to have enough servings which would otherwise be used for making any time payments. In the case of Kibaya-Cyunuzi scheme, water fees payment for the season that follows is paid during the harvesting time of the current season. This method is seen as suitable since it enables farmers to avoid spending water fees on other needs.

However, it was reported that owners of some plots which did not receive water properly even after the completion of the irrigation structure were hesitant in paying for the service that they were not sure of. Thus, it is recommended that the canal networks be extended as fast as possible in the whole area under the scheme.

4.8 Farmers' Opinions on the Scheme

From Table 11, 82.7% of farmers in the sample suggested that all famers in the scheme should pay for water and related services. This shows that farmers agree that irrigation water is a valuable good that should be paid for. But farmers with limited demand for water (owners of the plot that do not receive sufficient water due to incomplete irrigation structures) are not willing to pay. However, it is suggested by 17.3% of farmers that only farmers who irrigate a lot should pay. From these results it is recommended to the scheme officers and irrigation supporting projects to increase canal networks throughout the scheme for an equitable water distribution.

Table 11: Opinions of respondents on who should pay for water and related services

Opinions	Count(n=110)	Percentage
All farmers should pay	91	82.7
Farmers who irrigate a lot should pay	19	17.3
No payment	0	0

4.9 Problems Faced By Farmers in the Scheme

Table 12 shows major problems as disclosed by farmers. Generally, unfair market of their produce (paddy), high prices and untimely delivery of farm inputs and water shortages are the major problems facing the studied scheme. These problems may influence farm income which can discourage farmers from paying for their irrigation water and/or farming in the scheme. This makes the sustainability of irrigation infrastructure and productive lands questionable, since in irrigation farming water is the main input.

It has been observed that a large part (60%) of farmers market and opt to market their produce through hawkers. Farmers indicated that they do not have access to formal markets because of poor marketing characterized by lack of local markets.

The constraints experienced by farmers from Kibaya-Cyunuzi scheme were identical with those raised by rice growers in the whole country as illustrated by the analysis of production of rice cooperatives supported by Rural Sector Support Project (2009), Paddy rice is widely grown as an irrigated crop in Rwanda. However, farmers grow short and bold type varieties whose marketability is low.

Also water becomes scarce especially during the dry season in most of the marshlands where rice is grown. This scarcity is due to either problem in water availability and/or inequitable distribution of the available water. In old marshlands, water availability is a common problem. Due to poor maintenance, weeds and soils clog the irrigation canals. In new marshlands, the water equity, especially for rice fields in the tail ends of the water channels is perceived as a major concern by rice growers. Here, the sequential cropping of rice and the general attitude of farmers towards rice as the water loving crop raises the demand for water. However the equitable distribution of water is a major constraint here. Water equity is often the most fundamental cause of frictions amongst rice farmers in the country.

Table 12: Responses of farmers on problems faced in the scheme

Problem mentioned	Counts	Percentage
Unfair market of their produce	64	35
High price and untimely arrival of farm inputs	59	32
Water shortage	50	27
Incomplete construction of irrigation structures	12	6
Total responses	185	100

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

This Chapter dwells on the conclusion and recommendation of the study. The conclusion focuses on the following thematic areas: the economic value of irrigation water, famers' willingness to pay for irrigation water in Kibaya-Cyunuzi scheme, and Irrigation Management Transfer and WUA. The recommendations arise on the basis of the findings of this study and evidences from other studies on smallholder irrigation worldwide.

5.1 Conclusions

In view of the major findings of the study, the following are the conclusions made.

5.1.1 The economic value of irrigation water

The average value of irrigation water was calculated at 5.23 Rwf per m^3 of water, this value is low. One obvious reason identified was that Kibaya- Cyunuzi scheme suffered serious water shortage the previous season due to drought making a big part of it have insufficient water. The mono-crop cultivation of paddy was also among the reasons.

The average productivity of irrigation water (paddy produced per drop) was very low in the scheme. The study reveals that the average water productivity is 0.08 kg/m^3. It was also reported that the price charged for water does not reflect the actual cost of supplying the water to the site.

5.1.2 Willingness to pay for irrigation water in Kibaya-Cyunuzi scheme

The WTP value in the current study was reviewed for irrigation water, operation, and maintenance of irrigation infrastructure. Given that this value is perceived by farmers as combined, there is no value, which was attributed to irrigation water only. The mean WTP obtained from the open-ended question was 400 Rwf per plot (5 are or 0.05 Ha), which is equivalent to 8000 Rwf per annum (US$ 13.3 per Ha per annum). All farmers in the scheme admitted to have been aware of that contribution, they reported to have known its importance very well and that they were willing to pay.

Pricing the water is important not only for generating revenues but also for promoting efficient use of water resources. A free or very low water charge encourages overuse, reduces the incentive for farmers to cooperate or participate in irrigation obligations, and may result in low system productivity and poor conservation. The charges could also create a sense of ownership among the farmers, which would ultimately lead to better use of available water and increased crop production. Collecting irrigation fees should not create any disincentive for farmers to irrigate, which means that the cost recovery mechanism should be compatible with the resource use. This can be achieved if the fees are treated as payment for the service rendered and not as tax.

5.1.3 Irrigation Management Transfer and WUA

The socio-technical framework has allowed us to show the actual water management in our case study (Kibaya-Cyunuzi scheme). The transformation made in marshlands and water management in Rwanda has generated the emergence of new and formal arrangement in irrigation water management. The main driver of this change was the individualization of farming through Irrigation Management Transfer (IMT).

In this view, it has been revealed that the scheme is run jointly as a water users association (WUA) and as a farmers 'cooperative. The WUA, which is in charge of water management, holds a water permit and signs the irrigation management transfer (IMT) with the Ministry of Agriculture. Despite the fact that WUA' members are concerned to accomplish responsibilities assigned to them, they are facing some challenges on the side of water users in the scheme like, the adherence to the water delivery schedules, to tamper with the irrigation systems, not to follow proper irrigation methods and not to pay the water tax and spacial fee regularly.

5.2 Recommendations

In view of the major findings of the study and from the above conclusions, the following recommendations can be drawn.

a) Based on the result, the economic value of irrigation water for paddy is low but paddy is among traditional crops that thrive well and produce better yield during rainy season. Thus, paddy provides a viable alternate for millions of resource-poor rural farm families in Rwanda. The role that irrigated paddy plays as the major source of income must not be underestimated.

b) Since farmers are willing to pay for irrigation water and for operation and maintenance of infrastructures, the government should strengthen the existing WUA by empowering them to fix rational water charges for irrigation and collect it from the farmers to meet O & M activities. This option would promote the sustainable use of irrigation water and manage it effectively.

c) The government should facilitate equitable water distribution by encouraging pumping of water to areas that are topographically not inclined to receive water from the common irrigation channels in the scheme. Thus, it is important to have additional investments in the maintenance of scheme (especially for clearing the irrigation canals) and in the new infrastructure for areas in the tail ends with poor reach-ability of water from the main source (dam).

d) Training on improved irrigation water management and control, farm management, economics and marketing skills should be organized at farmer's level for farmers in the scheme.

e) Financial institutions including banks, local government and NGO's should consider giving rural farmers including farmers in the irrigation schemes loans to enable them purchase basic farm inputs and other requirements.

f) All problems mentioned by farmers are solvable if all stakeholders would work together to improve water allocation and management, and hence attain sustainable irrigation farming. To take into consideration farmers' opinions about their priorities can also be an incentive for farmers to be active and take care of all the services that are delivered to them. A collective responsibility among stakeholders is highly recommended.

5.3 Area for Further Research

a) A small number of farmers appear to be economically efficient and so policy needs to take greater account of the wide variation in opportunities and constraints facing different smallholder farmers. Further studies are needed in this area.

b) Designing irrigation water pricing policies and generally, economic instrument for managing water resources.

c) Efficient techniques that provide potential for investigation on water value and productivity in the smallholder irrigation sector need to be developed, taking into consideration variables such as labour, water and time efficiency.

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APPENDICES

Appendix 1: The questionnaire administered to the sample households

ECONOMIC VALUATION OF IRRIGATION WATER IN SMALLHOLDER FARMING SYSTEM IN RWANDA. A CASE STUDY OF KIBAYA-CYUNUZI SCHEME

Dear farmer,

You have been selected to provide some information on the economic value of irrigation water in your scheme Kibaya-Cyunuzi. We would appreciate if you could share with us your experiences on the subject, by answering the following questions freely and honestly. Your answers to these questions will remain confidential.

a) **A: SOCIO ECONOMIC CHARACTERISTICS OF THE RESPONDENT**

b) A.1. Questionnaire No................. Date of interview........................

c) A.2. Name of Interviewer/ number...

Village	**Sex**	**Age**	**Education level**	**Main occupation**	**Marital status**	**Household size**
	1 = Male		1 = None	1 = Farmer only	1 = Married	
	2 = Female		2= no completed primary	2 =Govt. employee	2 = Single	
			3 = primary	3 = Private employee	3 = Divorced	
			4 = post primary	4 = Self employee	4 = Widowed	
			5 = no completed secondary			
			6 = completed secondary			
			7 = university			

d) A.3. Basic Respondent's Information

A.3.1 what is the role of the respondent in the scheme? ( )

1. A scheme leader
2. A member of the committee

3. A block leader (zone)

4. A farmer

5. Others specify...

A.3.2 Family member and composition

Name	Age	Sex 1=male 2=female	Relationship 1=partener 2=child 3= other relationship	Education level 1=none 2= no completed pr. Sch 3=primary 4=post primary 5= no completed secondary 6= secondary	Main occupation 1= pre- school 2=school 3= house 4= full time farmer 5= gvt employee 6= private employee

B: Land ownership and Value

B.1 what is the total size of the plot belonging to you in the scheme .... hectare

B.2 what is the total size of the plot you cultivated in the scheme during 2010 season........................ hectare

B.3 Out of the total field you own in the scheme, what size of the field you rented out in 2010 season... ... ... hectare.

B.4 Out of the total field you cultivated in the scheme in season 2010, what was the farm size that properly received irrigation water for:

1. Paddy... ... ... hectare

2 .Vegetables... ... ... hectare

B.5 Can you sell the plot you own to another person? YES / NO

B.6 If YES what was the price of one hectare in 2010 season? ....Frw

B.7 What was the price of renting one plot in 2010 season? ...... Frw

B.8 How much money have you spent in 2010 season as capital in farming activities ....Frw

B.9. Was the irrigation water sufficient to make your crop mature well in the last season?

1. Quite enough

2. Partially enough 3. Not at all

C: Information on income from crops

C.1. what was the crop production you obtained in 2010 season?

S/N	Type of crop	Area grown (hectare)	Variety	Total harvest
1.	Paddy			
2.	Vegetables			

C.2. Crops marketing 2010 season

S/N	Type of crop	Unit of measure	Unit prices	Total value
1.	Paddy			
2.	Vegetables			

3. What is your main market outlet? ( )1. Local, 2. Shop, 3. Neighours , 4. Hawkers, 5. Contractor, 6. Other specify

4. Is that market outlet your favorite one? YES/Non

5. If Non why don't you access your favorite?

C.3. Production costs for Paddy:

1. Input (material) costs

S/N	Item/Operation	Cost per unit	Total costs
1.	Variety		
2.	Size of the plot/field cultivated (hectare)		
3.	Seeds		
4.	fertilizers		
5.	Insecticides		
6.	Water charges		
7.	Other costs		
TOTAL			

2. Labour costs

S/N	Item/Operation	Hired Labour used (man days)	cost per unit	Total cost
1	Size of the plot/field (hectare)			
2	Land clearing			
3	Bund repairing			
4	Ploughing			
5	Nursery preparation			
6	Transplanting			
7	weeding(kubagara)			
8	Bird scaring (kwirukanaa inyoni)			
9	Haversting			
10	Threshing (guhura)			
11	Packing and transporting			
12	Other specify			

C.4. Production costs for other crops

1. Inputs (material) costs

	Item	Vegetables
1	Size of the plot/field	
2	Cost of seeds	
3	Costs of fertilizers	
4	Insecticides costs	
5	Water charges	
6	Other charges	

2. Labour (Hired) costs

SN	Item		Vegetables	
		Man-days	Cost per unit	Total cost
1	Size of the plot/field			
2	Land preparation			
3	Ploughing			
4	Planting			
6	Costs of fertilizers application			
7	Insecticides application			
8	Harvesting			
9	Transportation from the Field			
10	Other charges			

D. Assets: Livestock and Housing

D.1. Livestock

Type	N° now	N° born	N° died	N° bought	N° sold	N° gift in	N° gift out	Gross income
cattle								
goats								
sheep								
pigs								
hen								
others								

D.2 Household construction

Wall construction	Roof construction	Piped water	Drinkable water	Electricity
1.ibiti 2.brick 3.wood 4.mud&wattle	1.tiled 2. griddle 3.others	1.yes 2.no	1.yes 2.No	1.yes 2.No

E: Benefit from farming in the scheme

E.1. what are the benefits you get from the scheme? ( )

1. Food security
2. Managed to build good house
3. Able to meet health requirement for the family
4. Able to meet education requirement for the family
5. Able to meet dressing requirement
6. Others (specify) ....
7. All

E. 2. What is the trend of your income from farming activities in the scheme?

1. Increasing

2. Decreasing

3. No change

F: Other information

F.1 Are you a member of the farmers' organization (WUA) in the scheme? YES/NO

F.2 Have you paid organization contributions in the last season? YES/NO

F.3 Are there any technical personnel in the scheme? YES / NO

F.4 On your opinion, are the technical advices or services provided adequate?

1. Completely adequate

2. Partially adequate

3. Not adequate

F.5 have you an access to credits in the scheme? YES / NO.

F.6 Have you got any problem about input supply in last season? ....

F.7 have you got other source of income in the household? (pension, wages,salaries, grant)

1. Yes 2. Non

7.1 If yes, from whom?

7.2 How much per month?

F.8 what are you major problems, as a beneficiary of the scheme? .....

F.9 How do you see the future and what are your prospects as a beneficiary of the scheme?..

G: Willingness to pay for water and operation and maintenance costs

G.1. Background information and proposal

Good management of water for irrigation and sustain its infrastructure can reduce agricultural water loss and shortage in the scheme (especially for paddy crop). But because of an increasing water scarcity and production costs, we have a long way to go to position water supply. More support is needed than just the government for operation and maintenance because it will not be always there. So, we plan to raise a 'Water management fund (a provisional appellation)' for improving water service in our scheme. The following services are provided by the government in our scheme;

One of the most important services provided by the government through various supporting projects is to provide required irrigation infrastructures and rehabilitate the old ones.

After rehabilitation water supply is also insured, but once all this services are given to us farmers, we have to show our support also in order to sustain them; because is not the government who is going to come back to repair or to extent this while the interest is to us who harvest and sell our production because of that water. So is in that perspective by which we have to contribute to recover all those costs of operation and maintenance.

G.2. Is the information presented new to you? 1=Yes, very new;

2= only some of it is new; 3=I know all this already

G.3. To sustain and extend those services provided by contributing some amount;

3.1 Who has to pay for those services? 1. All farmers

2. Those who irrigate a lot

3. None

3.2 What is the maximum amount the household would pay? ....

G.4 Is it important to value water in this scheme? ( )

1= not important, 2= somewhat important, 3=very importan

THANK YOU

Appendix 2: Probe Questions (Checklist) for the Scheme leaders

1. What is (are) the source(s) of water for irrigation? (Indicate the name of river/stream that the furrow gets water from)...............
2. When the furrow was built (approx. water)?...... who built the furrow?............
3. How is the furrow managed? ....
4. Are there any rules and regulations governing land and allocation, ownership and /or transfer in the scheme?
5. What are they in brief?
6. What are the criteria governing the acquisition of the water right for the scheme?
7. Whose responsibility to make sure that the scheme gets the water right?
8. How is IMT in your scheme
9. Who design or propose the management structure of the scheme?
10. How do you collaborate or involve other stakeholders in the process of improving your scheme management?
11. How do you involve farmers in O&M activities?
12. How is your WUA structured?
13. Do you plan to increase the area under irrigation? 1= Yes; 2= No ( )

THANK YOU.