

**ECONOMIC VALUATION OF IRRIGATION WATER AND RIVERSIDE
WETLAND SERVICES: THE CASE OF LOWER MOSHI IRRIGATION
SCHEME IN TANZANIA**

BY

ABIUD JANUARY

**A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN
AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF
AGRICULTURE. MOROGORO, TANZANIA.**



2010

ABSTRACT

This study was carried out to determine the economic value of irrigation water and riverside wetland services in the Lower Moshi Irrigation scheme. The specific objectives were to assess the economic value of water for irrigation, investigate the willingness to pay among smallholder farmers for riverside wetland services conservation in the Rau River and to assess factors that determine WTP for riverside wetland services conservation by water flows in the Rau River. The study counted on the data collected from 105 respondents from four villages of Lower Moshi in Kilimanjaro region which are Rau, Mabogini, Chekereni, and Oria. Data were analyzed using descriptive and quantitative methods. The Residual Computation Method was used to compute the economic values of irrigation water for paddy, maize and sunflowers. The Contingent Valuation Method was employed to elicit the willingness to pay for the riverside wetland services conservation, while the logit and linear regression models were used to assess the factors that determine willingness to pay for the riverside wetlands. The findings showed that, the economic value of water for irrigation for paddy was Tshs 366/m³, sunflower Tshs 448/m³ and maize Tshs 329/m³. The economic value for sunflower is high compared to that of maize and Paddy as compared to their profit margin. This is due to the fact that, sunflower use less water compared to other crops and mature early than paddy and maize. The results from CVM indicated that, the respondents were willing to pay an average of Tshs 27 860 per Ha per annum to conserve wetland services in the Rau River. The information on water's economic value enables decision makers to make informed choices on water development, conservation,

allocation, and use when growing demands for all uses are made in the face of increased scarcity.

DECLARATION

I Abiud January, do hereby declare to the Senate of Sokoine University of Agriculture that, this dissertation is my own work and it has not been submitted or concurrently being submitted for higher degree award in any other University.

AJ Bayole

13.08.2010

Abiud January

Date

(MSc Agricultural Economics)

R.M.J Kadigi

16.08.2010

Dr. R.M.J Kadigi

Date

(Supervisor)

P. Munishi

16.08.2010

Prof. P. Munishi

Date

(Supervisor)

COPYRIGHT

No part of this dissertation may be reproduced, stored in any retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the author or Sokoine University of Agriculture in that behalf.

ACKNOWLEDGEMENTS

I acknowledge the contribution of every individual, group and institution that assisted me in one way or another to make this study a reality. Due to the fact that this indebtedness is extensive, it is not easy to account for every contribution rendered to me. However, I would like to mention the following contributors taking into account that the list is inexhaustive:

First, I wish to express my sincere thanks to my supervisors, Dr. R. Kadigi and Professor P. Munishi. Indeed their valuable guidance, endless efforts and determination have made it possible for me to complete this dissertation. My sincere gratitude is also due to the management of Kyela District Council (KDC) for providing me with funds for field work. I express my sincere thanks to Professor Fred Johnsen and Stale Navrud for their tireless support during my proposal write-up while at the Norwegian University of Life Science (UMB).

My deepest gratitude is due to my lovely wife Elizabeth and our children, Julitha Dementria, Joshua and Jeremia. Their understanding, love, patience and prayers were a source of strength and inspiration, which enabled me to accomplish this academic endeavour.

Above all, I would like to thank the Almighty God and my Lord Jesus Christ for the blessings which enabled me to accomplish this work.

DEDICATION

This dissertation is dedicated to my mother Julitha, my father January, my sister Yasinta and my cousin Joseph for their heartfelt love, care and constant encouragement.

TABLE OF CONTENTS

ABSTRACT	ii
DECLARATION.....	iv
COPYRIGHT	v
ACKNOWLEDGEMENTS	vi
DEDICATION.....	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF PLATE.....	xiv
LIST OF ACRONYMS	xv
CHAPTER ONE	1
1.0 INTRODUCTION.....	1
1.1 Background Information.....	1
1.2 Problem Statement and Justification.....	4
1.3 General Objective	8
1.4 Specific Objectives	8
1.5 Research Questions.....	8
CHAPTER TWO	9
2.0 LITERATURE REVIEW	9
2.1 Overview.....	9
2.2 The Economic Value of Water.....	9

2.3	What are the Economic Values of Riverside Wetland Services?	11
2.4	Valuing Agricultural Water Use	12
2.4.1	The residual imputation method	13
2.4.2	Mathematical programming method	15
2.4.3	Hedonic price analysis	15
2.4.4	Contingent valuation method	18
2.5	Economic Valuation of Wetland Services.....	20
2.5.1	Revealed preference methods	21
2.5.2	Stated preference methods	21
2.6	Empirical Examples of Resource Valuation.....	22
CHAPTER THREE.....		25
3.0	METHODOLOGY.....	25
3.1	Overview	25
3.2	Conceptual Framework	25
3.3	Location of the Study Area.....	27
3.4	Sampling Procedure	28
3.5	Methods of Data Collection.....	29
3.6	Determination of Environmental Services (riverside wetland services).....	30
3.7	Description of Payment Vehicle	30
3.8	Survey Structure.....	30
3.9	Questionnaire Design and Administration	31
3.10	Data Analysis.....	32
3.10.1	Measurement of economic value of water for irrigation	32
3.10.2	Estimation of economic value of riverside wetland services.....	34

3.10.3 Factors that determine the willingness to pay for riverside wetland services.....	35
CHAPTER FOUR	38
4.0 RESULTS AND DISCUSSIONS.....	38
4.1 Overview	38
4.2 Socio-economic Characteristics of Respondents.....	38
4.2.1 Sex of respondents.....	38
4.2.2 Marital status of the head of the households.....	39
4.2.3 Education level of heads of households.....	40
4.2.4 Average farm size of household.....	40
4.2.5 Household size and age of respondents.....	41
4.3 Economic Value of Irrigation Water.....	42
4.4 Returns to Labour, Profit Margins and Values of Irrigation Water.....	44
4.5 Water Right at Lower Moshi Irrigation Scheme	46
4.6 Economic Value of Riverside Wetland Services.....	47
4.7 Dichotomous Choice Results.....	47
4.8 WTP Distribution.....	48
4.9 Statistical Analysis.....	49
4.10 The Effect of Social Economics Characteristics on WTP.....	51
CHAPTER FIVE.....	53
5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	53
5.1 Overview	53
5.2 Summary.....	53

5.3	Conclusions	54
5.3.1	The economic value of irrigation water.....	54
5.3.2	Economic value of riverside wetland services.....	55
5.3.4	Factors that determine the WTP for conservation of riverside wetland services.....	55
5.4	Recommendations.....	56
	REFERENCES.....	58
	APPENDICES.....	68

LIST OF TABLES

Table 1:	Distribution of respondents by sex in the study area	38
Table 2:	Distributions of head of household by marital status.....	39
Table 3:	Distribution of heads of households by education levels in the study area	40
Table 4:	Distribution of households by farm size in the study villages.	40
Table 5:	Distribution of respondents by household size and age.....	41
Table 6:	Comparison of value of irrigation water in paddy, maize and sunflower for smallholder farmers within Lower Moshi Irrigation Scheme.....	44
Table 7:	Lower Moshi irrigation scheme: comparison of profit margins and returns to labour in paddy maize and sunflower production.....	45
Table 8:	Distribution of initial bids and corresponding answers	48
Table 9:	Logit and Linear regression models results	50
Table 10	Correlation between the WTP and factors that determine WTP.....	52

LIST OF FIGURES

Figure 1: The conceptual framework of the study.....	26
Figure 2: The map of Kilimanjaro region.....	28
Figure 3: Distribution of willingness to pay.....	49

LIST OF PLATE

Plate 1: Farmers harvesting their irrigated paddy in Chekereni village ready
for the market 43

LIST OF ACRONYMS

MATP	-	Maximum Ability To Pay
WTP	-	Willingness To Pay
WMO	-	World Meteorological Organization
URT	-	United Republic of Tanzania
PRB	-	Pangani River Basin
CVM	-	Contingent Valuation Method
COI	-	Cost of Illness
SPM	-	Stated Preference Methods
TEV	-	Total Economic Value
US\$	-	United States Dollar
KADP	-	Kilimanjaro Agricultural Development Programme
KATC	-	Kilimanjaro Agricultural Training Centre
TVP	-	Total Value Product
VMP	-	Value Marginal Product
DC	-	Dichotomous Choice
OLS	-	Ordinary Least Square
NPES	-	National Poverty Reduction Strategy
WRI	-	World Resources Institute
PRSP	-	Poverty Reduction Strategy Paper
RIM	-	Residual Imputation Method
MPM	-	Mathematical Programming Method
SSA	-	Sub Saharan Africa
LMIS	-	Lower Moshi Irrigation Scheme

RPM	-	Revealed Preference Method
IWMI	-	International Water Management Institute

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Globally, water is becoming an increasing scarce resource which causes the demand for human needs to grow at more than twice the rate of the population increase during the 21st century and already a number of regions are chronically short of water (Molle *et al.*, 2008). In addition, water scarcity and its impacts on agricultural production and food security are growing concerns worldwide (Esmaeili and Vazirzadeli, 2008).

Water has been recognized as a scarce resource by the international community since the 1992 Dublin Statements which clearly stated that water resources are not infinite and they are “vulnerable” (WMO, 2007). The fourth principle of 1992 Dublin statements defines water as an economic good. The first principle of the 1992 Rio statements that supplemented the fourth Dublin principle implicitly suggests that water is a social good; therefore humans are entitled to, at least, to certain levels of water especially under the responsibility of their respective governments (Han and Zhao, 2007).

Water as an economic good has become important, since 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 consequence of the climate and the socio-economic structure, water is not only an essential input for a profit-making agriculture, but also, for the economic viability

and the social coherence of various rural areas. Irrigation water is one of the most important inputs for agricultural production (Latinopoulos, 2008). However, reliable sources of irrigation water especially in arid and semi arid areas reduce risk and stabilize agricultural production (Tarimo *et al.*, 1998; Esmaeili and Vazirzadeli, 2008).

As irrigation is a large consumer of water (about 50% to 70 % of global water resources) (Kadigi, 2006), developments in irrigation have profound impacts on basin-wide water use and availability. Yet, planning and implementation of irrigation interventions often take place without consideration of other uses. One of the main reasons for this restricted view of irrigation workers is inadequate means to describe how irrigation water is being used. Irrigation efficiency is the most commonly used term to describe how well water is being used, but increases in irrigation efficiency do not always coincide with increases in overall basin productivity of water (Molden 1997; Postel, 2001).

Irrigation inefficiency in Africa is due to the under renewed attention in relation to food security and poverty alleviation, as a driver in agricultural development and for transformation of subsistence production, but also it causes externalities to the environment due to poor water use efficiency which leads to loss of riverside wetland functions and services conserved by inflow of rivers (Kalunde, 2008).

According to Maganga *et al.* (2001), protection of the environment is becoming one of the major goals of civil societies and awareness of the direct and indirect benefits

of ecosystems services is increasing among the general public and political levels while the protection of wetlands, forests and biodiversity is moving up on the agenda.

Ecosystem products do have an economic value and can represent an important source of income for rural and urban communities (Speelman, 2008). Riverside wetlands, for example, exhibit large diversity in size and shape, are complex and dynamic ecosystems that protect rivers by storing nutrients and reducing sediment loads. Considerable progress needs to be made in the science and art of river side wetlands development planning and management to conciliate production and conservation objectives (Kosz, 1994).

Wherever water is scarce, whether because of natural shortage or inadequate allocation, ways need to be found for its best possible use such as allocation efficiency which addresses how water should be allocated among social strata, sector, activities and regions in order to achieve the most worthwhile overall use across sectors in the society (Muhammad *et al.*, 2005).

At present, the main water users in Tanzania are industries, irrigated agriculture, fisheries, wetlands and hydro-power generation. However with a large and rapidly increasing population of 36 million, 80% living in rural areas, there are many and often conflicting pressures on the water resources. Although there is a theoretical priority in water resource allocation and development for domestic supply, in reality considerably greater resources are put into irrigation (for food security) and hydropower (for energy security) schemes (Turpie *et al.*, 2003).

According to Kadigi (2006), Tanzania irrigation is important for rural development since it generates income, creating employment opportunities, and enhancing food security and alleviation of poverty. This tip enables the government to point out efficiency use of water resources as one of the fundamental goals in her national policies such as *Tanzania's Development Vision 2025*, *Tanzania's Poverty Reduction Strategy Paper (PRSP)* and *National Poverty Reduction Strategy (NPES)*.

Rational decision making about water use efficiency and management issues requires reliable estimates of the economic value of irrigation water and riverside wetland services such as control of erosion, purification of water and recreation (Molle *et al.*, 2008). Knowledge of these values are necessary when, for instance, making investment decisions concerning water resources development, policy decisions on sustainable water use and water allocations, or when the socio-economic impacts of water management decisions must be determined (Molle *et al.*, 2008). Specifically for the agricultural sector, this knowledge is important to design fair, informed and rational pricing systems for water, providing incentives to irrigators to use water efficiently and allowing sustainable riverside wetland services provided by restoration inflow of the river (Wang, 2008).

1.2 Problem Statement and Justification

Water resource allocation in the Lower Moshi Irrigation Scheme in Pangani River Basin (PRB) leads to improved agriculture production, conserve riverside wetland services and provide services to other water users, hence national development.

However, water resource in Lower Moshi Irrigation Scheme (LMIS) is stressed with many latent and emerging conflicts among its users, and current supplies are unable to meet demands. There are many factors which have contributed to the current state of the Lower Moshi Irrigation Scheme in the PRB. These include the increased demand for water, changing climatic conditions, competing uses, over-abstraction, and watershed degradation (Turpie *et al.*, 2003).

An increasing scarcity of water supply relative to demand has resulted into resource competition, insufficiency water to support riverside wetland ecosystems, recreational amenity and disputes among multiple users. Due to the increase of water resources competition, the livelihoods of the poor and other vulnerable groups like women and children are highly insecure (Kadigi *et al.*, 2006).

According to a number of studies, water scarcity in the Lower Moshi Irrigation Scheme has resulted into a severe deficit in water available for irrigation and conservation of riverside wetland services. As a result, water demands are not being met. Decreased instream flow of water in the Rau river causes poor conservation of the functions and services provided by riverside wetlands while the competition for water between upstream and downstream farmers has been increased (Turpie *et al.*, 2003). This in turn requires a good understanding of the value of irrigation water and riverside wetland services and the implications of water management for irrigation and conservation of riverside wetland services (Johnson and Baltodano, 2004). In other words, decision makers and other stakeholders need to be precisely informed of the economic value of irrigation water for different crops such as

paddy, maize and sunflower and the value of riverside wetland services if efficient management and allocation of water resources are to be achieved (Kadigi *et al.*, 2006).

The quantification of the value of irrigation water and riverside wetland services is relatively new area of research, particularly in developing countries. Much less attention has been paid in developing countries to measuring the economic value of irrigation water and value of ecosystem services in complex natural systems such as rivers. Study carried out by Kadigi *et al.* (2004) on benefit of water utilization in Great Ruaha River catchment in Tanzania; found that, the average values of water for irrigated paddy were estimated at USD 0.01 and 0.04 per m³ for abstracted and consumed water respectively is a good example.

Also a recent study by Kalunde (2008) in the Lower Moshi irrigation scheme in Tanzania adds interesting new findings. The study shows that the irrigation development intervention has affected and been affected by gender relations in the areas of ownership of plots, division of labour, intra-household organisation for crop production and distribution of benefits within different categories of households. Furthermore, Shin and Kim (2005), in the study on economic valuation of environmental friendly agriculture for improving environmental quality, found out that, environmental friendly agriculture has made contribution in improving the environmental quality with respect to the conservation of water and soil, species and ecosystem diversity in addition to stimulating agriculture.

Most of these studies provide inadequate information about the magnitude of actual and potential outcomes of differential water access, economic rent earned by the poor from different agricultural water use option, and willingness to pay for riverside wetland services conservation. There seems to be a knowledge gap, particularly on the important economic value of water for irrigation and the economic value of riverside wetlands services for the broad based of water use efficiency in the study area.

This study is therefore a contribution towards addressing this drawback. It is a first step in the assessment of the Total Economic Value (TEV) of water utilization in the Pangani river basin in Tanzania. The analysis of the value of irrigation water could be made for several other sectors, but given the scope of this study, it was limited to irrigated crops (paddy, maize and sunflower) and economic value of riverside wetland services.

In this context, knowledge about the economic value of irrigation water and the value of riverside wetland services can contribute to the allocation of irrigation water according to the crops water requirements, conservation and management of riverside wetland services and other ecosystem services. In addition, knowledge about irrigation water values can reduce conflicts among water users (due to proper water allocation) and provide indications on the reliability of the large governments' investment in the sector.

1.3 General Objective

The general objective of this study was to determine the economic value of irrigation water and riverside wetland services in the Lower Moshi Irrigation scheme.

1.4 Specific Objectives

- a) To assess the economic value of water for irrigation in the Lower Moshi Irrigation Scheme
- b) To investigate the willingness to pay among smallholder farmers for riverside wetland services conservation in the Rau River
- c) To assess factors that determine willingness to pay for riverside wetland services conservation in the Rau River

1.5 Research Questions

- a) What is the value of water for irrigation across different crops?
- b) What is the willingness to pay to conserve riverside wetland services in the Rau River?
- c) What are the factors which determine the willingness to pay for riverside wetland services conservation in the Rau River?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

This chapter presents a review of literature related to the economic value of water for irrigation and riverside wetland services including different valuation techniques as well as previous studies done in the study area and elsewhere in the world.

2.2 The Economic Value of Water

Water has economic value only when its supply is scarce relative to its demand. Whenever water is available in unlimited supply, it is free in the economic sense. Scarce water takes on an economic value because many users compete for its use (Perry, 1997). In a market system, economic values of water, defined by its price, serve as a guide to allocate water among alternative uses, potentially directing water and its complementary resources into uses in which they yield the greatest total economic return (Ward, 2002).

In dry places, economic and population growth create situations where water is economically scarce. In these places, water institutions, laws, projects, policies, and programmes are designed to provide for maximum benefits from the use of scarce water. Not only is water itself scarce, but also are money, manpower, and other resources required to develop, allocate, transport, and purify water. (Xu *et al.*, 2003). Competing claims for money and other resources and the economic and political difficulty of increasing taxes to pay for water programmes constrain the resources available for water programmes. While the political process always

determines which programmes are undertaken, there is also a need for more general economic standards by which competing water policies and programmes can be gauged (Perry, 1997).

According to Ward (2002), the economic principles underlying water policy decisions rest on the ideas of benefit and cost. For example, releasing water from a dam to increase stream flow by 100 cubic feet per second may add 500 units of endangered species habitat, which, for example, might be worth USD 25 each. The benefit of this policy will be $500 \times \text{USD } 25 = \text{USD } 12\,500$. According to the basic rule of benefit maximization, in which increasing the total value of scarce resources is presumed desirable, this action should be undertaken if its cost is less than or equal to USD 12 500.

All the additional costs resulting from a proposed action are its marginal costs, and the extra benefits are its marginal benefits. If enacted policies are limited to those that increase economic efficiency, a water program will only be implemented if its marginal benefits equal or exceed marginal costs. For public water policy proposals, maximum beneficial use of water and its complementary resources require governments to formulate, implement, and evaluate their program plans and select their programmes using these economic principles (Ward, 2002).

An important aim of efficiency water use particularly for irrigation can be stated in terms of maximization of the product or revenue obtained from that water use. What is to be maximized is the social benefit from the water used and not the quantity of

water itself (Hellegers and Perry, 2006) In areas of intense competition for water, an important objective of water allocation policy, in addition to protecting the public interest, is to allocate the water resource to those agricultural, residential, industrial, recreational, endangered species, and other uses that will make the most productive use of the water available for these purposes. Put differently, this goal is that water institutions and programmes should help shape civilization along lines desirable to those people who use water by increasing their living standards (Acharya and Barbier, 2000).

According to Ward (2002), the principle of maximizing the total economic value of resources such as water is an essential concept of modern natural resource economics. There is considerable debate among water policy makers and the public at large on how this can be achieved. In principle, one could examine a given river basin with known potentials of water use and look for that use or combination of water uses which produce the greatest economic product from a given expenditure of goods, services, and water.

2.3 What are the Economic Values of Riverside Wetland Services?

Ecosystem services provide many benefits to people such as dilution of wastewater, erosion control, water purification and improvement of water quality. Increased water quality reduces water treatment costs to downstream cities, increases the aesthetics of water for visitors and supports native fish and wildlife that different people like to view or harvest. These services are scarce and benefit people, hence have an economic value (Thomas *et al.*, 2004).

According to Chambouleyron (2004) ecosystem services have characteristics of public goods. Specifically, it is difficult to exclude downstream users from receiving the benefits of improved water quality and many of the benefits are non-rival in nature. Many individuals can view the same wildlife without precluding others from doing the same thing.

While these ecosystem services are often without prices, they do contribute utility to individuals and therefore have value. This value is monetized as the individual's net willingness to pay (WTP) or consumer surplus. It is represented by the area under the individual's demand curve but above any cost to the user of the ecosystem service (Ojeda *et al.*, 2008).

2.4 Valuing Agricultural Water Use

The valuation of water in irrigated agriculture can be approached in various ways such as Residual Imputation Method (RIM), which consists of assigning the difference between incomes and all costs associated with production factors unrelated to water (including the owner's management work) as the value of water, mathematical programming models that allow the shadow price of the water to be calculated and the Hedonic Price Analysis, can be applied using information regarding farmland transactions to estimate the implicit price of water (Han and Zhao, 2007; Young, 2005)

2.4.1 The residual imputation method

According to David and Shore (2006) 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.

The prices of all resources are equated to returns at the margin (value of marginal product). (This is a well-known condition for competitive equilibrium, i.e. as would occur if perfectly competitive markets were to exist for all agricultural inputs) (Venkatacham, 2004). Profit-maximising 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 unpriced, 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).

According to David and shore (2006) the total value of product can be divided into shares, in such a way that each resource is paid according to its marginal productivity and the total product is completely exhausted. This is satisfied when the total value function is a linear homogeneous production function.

Wichelns (2000) explained that, there is a standard mathematical result, called *Euler's* theorem, which shows that, if a production function involves constant returns to scale, the sum of the marginal products will actually add up. In referring to this method, some

authors use the term 'farm budget approach'. However, Wichelns (2000) found that this is just a name given to the residual valuation technique when it is specifically applied to agriculture. The name arises from the fact that representative farm crop budgets developed for a region are used to estimate the maximum revenue share of the water input.

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 (Venkatacham, 2000).

A variation on the theme of crop budgeting can be used where dry-land and irrigated production of a crop occur within a homogenous farming area. When all other factors such as soil type and climate are similar, the difference in net returns can be attributed to the irrigation water (Venkatacham, 2000). According to Wichelns (2002) 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).

2.4.2 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).

2.4.3 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 recognised by purchasers (Chiara and Peter, 2008).

According to Thomas *et al.* (2004), these attributes cannot be separated when purchasing the property. By comparing the market value of two properties which differ only in respect of a specific environmental feature, economists may assess the implicit price of

that amenity (or its costs when undesirable) as shown by the behaviour of buyers and sellers.

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 *et al.*, 2008).

In natural resource and environmental economics, the hedonic method has been most frequently applied to the residential housing market, for the analysis of real property (land) sales price data which show differing but measurable environmental characteristics. The hypothesis is that consumption of housing services depends on the structural characteristics of the dwelling (area under roof, age, number of rooms, size of lot), a collection of neighbourhood characteristics (crime risks, accessibility to jobs, shopping and parks) and location-specific environmental amenities (water quality, air quality) (Thomas *et al.*, 2004).

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.

However most environmental features will have only limited, if any, effects on house prices. Even where effects do exist, they may be difficult to estimate using econometric methods, because many, often related, factors influence house prices. Even when implicit prices for environmental amenities can be estimated, it is usually very difficult to obtain measures of value from these models. The connection between the implicit prices and value measures is technically very complex and sometimes empirically unobtainable (Perry, 1997).

The hedonic technique is as yet relatively rarely applied to measuring values of water or water quality. To estimate economic values of environmental resources through hedonic methods is quite difficult in practice, and the technique is subject to serious limitations. Unlike the value of structural features of the property itself, the value of environmental attributes is imperfectly perceived by market participants and difficult to isolate (Thomas *et al.*, 2004).

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 recognise 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. With such limitations, it is difficult to generate statistically reliable and economically plausible results using the hedonic technique (Chiara and Peter, 2008).

2.4.4 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), calls 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 scenario (Shyamsundar and Kramer, 1996).

According to Lankford and Franks (2000), many analysts have applied the CVM to water-related issues. 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 streamflow.

The CVM has great flexibility, allowing valuation of a wider variety of non-market goods and services than is possible with any of the indirect techniques. Currently the available method for estimating non-use values, in other words it is the only method that has any hope of measuring 'existence values', the value that individuals place on simply knowing the natural resource exists in an improved state (Han and Zhao 2007). According to Windevoxhel (1993) for natural resources, contingent valuation studies generally derive values through the elicitation of respondents' WTP to prevent damage to, or to restore, natural resources.

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. They are then asked how much they would be willing to pay for instance in extra utility taxes, income taxes, or access fees either to avoid a negative occurrence or bring about a positive one (Griffin and Mjelde, 2000). The actual format may take the form of a direct question ('how much'), or it may be a bidding procedure (a ranking of alternatives) or a referendum (yes/no) votes. Economists generally prefer the referendum method of obtaining values, since it is one most people are familiar with (Windevoxhel, 1993).

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 (Moran and Dann, 2008).

2.5 Economic Valuation of Wetland Services

According to Loomis (1987) and Brander and Jane (2006) dollar values for instream flows can often compare favourably against the value of water in traditional economically beneficial uses such as irrigation. While limited in number, attempts by ecological and environmental economists and other researchers to assess the monetary value of protecting instream flow and associated riparian areas to sustain several environmental services are increasing.

Several researchers have estimated non-market values for environmental friendly agriculture such as Shin and Kim (2005), and instream flow combinations of environmental services such as Loomis *et al.* (2000) and (Ojeda *et al.* (2008). In his study Loomis (1987) found that, when instream flow rates were 30% of peak flows in several rivers in the western United States, the values of instream flow are at least as much as the value of water for use in irrigation. However, just imposing a minimum flow constraint also has its problems, however, because it imposes a fixed relative allocation of resources between in-stream and out-of-stream uses. There are several techniques that can be used to value the benefits of improved ecosystem services. The Non-market valuation approaches can be divided into two categories: revealed preference and stated preference methods.

2.5.1 Revealed preference methods

Revealed preference methods, also known as indirect valuation methods, look for related or surrogate markets in which the environmental good is implicitly traded (Birol and Phoebe, 2006; Garrod, 1999). Information derived from observed behaviour in the surrogate markets is used to estimate willingness to pay (WTP), which represents individual's valuation of, or the benefits derived from, the environmental resource. Two such methods prevalent in the environmental economics literature are the hedonic pricing and the travel cost methods. These methods are suitable for valuing those water resources that are marketed indirectly and are thus only able to estimate their use (direct and indirect) values (Ojeda *et al.*, 2008; Chiueh and Ming, 2008).

The revealed preference methods include the Travel Costs, Replacement Cost, Avertive Expenditures, Production Function Approach, Net Factor Income, Cost-of-Illness (COI), and Market prices. The description of several revealed preference approaches, advantages, and disadvantages as well as their use for valuing water, are discussed in detailed by Birol and Phoebe (2006).

2.5.2 Stated preference methods

According to Birol and Phoebe (2006), Stated Preference Methods (SPM) also called Direct Valuation Methods, have been developed to solve the problem of valuing environmental resources that are not traded in any market, including the surrogate. In addition to their ability to estimate use values of environmental goods, the most important feature of these survey-based methods is that they can estimate the nonuse values, enabling the estimation of each component of TEV.

Stated preference methods, such as Conjoint, Choice Experiments, and Contingent Valuation, attempt to solve the problem of non-use valuation of water by capturing benefits that may be neglected by the other methods. These methods are commonly used to estimate the non-use value of the environment by directly surveying consumers on their willingness to pay (WTP) for existing or potential environmental attributes in a hypothetical, constructed market. The most commonly used form of questioning on hypothetical futures is the CVM (Chiare and Peter 2008; de Oca and Bateman, 2006). According to Birol and Phoebe (2006) and Ojeda *et al.* (2008) the advantage of CVM is that, it does not require the conceptual linkage between market prices and a non-market resource, since the researcher elicits information on the value of the amenity directly by using a questionnaire or interview to create a hypothetical market or referendum in which individuals reveal the values they place on the resource.

2.6 Empirical Examples of Resource Valuation

There are a range of studies that have examined the economic value of natural resources using contingent valuation method. The empirical results from the studies are somewhat mixed up. Griffin and Mjelde (2000), for example examined customers' preferences in seven Texan cities, using CVM.

Loomis (1987) found that, when instream flow rates were 30% of peak flows in several rivers in the western United States. The values of instream flow are at least as much as the value of water for use in irrigation. However, just imposing a minimum flow constraint also has its problems because it imposes a fixed relative allocation of resources between in-stream and out-of-stream uses.

A recent study by Travisi and Nijkamp (2008), on economic assessment of the non-market benefits of safety improvements in the environmental and health safety of agricultural production revealed that, the annual WTP of an Italian household ranges from € 874 to protect all the 15 endangered bird species; € 1 465 to eliminate soil and groundwater contamination in farmland areas (currently set at 65%); to € 1 286 to eliminate all the cases of acute pesticide intoxication.

Ojeda *et al.* (2008) used a CVM to study on economic value of environmental services provided by instream flows of water in Yaqui River Delta in Mexico. In such a study, respondents indicated that, they were willing to pay an average of 73 Pesos/month to restore instream flows in the water-scarce Yaqui River Delta. Shin and Kim (2005), studying on economic valuation of environmentally friendly agriculture for improving environmental quality, found that environmental friendly agriculture has made contribution in improving the environment quality with respect to the conservation of water and soil, species and ecosystem diversity in addition to stimulating agriculture.

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

Kulshreshtha and Gillies (1994) examined the value of the river in terms of its marginal waterflow. River flows have an economic value particularly, if changes in the flow result in changes in economic benefits (or costs). Several benefit components, such as instream

recreation, power generation, waste transport, aesthetics, water supply, and the aquatic ecosystems are associated with instream flow. These benefits were examined in this study for the South Saskatchewan River from a City of Saskatoon accounting perspective. Three levels of minimum flows were examined: present flow ($42.5 \text{ m}^3/\text{S}$), reduced flows ($25 \text{ m}^3/\text{S}$) and increased flow ($100 \text{ m}^3/\text{S}$).

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 found that, 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).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Overview

This chapter presents the methodology used to conduct the study. The chapter begins with presenting the conceptual framework for the study which is followed by description of the study area, description of the Residual Imputation Method (RIM), Contingent Valuation Method (CVM), sampling procedure, environmental service determination, payment vehicle, survey structure, questionnaire design and administration and statistical analysis of the data.

3.2 Conceptual Framework

The conceptual framework for the study reflects on the valuation of the irrigation water, riverside wetland and factors that determine the willingness to pay for conservation of riverside wetlands services. The willingness to pay for the conservation of riverside wetland services was considered as dependent on the age of the respondent, education level, Sex, bid amount, household size and income of the household. These factors were considered as stimuli for the acceptance or rejection of the proposed hypothetical market for conservation of riverside wetland services.

However, the economic value of irrigation water gives clue to appropriate water allocation to the different crops which lead to increase in yield of crops cultivated in the study area, a result of which, increases income and the livelihood of the entire community.

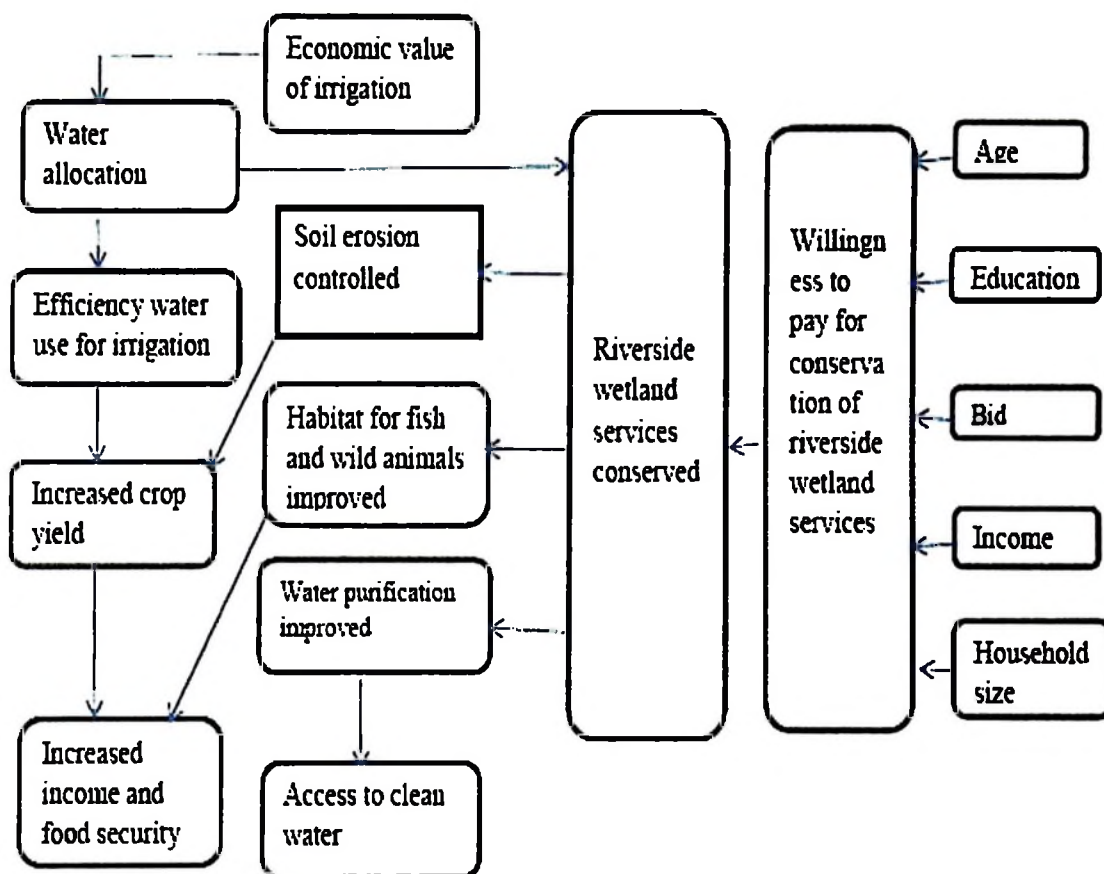


Figure 1: The conceptual framework of the study

Valuation of riverside wetlands can be used in many ways: to assess the total contribution that make for human well-being, to understand the incentives that individual decision-makers face in managing riverside wetland in different ways, and to evaluate the consequences of alternative courses of action. This study uses valuation primarily in the latter sense as a tool that enhances the ability of decision-makers to evaluate tradeoffs between riverside management regimes and courses of social actions that alter the use of riverside wetlands and the multiple services they provide. This usually requires assessing the value of services provided by riverside wetlands resulting from a given change in its management (Yang, 2005).

Figure 1 provides a schematic presentation that summarizes the key issues in as far as the conceptual framework for this study is concerned. In order to achieve the study objectives, four villages (Mabogini, Oria, Rau and Chekereni) were selected for the study. Primary data were collected using participant observation, focused group discussions and questionnaire surveys while secondary data were collected by review of publications and reports. Then collected information were analysed and interpreted to address the study objectives.

3.3 Location of the Study Area

The Lower Moshi Irrigation Scheme lies in the Kilimanjaro region in the north-eastern Mainland Tanzania, bordering Kenya to the north, the Arusha region to the west, and Tanga region to the south-east. The region has six districts: Hai, Rombo, Same, Moshi Rural, Moshi Urban and Mwanza. The Lower Moshi irrigation scheme is located in Moshi Rural, 6-20 km south west of Moshi town. Administratively, the scheme is divided into four villages, namely Mabogini, Chekereni, Rau and Oria.

The scheme consists of a relatively narrow strip of land developed on alluvial plains along the right bank of the Rau River. It is bound by the Rau River on the east, the sugar plantation of Tanganyika Planting Company (TPC) on the west and north and by the National Agriculture and Food Cooperation Farms on the southern side. The rainfall distribution in the area is bimodal, with two distinct seasons (short and long rain seasons). The short rains fall between November and February, and this less predictable rainfall season is called "VULI", while the long rainy season (March

and May) is locally termed "MASIKA". The dry season falls in the period of June to mid-November or December. Mean temperatures range between 21°C and 26°C, and are suitable for irrigated paddy cultivation (JICA, 1980).

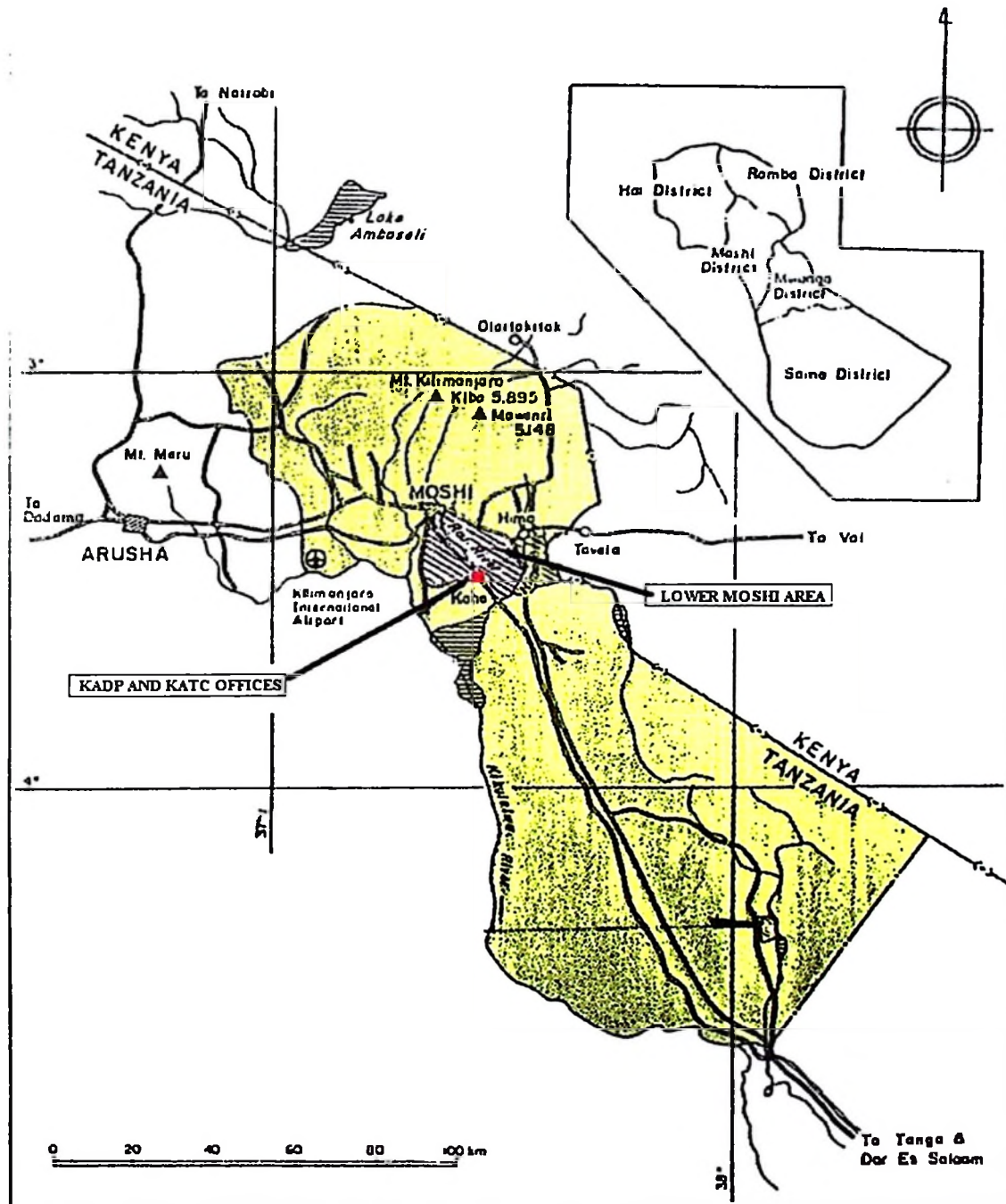


Figure 2: The map of Kilimanjaro region

(Source: KADP, 2009)

3.4 Sampling Procedure

The primary data for this study were collected from 105 households selected from four villages (Mabogini, Rau, Chekereni and Oria) at the Lower Moshi Irrigation Scheme in Pangani River basin. Farmers who were in the project from each village constituted a sampling frame from which, 105 farming households were randomly selected.

3.5 Methods of Data Collection

Primary and secondary data collection for the present study was undertaken over a period of three months (January 2008 to March 2009). Before the exercise was carried out, sources and types of information to be collected and techniques to be used were identified. Primary data collection was done through field survey, whereby a semi structured questionnaire was used. Swahili was used as a medium of communication to avoid language barrier and to maximize the freedom of expression among the respondents. The questionnaire was translated from English into Swahili to ensure high response rate.

The KADP/KATC- representatives, Water Users' Groups and farmers gave the history of the scheme and the improvement made. They also provided the information on water management organisation, operation and maintenance of irrigation systems, command area/cultivated area, irrigated rice and upland crops, production costs, revenue and estimated volume of water used for irrigation. The gathering of such information was done through focus group meetings/ discussions and questionnaire administration to the sampled farmers.

3.6 Determination of Environmental Services (riverside wetland services)

The important activity was to undertake a CVM to identify the functions or services used to describe the environmental outcomes. Based on this methodology, different riverside wetland services used in conservation of the Rau River were identified such as prevention and control of soil erosion, natural purification of water, and habitat for fish, amphibians, birds and other wildlife. This was done through focus group meetings/ discussions.

3.7 Description of Payment Vehicle

Selection of the right payment vehicle depends on the resource to be valued, the socio-economic characteristics of the sample, and the institutional structure governing the area (Chiueh and Ming, 2008). In this study fund contribution was used as the payment vehicle to riverside wetlands services conservation in the Rau River as proposed by Ojeda *et al.* (2008) and de Oca and Bateman (2006) in their respective CVM studies in Mexico City and Loomis (2000) in a CVM study in California.

3.8 Survey Structure

The format for the survey was patterned basing on previous CVM questionnaires conducted around the world such as by Loomis *et al.* (2000) and de Oca and Bateman (2006). This is in terms of introductory questions, background information, proposals, alternatives, visual aids and WTP questions. In addition, the respondents were presented with the following information (shown in appendix 1) to frame the hypothetical market and set the CVM scenario, in the form of

photographs. The respondents were first handed a card that listed the key riverside wetland services such as prevention and control of soil erosion, natural purification of water, and habitat for fish, amphibians, birds and other wildlife. The survey questions are listed in appendix 1. In addition, the respondents were presented with the following information to frame the hypothetical market:

- a) **Background of Rau River:** The descriptions on agricultural activity, summary of some of the environmentally sensitive issues and ecosystem health losses that the Rau River is facing due to the lack of water in the River was presented.
- b) **Riverside wetland services used in conserving the Rau River:** The information on the key riverside wetland services that could be provided by Rau River riverside wetland was presented.
- c) **Scenario description:** The overall riverside wetland services under the current conditions and with increased riverside wetland services used to conserve the existence of the Rau River wetland was explained.
- d) **Payment vehicle:** The interviewer explained that, improvement of the Rau River riverside wetland would require introduction of funds for environmental management and these funds would be obtained by the increase of irrigation water fee per Ha per irrigation season.

3.9 Questionnaire Design and Administration

The primary data for this study were collected from January 2008 to March 2009 using a structured questionnaire. The collected information included data on crop

output, price of output, production costs such as prices of fertilizers, insecticides, and the quantity required. Other information collected were willingness to pay to conserve riverside wetland services, management, and income from other sources away from paddy/rice production such as upland crops (maize and sunflower). Secondary data were obtained from KATC and KADP in the Lower Moshi such as volume of water used for irrigation as shown in the appendix 3. The pre-testing of questionnaire was done in the study area in December 2008 before data collection. Necessary corrections such as translating the questionnaire from English to Kiswahili were done before the actual data collection.

3.10 Data Analysis

Quantitative and qualitative techniques were used to analyse the data. For more precise analysis, computer based statistical programmes (Microsoft EXCEL, LIMDEP 8.0 and SPSS 12) were used. Descriptive statistics, and charts and tables were used to present the results. Different analytical tools were used to estimate the economic value of irrigation water and willingness to pay for conservation of riverside wetland services.

3.10.1 Measurement of Economic Value of Water for Irrigation

The Residual Imputation Method was applied to estimate the economic value of water for irrigation, where data on production cost and revenue were used to estimate the economic value of irrigation water. The method (RIM) assumes that, if all markets are competitive except for water, then the total value of production exactly equals the opportunity costs of all the inputs. For an agricultural production

process in which crop (Y) is produced by the following factors of production: capital (K), labour (L), and other natural resources such as land (R) and irrigation water (W); the production function was specified as:

$$Y = f(K, L, R, W)$$

(1)

If competitive factor and product markets are assumed, prices can be treated as constants. By the second postulate, it then follows that:

$$TVP_Y = (VMP_K * Q_K) + (VMP_L * Q_L) + (VMP_R * Q_R) + (VMP_W * Q_W)$$

(2)

Where

TVP - represents total value of product Y ;

VMP - represents value marginal product of resource i ; and Q is the quantity of resource i . The first postulate, which asserts that, $P_i = VMP_i$, permits substitution of P_i into (2) and rearrangement of the same equation as follows:

$$TVP_Y - [(P_K * Q_K) + (P_L * Q_L) + (P_R * Q_R)] = P_W * Q_W$$

(3)

On the assumption that all variables in (3) are known except P_W that expression can be solved for that unknown to impute the value (shadow price) of the residual claimant (water) P_W , as follows:

$$P_w = \{TVP_Y - [(P_K * Q_K) + P_L * Q_L] + (P_R * Q_R)\} / Q_w$$

(4)

The “residual” method has been widely used to derive economic values of water, particularly in irrigated agriculture (Hussain *et al.*, 2001; Renwick, 2001; Young, 2005 cited by Kadigi *et al.*, 2004). The method entails identification of the incremental contribution of each input to the value of total output.

In this method, both simple and more advanced analytical models can be used, but experience has shown that many researchers have centered their analysis on simplicity of the functional forms giving little attention to other factors (e.g., the nature of factor substitution, whether variable, constant or a unit) (Raggkos and Asimakis, 2006). In sense, these may dictate the forms (e.g., constant elasticity, production function, variable elasticity production function and unitary elasticity production function). For “intermediate good uses” of water, models of the “profit-maximizing” firm can be used (Zekri and Eager, 2005). However, the general characterization of most rural producers (peasants) in developing countries as risk aversors, drudgery aversors, sub-optimal producers, partial engagers in incomplete markets, and the like, would make these models to be seen as inadequate portrayals, but the degree of market integration of most contemporary peasants, means that some elements of the economic calculus characterized by “profit maximization” are almost always present in peasant economic behaviour (Strange *et al.*, 1999).

3.10.2 Estimation of economic value of riverside wetland services

The CVM was used to elicit information on household willingness to pay for conservation of riverside wetland services. Two different sets of household WTP information were used as dependent variables in these analyses that is the yes/no answers to the first annual bid offered in the Dichotomous choice format question and the follow-up question which allowed the respondent to give open-ended maximum WTP answer. The bid amount X was assigned randomly to the respondents and came from a set of 7 possible values in the range of 20 000 to 50 000Tshs per annual, in increments of 5 000Tshs.

A logit model was applied to fit the yes/no answers to the first water fee offered in the Dichotomous choice format question data.

$$\text{Log} \left[\frac{P(\text{Yes})}{1 - P(\text{Yes})} \right] = \beta_0 + \beta_1(\text{Bid}) + \beta_2(\text{Age}) + \beta_3(\text{Income}) + \beta_4(\text{Education}) + \beta_5(\text{HH}) + \beta_6(\text{Sex})$$

(5)

$P(\text{Yes})$ and $1 - P(\text{Yes})$ are the probabilities that a respondent accepts or rejects the payment of a certain bid respectively.

β_0 is the intercept term and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ are the variable coefficients.

“Bid” is the bid amount. The expected sign of the coefficient is (-), as respondents are bound to reject a payment as it gets higher.

“Gender” is a nominal variable. There are no priori indications for its expected sign (Raggkos and Asimakis, 2006).

The expected sign of the coefficient of variable “Age” is (+),

HH - Household size

3.10.3 Factors that determine the willingness to pay for riverside wetland services

The factors that determine the WTP were analysed using ordinary least square (OLS) regression to test the robustness of the model, which has been commonly applied in other similar studies (Ojeda *et al.*, 2008). To simplify the regression analysis, the socio-demographic and attitude variables were subjected to tests for determining whether the mean responses for a given independent variable were statistically different.

$$WTP = \beta_0 + \beta_1(Bid) + \beta_2(Age) + \beta_3(Income) + \beta_4(Education) + \beta_5(HH) + \beta_6 Sex$$

(6)

Where;

WTP - Willingness to pay

β_0 is the intercept term and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ are the variable coefficients.

“Bid” is the bid amount. The expected sign of the coefficient is (-), as respondents are bound to reject a payment as it gets higher.

“Gender” is a nominal variable. There are no priori indications for its expected sign (Raggkos and Asimakis, 2006).

The expected sign of the coefficient of variable “Age” is (+).

HH - Household size

The mean WTP from the dichotomous choice results was calculated using the formula:

$$\frac{1}{N} \sum_{i=1}^N X_i Y_i \quad (7)$$

Where

N_i - is the total number of responses

X_i - is the bid level

Y_i - is the number of "yes" responses to that bid level

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Overview

This chapter presents the results of analysis and discussion of the economic value of water for irrigation, riverside wetland services and the factors that determined willingness to pay for conservation of riverside wetlands. In addition, the chapter also presents the discussion of profit margin, return to labour for different crops such as paddy, maize and sunflower in the Lower Moshi Irrigation Scheme.

4.2 Socio-economic Characteristics of Respondents

The socio-economic characteristics discussed in this section include, sex, marital status, education level, occupation, farm size, and household size.

4.2.1 Sex of respondents

Table 1: Distribution of respondents by sex in the study area

Sex	Village Name				Total
	Mabogini	Rau	Chekereni	Oria	
	n=30 %	n=30 %	n=30 %	n=15 %	
Male	11.42	19.04	17.14	7.61	55.24
Female	17.14	9.52	11.42	6.67	44.76
Total	28.57	28.57	28.57	14.29	100

From the results presented in the Table 1, 55.2% of respondents were males while 44.76% were females. However, in Oria village, males and females were approximately equally represented during the interviews. This implies that, in the

Oria village local community members were more aware of the importance of gender balance in owning irrigated land in the study area than in the other villages.

4.2.2 Marital status of the head of the households

Table 2: Distributions of head of household by marital status

Marital status	Mabogini	Rau	Chekereni	Oria	Total
	n=30 %	n=30 %	n=31 %	n=14 %	N=105 %
Married	20	19.04	21.9	7.62	68.57
Single	7.61	8.57	5.71	5.71	28.57
Widow	0.95	0.95	6.67	0	2.86
Total	28.57	28.57	29.52	13.33	100

From the results presented in the Table 2 the majority of respondents (68.57%) were married while 28.57% were single and 2.86 % of heads of households were widows. This implies that there is a gender-balanced division of labour and shared responsibilities in agricultural activities and managing water resources for sustainable livelihoods. Marital status influences decision making at the household level, including the use of irrigated agriculture and management of water sources and environmental services. Understanding the distribution of marital status of heads of households is important for assessing management and utilization of water for irrigation and protection of riverside wetlands.

4.2.3 Education level of heads of households

Table 3: Distribution of heads of households by education levels in the study area

Education level	Village Name				Total
	Mabogini	Rap	Chekereni	Oria	
	n = 30	n=30	n=30	n=15	N=105
	%	%	%	%	%
Std IV	3.8	0	3.8	0	7.61
Std VII	9.52	20	7.61	6.67	43.8
Std VIII	3.8	0	5.71	0	9.52
Form IV	8.57	5.71	6.67	0.95	21.9
Form VI	1.9	0.95	1.9	3.8	8.57
Higher	0.95	1.9	2.85	2.85	8.57
TOTAL	28.57	28.57	28.57	14.29	100

From the results presented in the Table 3, the majority of respondents (43.8%) had attained primary education. Increase in education level is leads to the increase knowledge on riverside wetland services and wise use of irrigation water. According to Sumbi (2004), educated people have more knowledge on the benefits of the ecosystem services and management approaches. The higher level of education promotes willingness to pay for conservation of the riverside wetland services and functions (Sumbi, 2004).

4.2.4 Average farm size of household

Table 4: Distribution of households by farm size in the study villages

Variable	Mean (Ha)	Minimum (Ha)	Maximum (Ha)
Paddy	0.8	0.2	2.4
Maize	0.3	0.2	0.5
Sunflower	0.31	0	0.6

From the results presented in the Table 4, the average land area owned by a family from the sample respondents and under cultivation was 0.8 Ha for paddy, 0.3 Ha for maize and 0.31Ha for sunflower. The farm size of respondents has implications on the restoration of riverside wetlands. This is because the smaller the farm size the more people would encroach into the riverside wetlands for cultivation.

4.2.5 Household size and age of respondents

Table 5 below shows the average household size and age of respondents. The average household size is 4.03. The age of respondents is 38.76 years with the standard deviation of 11.09 years.

Table 5: Distribution of respondents by household size and age

Variable	N	Mean	Std. Deviation
Age	105	38.76	9.47
Household size	105	4.03	1.83

From the results presented in the Table 5, the average household size seems to be high. This implies that as the household increases, the demand for water for irrigation increases. This concur with those by Kessy (1998) as cited by Sumbi (2004), who documented that, development pressures over resources are caused by, among others increasing human population. In that regard, rural communities are supposed to have a very high real social rate of time preference i.e. they prioritize short-term development problems more than conservation of the same resources. This might also be magnified by uneven distribution of conservation benefits, which

act as disincentives for effective conservation and hence ineffective positive conservation interventions such as poor enforcement of conservation laws (Hartwick and Olewiler 1998).

It is believed that, different age groups respond differently to the willingness to pay for riverside wetlands conservation (Loomis *et al.*, 2000). The older people are more open-minded and often, express the need to have the riverside wetlands conserved, unlike the youth whose major interest is to create economic benefits out of environment (riverside wetlands) (Han and Zhao, 2007).

4.3 Economic Value of Irrigation Water

Costs of production for paddy, maize and sunflower without irrigation cost were calculated. These costs of production were deducted from gross returns of the specific crop. These residual revenue were further divided by the amount of water applied (m^3) (Appendix 3) to get the economic value of water for irrigation for a specific crop. The economic value of water for irrigation has been estimated for the crops cultivated in the study area according to the empirical information drawn from the KADC, KATC (show in appendix 3) and questionnaires completed by farmers (Appendix 1). Calculated results are shown in Table 6.



Plate 1: Farmers harvesting their irrigated paddy in Chekereni village ready for the market

Table 6: Comparison of value of irrigation water in paddy, maize and sunflower for smallholder farmers within Lower Moshi Irrigation Scheme

Parameters	Paddy	Maize	Sunflower
Average revenue from irrigated crop per Ha (Tsh)	4 106 921	1 422 529	1 360 000
Average cost for non-water inputs in irrigated crop per Ha (Tsh)	1 639 310	680 079	709 909
Average residual revenue attributable to water (Tsh)	2 467 611	742 450	650 091
Estimated volumetric water demand (m ³)	6 739	2 255	1 450
Estimated average value of irrigation water (Tsh/m ³)	366	329.25	448
*Value in US Dollar per m ³	0.26	0.24	0.32

*Calculated using the June 2010 Exchange Rate of 1 US\$ = Tshs 1 400.

4.4 Returns to Labour, Profit Margins and Values of Irrigation Water

Returns to labour, profit margins and values of irrigation water were compared for three crops cultivated in the study area using both secondary and primary data collected during the study. The results are summarized in Tables 7 and 8. The profit margins and returns to labour were calculated from averages of individual economic data using average current prices as collected during the interview.

The estimation of the value of irrigation water in paddy, maize and sunflower involved the use of figures for average volume of water applied in paddy, maize, sunflower fields as reported in KATC (2006) as shown in appendix 2. Returns to labour and profit margins vary among different crops as shown in Table 7.

Table 7: Lower Moshi irrigation scheme: comparison of profit margins and returns to labour in paddy maize and sunflower production

Type of crop	Yield/Ha (Bags)	Average price (Tshs)	Gross income	Production costs (Tshs)	Profit margin (Tshs)	Man days	Return to labour(Tshs /Mandays)
Paddy	85.5	48 000	4 104 000	1 639 310	2 464 690	120	20 539
Maize	50.8	28 000	1 422 400	680 079	742 324	57	13 023
Sunflower	34	40 000	1 360 000	709 909	650 091	42	15 590

Results of the analysis in Table 7 indicated that the more profitable enterprise is irrigated paddy with a profit margin of Tshs 2 464 690 per Ha, followed by maize and sunflower with a profit margin Tshs 742 324 per Ha and Tshs 650 091 respectively. The economic value for sunflower is high compare to that of maize and Paddy as compare to their profit margin. This is due to the fact that, sunflowers use less water compared to other crops.

However, considering labour requirements and returns, maize has low returns to labour which stands at Tshs 13 023 per Ha as compared to Tshs 15 590 for sunflower and Tshs 20 539 of paddy. When profit margins per hectare are compared, the differences among the above three crops would be described as determined more by the extent to which commercial inputs were used and less by the differences in economies of scale. As the evidence in this study indicates, commercial inputs were relatively very expensive and their use might have eroded a large share of profit margins. It should however be noted that, what is important from the household perspective might be the return to labour and not the profit margin.

The average economic value of irrigation water was also relatively lower for maize production and paddy compared to sunflower production, such that the economic value was Tshs 366/m³ for paddy, Tshs 329/m³ for maize and Tshs 448/m³ for sunflower.

The values of water estimated in this study can be compared with those of other studies in Tanzania and elsewhere in Sub-Saharan Africa (SSA). In Great Ruaha River basin in Tanzania, for example, Kadigi *et al.* (2006), estimated the gross income per m³ of water at the range of Tshs 47/m³ in the irrigated paddy systems which is 8 times less than in the lower Moshi Irrigation Scheme. The differences may be attributed to less water consumption and higher yield in the Lower Moshi Irrigation Scheme.

Generally, water productivity of paddy in Sub-Saharan Africa ranges from 0.10 to 0.25kg per m³, with an average yield of 1.4 metric tonnes per ha and water consumption per ha close to 9 500m³ (Kadigi *et al.*, 2006). Among developing countries, China and some South- East Asia countries have higher water productivity for rice, ranging from 0.4 to 0.6 kg/ m³.

4.5 Water Right at Lower Moshi Irrigation Scheme

According to the regulations, only the farmers within the scheme had the right to the water source and the infrastructure. Although there were many farmers around the four villages of the irrigation scheme, not all of them were formal water user members. The water user membership was tied to plot ownership and only farmers

who lived within the scheme and owned plots were counted as formal water user members. Married women who were assigned plots through their husbands and all other men and women who did not own plots were excluded from being formal water user members.

Other informal water users were those farmers who had plots within the scheme, but did not live within the villages. Although they were paying the water fees, these farmers were not formal water user members. Although there was no more land for allocation in the scheme, new farmers could still acquire land through land purchases, inheritance, or through renting from farmers who failed to continue with farming. In the case of sale or inheritance, the water right could also be transferred to men and women farmers who obtained the land.

The farmers who rented out their plots could not transfer their membership, but could also not become members themselves. In all cases, the rules and regulations regarding membership of the water users' organisation were such that the number of farmers involved in irrigated rice farming was higher than that of members of the water users association.

4.6 Economic Value of Riverside Wetland Services

The economic value of riverside wetland services was elicited through dichotomous questions on the willingness to pay to conservation of the riverside wetlands services.

4.7 Dichotomous Choice Results

Table 8 shows the distribution of initial bids and the corresponding answers from the respondents.

Table 8: Distribution of initial bids and corresponding answers

Bid level in Tshs	Number of respondents per given bid level	Number of respondent agreeing to bid level	Number of respondent not agreeing to bid level
20 000	15	15	0
25 000	21	20	1
30 000	20	18	2
35 000	14	13	1
40 000	18	15	3
45 000	10	5	5
50 000	7	2	5
Total	105	88	17

Using the formula in Eq. (7), mean WTP was calculated at the mean of the other independent variables. The resulting annual mean willingness to pay per household to conserve riverside services in the Rau river was Tshs 27 860 per Ha per annum (equivalent to 19.9 US\$ per Ha per annum using an exchange rate of TShs 1 400 to 1US\$ as of June 2010).

4.8 WTP Distribution

The distribution of WTP obtained from the follow-up open ended question is shown in Figure 2. The mean WTP for riverside wetland services was Tshs 36 195 per Ha per annum (equivalent to US\$ 25.8 per Ha per annum). The mean WTP from the open-ended question is significantly higher than the mean WTP calculated from the

dichotomous choice question. This is because, on average, most respondents who accepted the initial bids indicated a WTP that was significantly higher than the initial bid when asked for their maximum WTP, while respondents who did not accept the initial bid chose a slightly lower WTP than the initial bid. The WTP distribution shown in figure 2 appears to be normally distributed which means that the sample comes from a normally distributed population of observations.

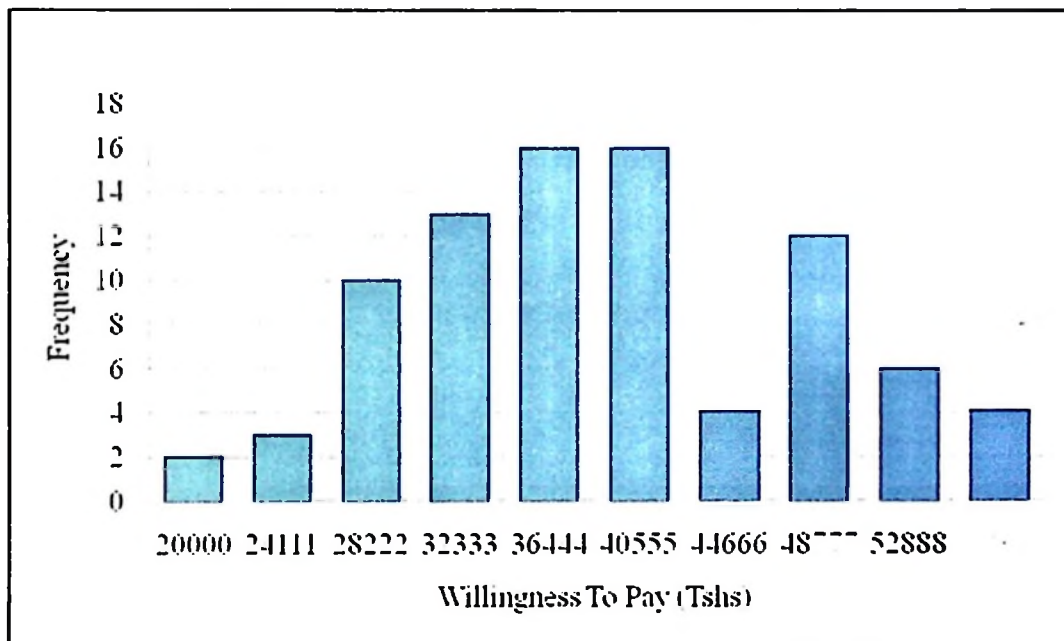


Figure 3: Distribution of willingness to pay

4.9 Statistical Analysis

Results from the t-test and the one-way ANOVA test indicated that the t and F statistics, respectively, were greater than the statistical critical values (at least at the 0.05 significance level) for six variables: bid amount, income, sex, age, education household size. This implies that, the mean WTP is not equal across different

groups for these variables and confirms that these variables have a significant influence on WTP.

Table 9 above shows the estimated coefficients and their associated t- statistics for logit model and linear regression model as shown in equation 5 and 6. In addition, the sign expected for each coefficient is indicated in this table

Table 9: Logit and Linear regression models results

Variables	Expected sign of coefficients	Logit regression model		Linear regression model	
		Estimated coefficient	t- Statistics	Estimated coefficient	t- statistics
Constant		66.10	1.79	4.54	4.92
Sex		-0.37	-0.36	-0.40	-1.00
Age	+	1.79	0.66	0.39	0.44
Education Level	+	2.21	0.95	0.28	0.45
Household size	+	-1.38	-1.46	-0.13	-0.01
Income of household	+	5.33	3.04	0.19	6.22
Initial bid amount	-	-14.33	-2.84	0.29	4.01
Adjusted R ²			0.43		0.41
Number of observations			105		

The linear and logit regression analyses gave roughly similar results in terms of the number of significant determinants and the corresponding levels of significance associated with the estimated coefficients. The four significant determinants for the WTP bids were found to be the initial bid amount, number of years of formal education, Size of households and household annual income. On the one hand, as

expected, the coefficient associated with the initial bid amount had a positive sign for the linear model, indicating that the higher the amount of money (in Tshs) the respondent was asked to pay initially, the higher the respondent's final WTP. On the other hand, the coefficient associated with initial bid for the logit model was negative, indicating that respondents were more likely to give a negative answer as the initial bid increased. The WTP also increased with income and household educational level. Finally, it was found out that the WTP also decreased with number of household size, which is different from the result found in most WTP studies (Ragkos and Asimakis, 2006).

The adjusted R^2 of the linear and logit models were 0.41 and 0.43, respectively, which, according to Mitchell and Carson (1989) are more reliable. The linear model fit, is slightly inferior to the logit model fit but the relative similarity between these two types of models indicates that the WTP-determinant relationships found here are robust.

4.10 The Effect of Social Economics Characteristics on WTP

A Pearson correlation analysis was carried out to determine the effect of respondents' characteristics on the WTP for riverside wetland services sustained by water flows in the Rau River. The results of the correlation analysis are summarized in Table 10. It is evident that, the correlation between age of the heads of households and WTP for the services was positive. This implies that, the WTP for these services increases with age of the respondent. In addition, the correlation between household size and WTP was negative, implying that small sized

households are willing to pay for riverside wetland services than large sized households. The correlation between education levels attained by the respondents WTP was positive and statistically significant at 1% probability level. This implies that, the willingness to pay for riverside wetland services increases with an increase in education level.

Table 10 Correlation between the WTP and factors that determine WTP

Variables	Correlation (r) (WTP)
Age of the respondent	0.091
Education level of the respondent	0.311**
Size of household	-0.098
Income of the household	0.419**
Initial bid amount	-0.402
Information on riverside wetland services	0.07

** Correlation is significant at 0.01 levels (2 – tailed)

As it can be seen from Table 10, the correlation between income and WTP was positive and statistically significant at 1% probability level. This implies that the willingness to pay for riverside wetland services increases with an increase in the level of household income. This finding concurs with that of Loomis *et. al.* (2000). This is probably due to the fact that people with high income have adequate financial resources to meet costs of living and hence can also afford to pay for riverside wetland services. The correlation between the WTP and initial bid amount was negative, indicating that the higher the amount of money the respondent was asked to pay initially, the lower the respondent's final willingness to pay.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter presents a summary of the major findings of economic value of irrigation water, riverside wetland services and factors that determined the willingness to pay for riverside wetland services, followed by conclusions and recommendations.

5.2 Summary

The main objective of the study was to determine the economic value of irrigation water and riverside wetland services in the Lower Moshi Irrigation Scheme. The Residual Imputation Method was used to determine the economic value of water for irrigation. The findings in this indicated that the economic value of water for paddy was Tshs 366/m³, maize Tshs 329/m³ and sunflower 448TShs/m³. A CVM survey was used to obtain estimates of the WTP for riverside wetland in the Rau River. Results from CVM indicated that, respondents were willing to pay an average of Tshs 27 860 annually per Ha per as irrigation water fee which will be used for conservation of riverside wetland services in the Rau River. The WTP was found to be significantly influenced by variables such as initial bid amount, age, income, education level, household size and information about riverside wetland services. Education of the respondent, age, information on riverside wetland services and income of the household were the significant factors that had positive correlation with the willingness to pay for the conservation of riverside wetland services in the Rau River. The initial bid amount and size of household were the factors that had a

negative correlation with the willingness to pay for the conservation of riverside wetland services in the Rau River.

Factors that determine the willingness to pay such as education level, age and income of the household were the significant factors that had positive correlation with the willingness to pay for conservation of riverside wetland services. The initial bid amount and size of household were the factors that had a negative correlation with the willingness to pay for the riverside wetland services.

5.3 Conclusions

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

5.3.1 The economic value of irrigation water

The economic values of irrigation water have shown that, sunflower has high economic value compared to paddy and maize. The high economic value was due to low consumption of water of and high price.

At the study site, large amounts of water are used in agriculture, primarily for irrigation. The price charged to water does not reflect the actual cost of supplying the water to the site. In other words, there is no price for water in the market. As such, farmers assume that water is cheap and plentiful. In such a situation, farmers consume water as they wish. Although efficiency, equity, and sustainability are basic principles for water resources allocation, it seems that in Tanzanian agricultural water allocation, equity is the major applied criterion.

5.3.2 Economic value of riverside wetland services

Access to irrigation water and suitable wetland for wet and dry season irrigated agriculture constitute one of the most important determinants of livelihood in the Lower Moshi Irrigation Scheme. Cultivation of crops such as paddy, sunflower and maize (as are main crops under irrigation in the area) require easy access to water and at the same time, protection of riverside wetland which assist in purification of polluted water (to access quality water for irrigation), control erosion and hence high yield for the cultivated crops.

Decreasing water supplies in the Lower Moshi Irrigation Scheme and poor water inflows in the Rau River especially during the dry seasons, affect negatively the existence of important services conserved by Riverside wetland. Thus it can be concluded that, current water use practices in the Lower Moshi Irrigation Scheme are unsustainable since there is high allocation of water for agricultural activities, thus leaving aside other important sectors such as riverside wetlands which also need water to conserve its services.

5.3.4 Factors that determine the WTP for conservation of riverside wetland services

Based on the results of the study it can be concluded that education of the respondent, age, information on riverside wetland services and income of the household were the significant factors that had positive correlation with the willingness to pay for the riverside wetland services sustained by water flows in the Rau River. The initial bid amount and size of household were the factors that had a

negative correlation with the willingness to pay for the riverside wetland services sustained by water flows in the Rau River. This can be concluded that people with high income in the study area are willing to pay for the riverside wetland services compared to low income households. Apart from that it is concluded that higher fee of irrigation water can reduce the willing to pay for the riverside wetland services.

5.4 Recommendations

In view of the major findings of the study and the above conclusions, the following recommendations are drawn.

- a) Based on the results, the economic value of irrigation water for paddy is lower while is higher for sunflower but the role that irrigated paddy plays as the major source of income and staple food for the majority of poor households in the study area, and in enhancing national food security, must not be underestimated.
- b) Since farmers are willing to pay for conservation of riverside wetlands, the government should establish riverside services conservation projects where farmers will participate through contribution for the water they use for irrigation for the purpose of the riverside services conservation. Funds collected should be used for conservation activities they should not misused, since this will discourage farmers to contribute for the project. The initial amount for farmers' contribution should be reasonable so that every farmer should be able to pay as the higher amount lead to low willingness to pay as found in the study.

- c) Natural resource conservationists should work hand in hand with the water user associations in the scheme to advocate for a total protection of the riverside wetland through training on the importance of riverside wetland services and functions such as purification of water, soil erosion control, and habitat for fish and other beneficial wild animals.

- d) It is worth noting that while the findings in this study serve to provide some lights regarding the value of irrigated paddy, maize and sunflower. Research is needed, particularly on the value of water in its multiple uses for both short run and long run values. Moreover, the approach used, that is the Residual Imputation Method, calculates only average values and not marginal values of water and therefore cannot be suitable for making decisions on cross-sectoral water allocation. Ideally, estimating the marginal values of water would require the use of optimization models, which in turn demand a large amount of data which are rarely available.

- e) Distribution of irrigation water across crops (paddy, maize and sunflower) on the basis of economic value of water should be considered for rational use of scarce water resources in the study area.

REFERENCES

- Acharya, G .and Barbier, E. (2000). Valuing groundwater recharge through agricultural production at Hadejia- Nguru Wetlands in Northern Nigeria. *Journal of Agricultural Economics* 22(3): 247-259.
- Biol, E. and Phoebe, K. (2006). Using economic valuation techniques to inform water resources management: A survey and critical appraisal of available techniques and an application. *Journal of Science of the Total Environment* 365: 105–122.
- Brander, L.M. and Jane, E.V. (2006). Empirics of wetland valuation: Comprehensive summary and a Meta-Analysis of the literature. *Journal of Environmental and Resource Economics* 33: 223–250.
- Bromley, D. (1997). Constitutional political economy: Property claims in a dynamic world. *Journal of Contemporary Economic Policy* 15: 43–54.
- Chambouleyron, A. (2004). Optimal water metering and pricing. *Journal of Water Resource Management* 18:305–319.
- Chapagain, A.K., (September, 2005). Value of Water Research (<http://www.waterfootprint.org>) site visited on 12/6/2008
- Chiara, M.T. and Peter, N. (2008).Valuing environmental and health risk in agriculture. *Journal of ecological economics* 67:598 – 607.

- Chiueh, Y. and Ming, C. (2008). Environmental multifunctionality of paddy fields in Taiwan: An application of contingent valuation method paddy. *Journal of Water Environment* 6:229–236.
- David, H., Shore, N. and Train K. (2006). Water supply security and willingness to pay to avoid drought restrictions. *Journal of the Economic record* 82(256): 56–66.
- de Oca, G.S.M. and Bateman, I.J. (2006). Willingness to pay for maintained and improved water supplies in a developing world urban area in Mexico City. *Journal of Water Resources Research* 42(7): 34-46.
- Esmaeili, A. and Vazirzadeh, S. (2008). Water pricing for agricultural production in the South of Iran. *Journal of Water Resource Management* 39(5): 455-462.
- Faux, J. and Perry, G.M. (1999). Estimating irrigation water value using hedonic price analysis in Malheur County, Oregon. *Journal of Land Economics* 75: 440-452.
- Garrod, G. (1999). *Economic Valuation of the Environment*. Edward Elgar Ltd. Northampton 384 pp.
- Glenn, E.P., Zamora, A. F., Nagler, P.L., Briggs, M., Shaw, W. and Flessa, K. (2001). Ecology and conservation biology of the Colorado River Delta, Mexico. *Journal of Arid Environments* 49: 5 – 15.

- Griffin, R.C. and Mjelde, J.W. (2000). Valuing water supply reliability. *American Journal of Agricultural Economics* 82: 414–426.
- Han, H. and Zhao, L. (2007). The impact of water pricing policy on local environment: Analysis of the irrigation districts in China agriculture. *Journal of Sciences in China* 6:1472–1478.
- Hartwick, J.M. and Olewiler, N.D. (1998). *The Economics of Natural Resource Use*. Addison- Wesley, New York. 456pp.
- Hellegers, P. J. and Perry, C. J. (2006). Can Irrigation Water Use be Guided by Market Forces? Theory and Practice. *Journal of Arid Environments* 22: 79-86.
- JICA (1980). Agricultural Development Project at Lower Moshi Irrigation Scheme. Unpublished Feasibility Study Report, Moshi, Tanzania, pp. 19-62.
- Johnson, N.L. and Baltodano, M.E. (2004). Economics of community watershed management: Some evidence from Nicaragua. *Journal of ecological Economics* 49: 57–71.
- Kadigi, R.M.J. (2006). Evaluation of Livelihoods and Economic Benefits of Water Utilization: at Great Ruaha River Catchment. Unpublished Thesis for Award of PhD Degree at Sokoine University of Agriculture, Morogoro, Tanzania, pp. 59-134.

- Kadigi, R.M.J., Kashaigili, J.J., Mdoe, N.S. (2004). Economics of Irrigated Paddy in Usangu Basin in Tanzania: Water Utilization, Productivity, Income and Livelihood Implications. *Journal of Physics and Chemistry of the Earth* 29/15 (18), 1091–1100.
- Kalunde, K. (2008). Irrigation Based Livelihood Challenges and Opportunities: Gendered Technography of Irrigation Development Intervention in the Lower Moshi Irrigation Scheme. Unpublished Thesis for Award of PhD Degree at Wageningen University, Netherlands, pp.3-20.
- KATC (Kilimanjaro Agricultural Training Centre) (2006). Lower Moshi Irrigation Project. Its Achievements and Prospects, Unpublished Report, Moshi, Tanzania, pp 43.
- Kosz, M. (1994). Valuing riverside wetlands in Donau-Auen national park. *Journal of Ecological Economics* 16: 109-127.
- Kulshreshtha, S.N. and Gillies, J.A. (1994). The economic value of the South Saskatchewan river to the City of Saskatoon: Value of alternative minimum river waterflow. *Journal of Canadian Water Resources Journal* 19: 39-55.
- Lankford, B. and Franks, T. (2000). Sustainable coexistence of wetlands and rice irrigation: A case study from Tanzania. *Journal of Environment and Development* 9:119 - 137.

- Latinopoulos, D. (2008). Estimating the potential impacts of irrigation water pricing using Multicriteria Decision Making Modelling: Application to Northern Greece. *Journal of Water Resource Management* 22:1761–1782.
- Lemly, A.D., Kingsford, R.T. and Thompson, J.R. (2000). Irrigated agriculture and wildlife conservation: Conflict on a global scale. *Journal of Environmental Management* 25:485 – 512.
- Loomis, J. (1987). Economic value of instream flow: Methodology and Benefit Estimates for Optimum Flows. *Journal of Environmental Management* 24:169-179.
- Loomis, J.B., Kent, P., Strange, L., Fausch, K. and Covich, A. (2000). Measuring the total economic value of restoring ecosystem services in an impaired river basin: Results from a contingent valuation survey. *Journal of Ecological Economics* 33 (1): 103–117.
- Maganga, F.P., Butterworth, J. A. and Moriarty, P. (2001). Domestic water supply, competition for water resources in Tanzania. A review and discussion paper. International Water Management Institute (IWMI) Colombo, Sri Lanka. 12pp.
- Manyatsi, A.M. and Mwendera, E.J. (2007). Contribution of informal water development in the improved livelihood in Swaziland. *Journal of Physics and chemistry of the Earth* 30: 1148–1156.

- Mitchell, R.C. and Carson, R.T. (1989). Using Surveys to value public goods: Contingent Valuation Method. *Journal of Resources for the Future* 40: 488- 495.
- Molden, D. (1997). Accounting for water use and productivity in Sri Lanka. System-Wide Initiative on Water Management (SWIM) paper 1. International Irrigation Management Institute Colombo Sri Lanka, 26pp.
- Molle, F., Venot, J.P. and Hassan, Y. (2008). Irrigation in the Jordan valley: Are water pricing policies overly optimistic? *Journal of Agricultural water management* 9 (5): 427 – 438.
- Moran, D. and Dann, S. (2008). The Economic value of water use: implications for implementing the water framework directive in Scotland. *Journal of Environmental Management* 87:484–496.
- Muhammad, A., Saima, J. and Irfan, A.B. (2005). Estimation of economic value of irrigation water. *Journal of Agricultural and social science* 1(3):270–272.
- Ojeda, M I., Mayer, A.S. and Solomon, B.D. (2008). Economic valuation of environmental services sustained by water flows in the Yaqui River Delta. *Journal of Ecological Economics* 65: 355-366.

- Perry, C.J. Seckler, D. and Rock, M. (1997). Water as an economic good: Solution or a problem. In: *Water Economics, Management and Demand* (Edited by Franks, T. M. and L. Smith). E & F Spon. pp 112- 125.
- Postel, S. (2001). Growing more food with less water. *Journal of Scientific American* 284(2): 46-60.
- Ragkos, A. and Asimakis, P. (2006). Using a functional approach to wetland valuation in Zazari Cheimaditida. *Journal of Environmental Change* 6: 193–200.
- Scholte, P., Kort, S. and Weerd, M. (2000). Floodplain rehabilitation in Far North Cameroon: Expected impact on bird life. *Journal of Resources for the Future* 71:112 – 117.
- Shin, Y.K. and Kim, C.G. (2005). Economic valuation of environmentally friendly agriculture for improving environmental quality. *Journal of Rural Development* 29(4): 73 – 86.
- Shyamsundar, P. and Kramer, R. (1996). Tropical forest protection: Empirical analysis of the costs borne by local people. *Journal of Environmental Economics and Management* 31 (2): 129–144.
- Speelman, S. (2008). Irrigation Water Value at Small Scale Schemes: Evidence from the North West Province, South Africa. *Journal of Agricultural and social science* 28: 270–283.

- Strange, E., Fausch, K. and Covich, A. (1999). Sustaining ecosystem services in human dominated watersheds: Biohydrology and ecosystem processes in South Platte river basin. *Journal of Environmental Management* 24 (1): 39–54.
- Sumbi P.E. (2004). Community Perceptions of Costs and Benefits of Different Forest Management Approaches at Udzungwa Mountain Forests and the Surrounding Miombo Woodlands. Unpublished Dissertation for Award of MSc. Degree at Wales University, United Kingdom, pp 48-63.
- Tarimo, A.K.P.R., Mdoe, N.S. and Lutatina, J.M. (1998). Irrigation water prices for farmer-managed irrigation systems in Tanzania: A case study of Lower Moshi Irrigation Scheme. *Agricultural Water Management* 38:33–44.
- Thomas, P.H., John, C.B., Eric H., Susan, B.K. and Fritz O. (2004). Contingent valuation, net marginal benefits, and scale of riparian ecosystem restoration. *Journal of Ecological Economics* 49: 19 – 30.
- Travisi, C.M. and Nijkamp, P. (2008). Valuing environmental and health risk in agriculture. *Journal of Ecological Economics* 67:598 – 607.
- Turpie, J., Ngaga, Y and. Karanja, F. (2003). A preliminary economic assessment of water resources of the Pangani river basin, Tanzania: Economic value, incentives for sustainable use and mechanisms for financing management. A report submitted to IUCN Eastern Africa Regional Office and Pangani Basin Water Office. 96pp.

- Venkatachalam, L. (2004). The Contingent Valuation Method: Environmental Impact Assessment Review *Journal of Ecological Economics* 24(1): 89–124.
- Wang, J.F. (2008). Optimal water resource allocation in arid and semi-arid area. *Journal of Water Resource Management* 22:239–258.
- Ward, F. (2002). The economic value of water in agriculture: Concepts and Policy Applications *Journal of water policy* 4: 423–446.
- Wichelns, D. (2002). An Economic perspective on the potential gains from improvements in irrigation water management. *Journal of Agricultural Water Management* 52:233–248.
- WMO (World Meteorology Organization) (2007). The Dublin Statement on Water And Sustainable Development. [<http://www.wmo.ch/>] site visited on 12/3/2009.
- Xu, Z., Cheng, G., Zhang, Z., Su, Z. and Loomis, J. (2003). Applying contingent valuation in China to measure the total Economic value of restoring ecosystem services in Ejina region. *Journal of Ecological Economics* 67:589 – 637.

Young, A. (2005). Non market economic valuation for irrigation water policy decisions: Methodological Issues *Journal of Contemporary Water Research and Education Issue* 131:21-25.

Zekri, S. Eager, W. (2005). Estimating the potential gains from water market in Tunisia. *Journal of Agricultural Water Management* 72:161–75.

APPENDICES

Appendix 1: The questionnaire administered to the sample households

ECONOMIC VALUATION OF IRRIGATION WATER AND RIVERSIDE WETLAND SERVICES. A CASE STUDY OF LOWER MOSHI IRRIGATION Dear farmer,

You have been selected to provide some information on the economic value of irrigation water and riverside wetland services sustained by water flows in the Rau River at Lower Moshi Irrigation Scheme. 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 strictly confidential.

A1: SOCIO ECONOMIC CHARACTERISTICS OF THE RESPONDENT

Questionnaire No..... A1.1 Date of interview.....

A1.2 Name of Interviewer.....

A1.3 Basic Respondent's Information

Village	Sex	Age	Education level	Main occupation	Marital status	Household size
1 = Mabogini	1 = Male		1 = None	1 = Farmer	1 = Married	
2 = Rau	2 = Female		2 = Std IV	2 = Govt. employee	2 = Single	
3 = Chekereni			3 = Std VII	3 = Private employee	3 = Divorced	
4 = Oria			4 = Std VIII	4 = Self employee	4 = Widowed	
			5 = Form IV			
			6 = Form VI			
			7 = Higher			

B1: IRRIGATION

B1.1 Do you practice irrigated agriculture 1= Yes 2 =No ()

B1.2 If Yes what is (are) the source(s) of water for irrigation? (Indicate the river/stream/that the scheme gets water from

B1.2 What is the name of village in which the intake is taken? Indicate the distance from the farm to the intake.

B1.2 When the irrigation scheme built.....

B1.3 Who built the scheme.....

B1.4 Do you pay for irrigation water? 1) Yes 2) No ()

B1.5 If yes how much do you pay per m³ () Tshs

B1.6 State the total area that was irrigated and the quantity of paddy/rice produced for dry/wet season in the last seasons

Season	Irrigated area (Ha)	Quantity of crop produce	Notes
Wet season			
Dry season			

B1.7 When do you have surplus water in the field?

.....

B1.8 What happen to surplus water in the field (Where does it drain to?).....

B1.9 when do you stop abstracting water fro the river?

.....

B1.10 Do you plan to increase the area under irrigation? 1 = Yes 2 = No ()

B1.11 If Yes or No why?

.....

B1.11 Is water used for activities other than irrigation? 1 = Yes 2= No ()

B1.12 If Yes what are the other

uses.....

C1: CROP OUTPUTS AND INCOME

C1.1 Fill the empty spaces where applicable ie Units, A, B, D and F

Crop	Unit	Quantity consumed	Quantity sold	Total produced	Average price D	Gross Income	Variable costs	Net Total income
		A	B	C=A + B		E=C*D	F	G=E-F
Paddy/rice								
Maize								
Sunflower								
Total								

Crop	Name of input	Quantity used	Price per unit	Cost of input	Total cost for all inputs (Sum of M Values)
		K	L	M = K*L	
Paddy/Rice					
Maize					
Sun flower					
TOTAL					

C1.2 working spaces for variable inputs include labour.

C1: ECONOMIC VALUE OF RIVERSIDE WETLAND SERVICES

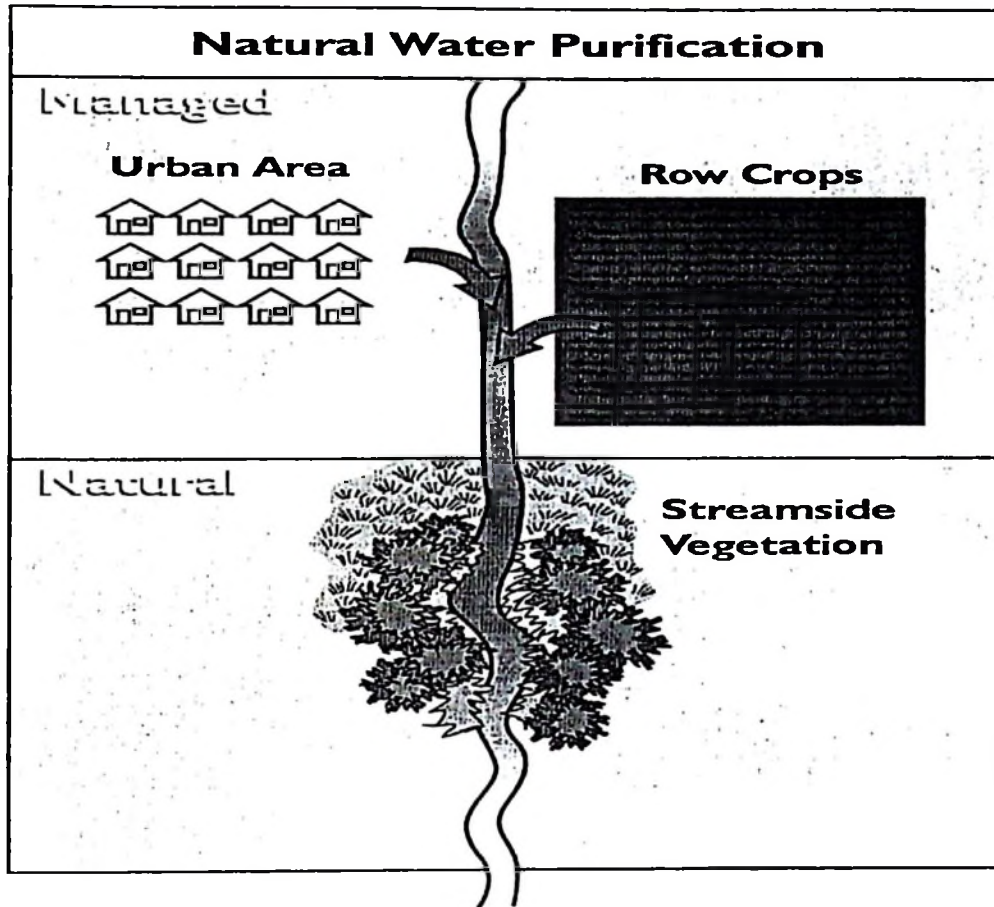
C1.1 Background information and proposal

Good management of water for irrigation and sustain riverside wetland services can reduce agricultural externalities such as environmental degradation (insufficiency

water use, soil erosion, species and ecosystem) and unsafe food. But because of a decreasing labor force and increasing production costs, we have a long way to go to put water management sustaining riverside wetlands into practice. More support is needed than just the efforts of farming families and the government. So, we plan to raise a 'Water management promotion fund (a tentative name)' for improving riverside wetland services. The following services are provided by riverside wetland;

Service 1 Natural purification of water: (Card A)

One of the most important services provided by riverside wetlands is the natural purification of water. Run-off from paddy/rice fields contains various pollutants such as pesticides, and fertilizer as well as excess soil. These pollutants are absorbed by the plants and broken down by plants and bacteria to less harmful substances. Pollutants attached to suspended soil particles are filtered out by grasses and other plants and deposited in floodplains. This process helps improve water quality and hence environmental friendly agriculture. (See a colour drawing contrasting the current condition and the natural purification process).



Service 2 Prevention of soil erosion: (Card B)

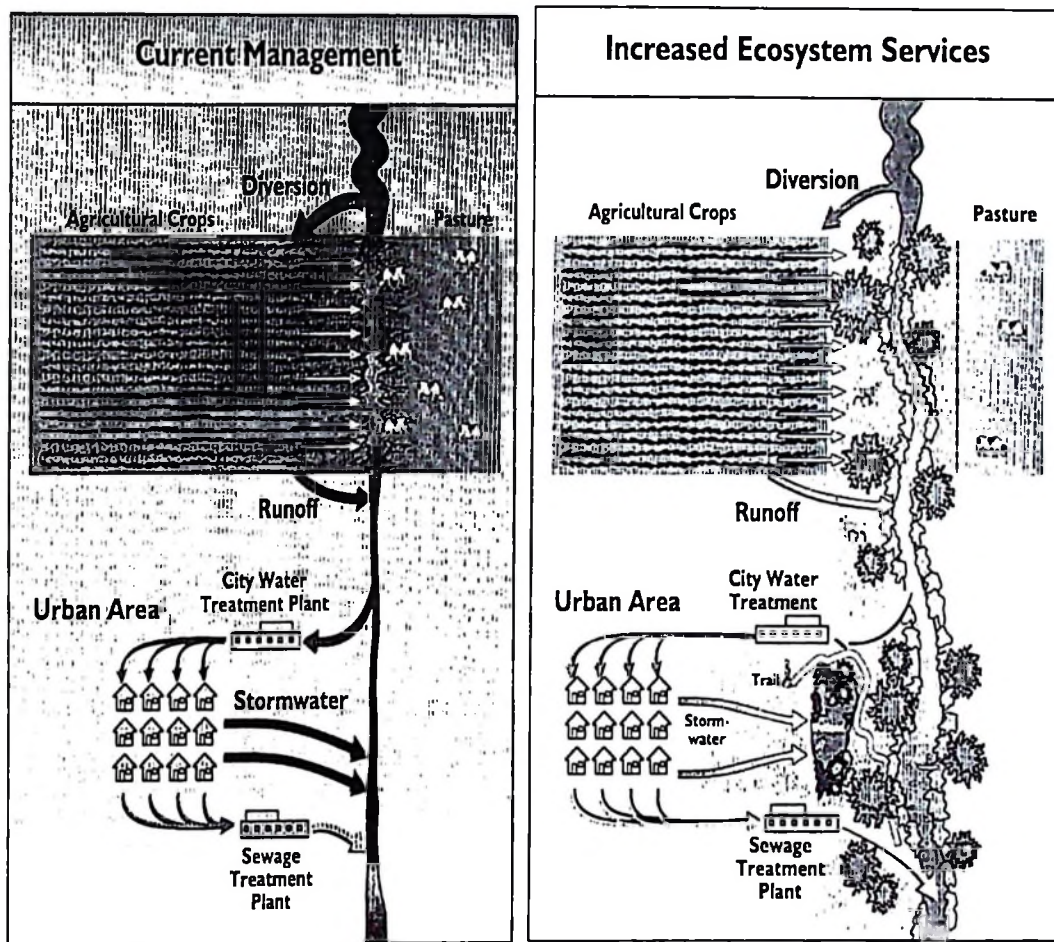
Stream side vegetation (Riverside wetlands) plays a role in the control of erosion. Plants and their roots hold stream banks and filter water. The results in clear, clean water required by fish. In the absence of vegetation, rain erodes the stream banks and rainfall washes soil from fields directly into river. This eroded soil fills the river bottom with mud. The result is muddy water and shallow rivers

Service 3 Habitat for fish and wildlife (Card C)

Vegetations along the river provides habitat for a wide range of wildlife including shorebirds and deer. Trees and shrubs in flood plains offer shelter and areas for

nesting and roosting of many bird species. In addition the vegetation shades the stream keeping the water cool for fish and reducing algae growth which is detrimental to fish. Stream side corridors also are important for animal migration.

NOTE. See the diagram which shows the current management and increase riverside wetland services



C1.2 Have you ever heard of the Rau River? 1= Yes 0 = No

C1.3. Does the information presented in card A to C new to you? 1=Yes, very new;
2= Only some of it is new; 3=I know all this already

C1.4. To secure the riverside wetland services provided by restoring instream flows in the water scarce Rau River;

Are you willing to donate (X) per Ha of irrigation water?

1 = Yes () 0 = No ()

C1.5 If Yes what is the maximum amount the household would pay?

.....

C1.6 If No what is the minimum amount the household would pay?

C1.7 Are you a member of an organization related to environmental conservation?

1=Yes; 2=No ()

C1.8. Should the environment be considered as a service that has an economic value? 1=Yes; 0=No ()

C1.9 Is it important to value water flows or environmental services in the Rau River

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

THANK YOU

Appendix 3: Estimated volumetric water demand

a) Measured Return flow at tertiary block RS 4-3

Location: RS 4-3 at Chekereni area

Month	Q _{in} (m ³)	Q _r (m ³)	Q _{out} (m ³)	Irrigation supply discharge (l/s/ha)
June	128 305	2 035	15 520	2.6
July	228 178	2 692	15 765	2.2
August	267 231		7 327	2.4
September	215 306	658	877	2.0
October	114 654	15 252	868	1.5
Total	953 674	20 637	40 357	10.7

Note: Q_{in} - Water supply discharge

Q_r - Rainfall

Q_{out} - Drain from tertiary block RS 4-3

$$\begin{aligned}
 \text{Return flow rate for one cropping season} &= \frac{Q_{out}}{(Q_{in} + Q_r)} \times 100 \\
 &= \frac{40357}{(953674 + 20637)} \times 100 \\
 &= 4\%
 \end{aligned}$$

Therefore the return flow rate for one season is 4% while the average irrigation supply discharge is 2.14l/s/ha

b) Irrigation water requirement of Paddy

Description	July	August	September	October	November	December
ETc (mm/m)		135	164	203	210	214
P (mm/m)		248	240	248	240	248
ER 80 (mm/m)	0	0	0	0	2	20
NWD (mm)		383	404	451	448	442
CI		0.25	0.75	1	0.94	0.5
NW (mm)		7	16			
PW (mm)	37	91	92			
NR (mm/m)	37	194	411	451	420	221
GR (mm/m)	54	281	596	654	609	320
GR (l/s/ha)	0.2	1	2.3	2.4	2.3	1.2

Note: ETc: Crop Evapotranspiration (Consumptive use water)

P: Percolation

ER80: Effective rainfall with 80% dependability estimated for area to be irrigated from Rau river.

NWD: Net water deficit (FWR – ER80)

CI: Crop index

NW: Nursery water

PW: Puddling water

NR: Net requirement

GR: Gross requirement using overall irrigation efficiency of 0.72 for area to be irrigated from Njoro and Rau rivers.

Average water requirement = 1.56 l/s/ha

Convert into m^3 : 1000 litre = $1 m^3$

1.56litre= Xm^3

$$X = \frac{1.56}{1000} = 0.00156m^3$$

Convert second into days

$$0.00156 * 60 * 60 * 24 = 134.78m^3 / day$$

For the season plot are irrigated for the interval of 3 days which made 50 days

$$\text{Therefore } 134.78 m^3 / day * 50 days = 6739.2 m^3$$

Therefore the volume of water used was $6739.2 m^3 / Ha$ under the overall irrigation efficiency of 0.72.

c) Irrigation water requirement of sunflower

Description	Oct.	Nov.	Dec.	Jan.	Feb.
ETc (mm/m)	72	118	185	192	113
ER 80 (mm/m)	0	2	21	7	0
NWD (mm)	72	116	164	185	113
CI	0.125	0.88	1	1	0.5
PI (mm)	30	30			
NR (mm/m)	39	131	164	185	56
GR (mm/m)	74	247	309	349	106
GR (l/s/ha)	0.3	1	1.2	1.3	0.4

Note: ETc: Crop Evapotranspiration (Consumptive use water)

P: Percolation

ER80: Effective rainfall with 80% dependability estimated for area to be irrigated from Njoro and Rau rivers.

NWD: Net water deficit (FWR – ER80)

CI: Crop index

NW: Nursery water

PW: Puddling water

NR: Net requirement

GR: Gross requirement using overall irrigation efficiency of 0.53 for area to be irrigated from Njoro and Rau rivers.

Average water requirement = 0.84l/s/ha

Convert into m^3 : 1000litre is equivalent to $1m^3$

1.5litre is equivalent to X m^3

$$X = \frac{0.84}{1000} = 0.00084m^3$$

Convert second into days

$$0.00084 \times 60 \times 60 \times 24 = 72.6m^3 / day$$

For the season plot are irrigated for the interval of 3 days which made 20 days

$$\text{Therefore } 72.6m^3 / day \times 20day = 1450m^3 / ha$$

Therefore, the volume of water used was $1,450m^3 / ha$

d) Irrigation water requirement of maize

Description	Oct.	Nov.	Dec.	Jan.	Feb.
ETc (mm/m)	72	118	185	192	113
ER 80 (mm/m)	0	2	21	7	0
NWD (mm)	72	116	164	185	113
CI	0.125	0.88	1	1	0.5
PI (mm)	30	30			
NR (mm/m)	39	131	164	185	56
GR (mm/m)	74	247	309	349	106
GR (l/s/ha)	0.3	1	1.2	1.3	0.4

Note: ETc: Crop Evapotranspiration (Consumptive use water)

P: Perculation

ER80: Effective rainfall with 80% dependability estimated for area to be irrigated from Rau river.

NWD: Net water deficit (FWR – ER80)

CI: Crop index

NW: Nursery water

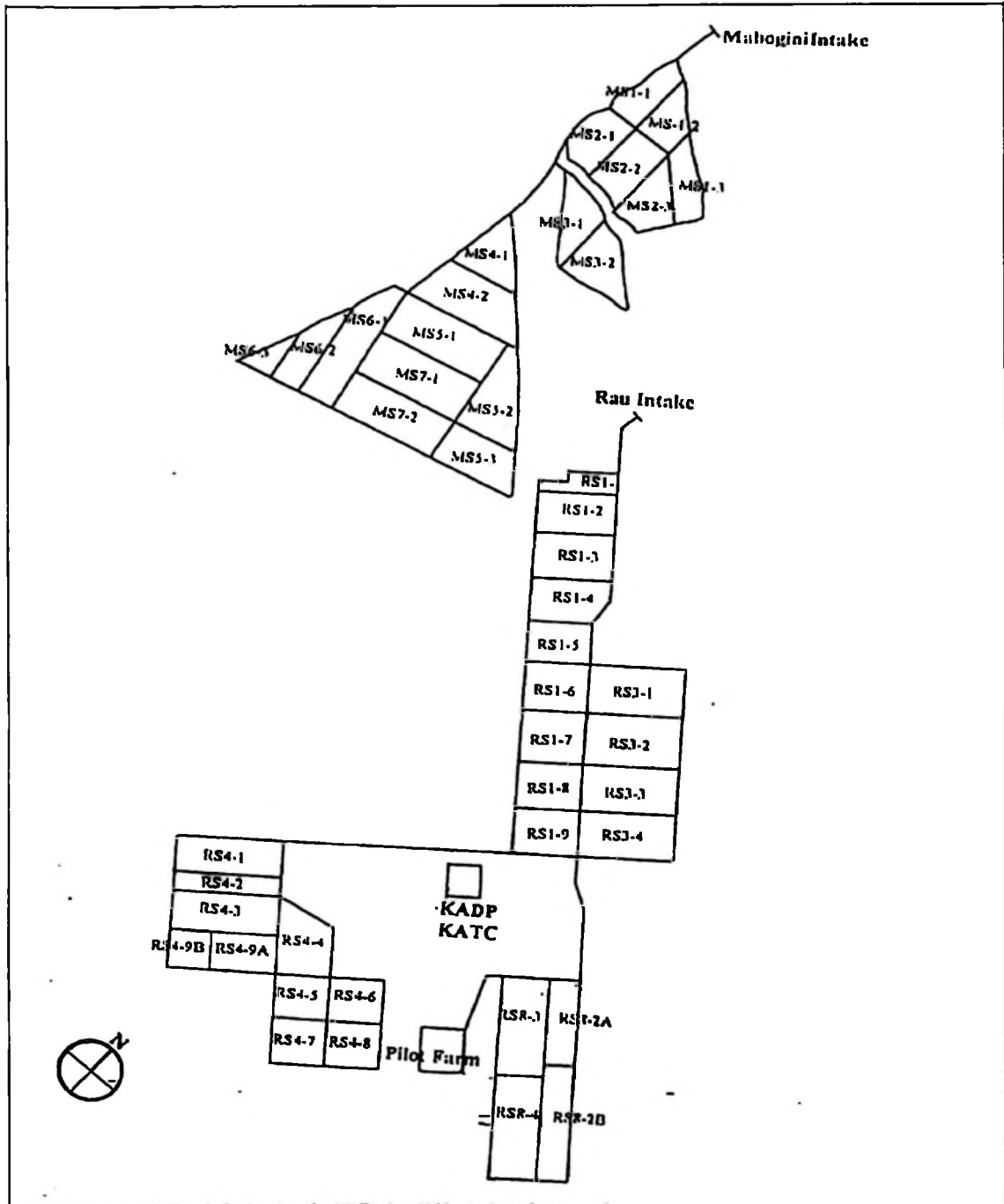
PW: Puddling water

NR: Net requirement

GR: Gross requirement using overall irrigation efficiency of 0.53 for area to be irrigated from Njoro and Rau rivers.

Average water requirement = 1.13l/s/ha equivalent to 2 255 m^3 / ha

Appendix 4: The command area of Lower Moshi Irrigation Scheme, showing plots



Source: Tamura, KATC 1996

SPE
5616
T34
J36