AN ESTIMATION OF THE ECONOMIC VALUE OF IRRIGATION WATER FOR WHEAT PRODUCTION AT SABLE FARMS.

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Declaration

I, Chitete Client, do hereby declare that this dissertation represents my own work, and that it has not previously been submitted for a post-graduate diploma at this University or any other University.

Signature……………………………………

Date….10/08/11………………………..

Abstract

Water is a finite and vulnerable resource which plays a vital role in economic development. It needs to be managed through demand management (pricing) other than supply management. This study was carried out at Sable farms in Lusaka District of Lusaka Province, Zambia. The main objective of this study was to suggest a methodology to evaluate the economic value of water. Knowledge of value for the resource can help in the process of proper pricing, the widely and most effective demand management tool. Both primary and secondary data used in this study were collected using structured and semi structured questionnaires. Although many methods are available for valuing of resources, residual method has been rated the best for valuing environmental goods like water. The study therefore used this method to value water used for irrigation of wheat at sable farms. Sable farms use about 5130m^3 of water per hectare of wheat during the entire growing period of wheat. Each cubic meter of water used to irrigate wheat generates an income of about ZMK 1,000 for the farmer. The financial and economic values of water used for irrigation of wheat at sable farms were found to be ZMK1000 (US$0.21) and ZMK1120 (US $0.23) per cubic meter respectively. These values indicate that the current price of water in Zambia which ranges from ZMK2/m^3 to ZMK10/m^3 is far below its economic value (ZMK1120/m^3). Residual imputation method proved to be a useful way of valuing water. The government should therefore encourage further research in this area through UNZA's IWRM Centre. The government should also come up with policies which will encourage water audits for all commercial farms in Zambia and consider the possibility of pricing water used for agriculture.

Dedication

I dedicate this dissertation to my father Luke Chitete for his encouragement and financial support, my wife Mwezi and my daughter Matimba for their inspiration.

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ACRONYMS

DWA	Department of Water Affairs
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GNP	Gross National Product
GRZ	Government of the Republic of Zambia
IWRM	Integrated Water Resources Management
MACO	Ministry of Agriculture and Cooperatives
MDGs	UN Millennium Development Goals
MEWD	Ministry of Energy and Water Development
UNCED	United Nations Conference on Environment Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WRM	Water Resources Management
ZMK	Zambian Kwacha Currency

Working definitions

In this document the following words and terms have the following meanings:

Catchment: is a geographical area which naturally drains into a water resource and from which the water resource receives surface or ground flow which originates from rainfall.

Climate Change: refers to the average change in climatic conditions in a specific region which is additional to the natural changes in the climate that may be expected to occur over time.

Domestic Purposes: means the household use of water for various purposes including the making of bricks for the private use of the occupier or for fire fighting.

Ecosystem: means the biological community of interacting organisms and their physical environment.

Equitable and Reasonable Utilisation: management and maintenance of a fair and justified allocation system, the utilisation of a water resource in a rational and sustainable manner so as to derive optimum benefits but not to cause significant harm to others and the environment.

Ground Water: groundwater is simply the subsurface water that fully saturates pores or cracks in soils and rocks.

Integrated Water Resources Management: is a process that promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

Permit: means a permit for the use of water.

Pollution: is any direct or indirect contamination or alteration of the biological, chemical or physical properties of water including changes in colour, odour, taste, temperature or turbidity of water.

Reserve: in relation to a water resource, means that quantity and quality of water required to satisfy basic human needs of all the people who are or may be supplied from the water resource; and protect aquatic ecosystems in order to secure ecologically sustainable development and use of the water resource.

Sustainable Water Resources Development:
is development which facilitates the equitable provision of adequate quantity and quality of water for all competing groups of users at acceptable costs that ensures security of supply under varying conditions.

Use: in relation to water, is the entitlement limited to the equitable and reasonable utilisation of water for the purposes and up to the limit prescribed or specified by a permit and includes: abstraction, obstruction or diversion of water; storing water; discharge of materials or substances into water; de-watering of a mine, quarry or any land; altering the bed, banks, course or characteristics of a water resource; or any prescribed activity of a kind relating to water but shall not include a guarantee as to the availability of water.

Water: includes surface water, water which rises naturally on any land or drains or falls naturally on to any land, even if it does not visibly join any watercourse, or ground-water.

Watercourse: is a system of surface waters and ground-waters constituting, by virtue of their physical relationship, a unitary whole and normally flowing into a common terminus.

Water Conservation Management Practices:
are practices that minimise wastage of water, encourage sustainable and efficient use of water and improve the quality of water.

Water Resources Management:
includes planning for sustainable development of the water resource and providing for the implementation of any catchment management plan and national water resources strategy and plan; promoting the rational and optimal utilisation, protection, conservation and control of the water resource; and improving the access to sufficient quality, quantity and distribution of water for various uses.

Water Resource: includes water, any river, spring, hot-spring, pan, lake, pond, swamp, marsh, stream, watercourse, estuary, aquifer, artesian basin or other body of naturally flowing or standing water.

Watershed: Either the equivalent to a Drainage Basin or the delineating points (divide) where water flows to two different outlets

Water Shortage: is when, among other things, the flow of water falls under a prescribed level in a water resource or in storage works.

CHAPTER 1: INTRODUCTION

1.1 Background

Zambia is located in Southern Africa with a size of 752,614 sq. km. It has a population of about 11.7 million people but only about 55% have access to safe drinking water (CSO, 2000). The annual surface water potential is estimated to be 114.8 km^3 and groundwater though not well understood is estimated to be around 49.6 km^3. The availability of the resource varies over much of the country (Nyambe and Feilberg, 2009).

Water is a very important factor for economic development. It provides benefits as a commodity for agriculture, industry, and households; and as a public good for scenic values, waste assimilation, wildlife habitats, and recreational use (Young, 2005). However, Water has traditionally never been considered a limited resource. This has led to mismanagement of water resources for centuries. About 70% of the world's water resources are used in agriculture, where irrigation allows wastage on a prodigal scale, with the water trickling away or simply evaporating before it can be of any use. For example, in China, it takes 1,000 tonnes of water to produce one tonne of wheat (UNEP, 1999). Despite this huge water loss Latinopoulos *et al*, 2004 point out that for many reasons but especially in order to promote irrigation crops, governments tend to favour the agricultural sector. They also conclude that even in developed countries, the price of agricultural water is far below its economic value, and farmers often pay little or nothing for water. Consequently, have little incentive to conserve it or refrain from growing water-intensive crops.

Zambia has performed very poorly towards the development of water resources to meet the ever increasing demand for the resource (MEWD, 2010). It has only built 5 very large dams and has approximately 2,000 small dams although it has a large potential to build more. It also has a poor record of maintenance of the existing infrastructure. This state of affairs can be attributed to limited funding to the sector. It is for this reason that the government of Zambia has seen the need to develop a water management policy which incorporates integrated water resources management (IWRM) in the management of water resources. Through this policy, management of water resources will shift from supply to demand management (Ministry of Energy and Water Development (MEWD, 2010). This will be achieved through the implementation of integrated water resources management (IWRM). Among one of the IWRM principles states that "Water has an economic value in all its competing uses and should be recognized as an economic good". According to this principle, failure to recognize the economic value of water might lead to wasteful and environmentally damaging uses of the resource. In order to follow this principle, water managers should have knowledge of value of water in alternative uses for decisions related to allocation and use of water in a given region (watershed). Furthermore, water resource development decisions are often based on an economic evaluation of such projects, which also requires knowledge of the magnitude of benefits accruing to various water uses (Young, 2005).

To aid in cost-benefit analysis under conditions where appropriate price incentives are absent, economists have developed a range of alternative or "non-market" methods for measuring economic benefits. Robert Young through his Residual Imputation Method has developed the most comprehensive exposition to-date of the application of nonmarket economic valuation methods to proposed water resources investments and policies (Young, 2005)

There is a common perception that farmers are earning a "rent" on the water they use, which should be recovered by government. The ultimate aim is to ensure that both ground and surface water are utilized as efficiently as possible, and to the benefit of the economy and the welfare of the citizens of Zambia. Owing to generous subsidies by government and a lack of monitoring and enforcement mechanisms in the commercial farming sector, there is a good possibility of inefficient practices (both economically and environmentally) existing, and land uses being sub-optimal.

1.2 Problem statement

Zambia is considered to have abundant water resources. However, development in the sectors of mining, irrigation, tourism, hydropower and drinking water supply and sanitation coupled with a rising predominantly urban population is exerting pressure on access to water resources. The availability of water also varies across the country with southern and western parts of the country being the driest and the northern parts being the wettest. There is also little effort towards water development to meet the ever growing demand for the resource meaning that the supply of water has remained constant. This has lead to a shortage or scarcity of water for present and future needs and to increased competing demand among different users. Agriculture is the major consumer of water and most affected by water shortages. For example, the recurrence of droughts of 1991/1992, 1994/1995 and 2000/2001 resulted in lower than average rainfall which reduced agricultural production thereby further increasing competing demand for the resource.

The Government has started addressing these issues by formulating a policy and passing a water resources bill which focuses on management of water resources through the principles of IWRM (MEWD, 2010). IWRM requires knowledge of value of water therefore, to implement IWRM, water managers need knowledge of value of water in alternative uses for decisions related to allocation and use of water in a given region (watershed). Furthermore, water resource development decisions are often based on an economic evaluation of such projects, which also requires knowledge of the magnitude of benefits accruing to various water uses. For example, the various uses of water in the different sectors of an economy add value to these sectors. Some sectors may use little water but contribute significantly to the gross national product (GNP) of an economy. Other sectors may use a lot of water but contribute relatively little to that economy.

The water for irrigation is usually provided for free or at prices lower than the economic value of water due to relaxed laws. Irrigation projects can not therefore run sustainably without continued funding by the government to cover management and operational costs. Pricing of water resources therefore require valuing of water. In Zambia little or no effort has been put to value water as an input to water pricing discussions. Not knowing the value of water may lead to consumers not paying the real price of water and this may convey the demander that the value of water is really the low price that they pay. So, the cheapness of water would create no incentive for economization of water. Also it does not encourage the companies to invest in water resources, since the profit is very low.

1.3 Aim of the study

The aim of this study was to calculate the economic value of water used for irrigation of wheat at Sable farms in Lusaka District.

1.4 Objectives

To ensure that the above aim is achieved, this study's objectives were to:

i. Determine the quantity of water needed for the production of wheat at Sable farms;
ii. Determine the levels of incomes and expenditures for wheat production at Sable farms;
iii. Carryout a financial and economic analysis for the farm; and
iv. Use the residual imputation method to find the marginal product value of water

1.5 Research Questions

This study sought to answer the following questions:

- How much water is used by Sable farms during winter season for the production of wheat; and
- What is the value-added by each unit of water in its current use?

1.6 Significance of the Study

Although valuing goods like water which has traditionally been treated as a public good is difficult, its valuation has been simplified by development of new and simple methods. Many countries including Namibia are now enjoying the benefits of valuing water. The results of this study will help in cost-benefit analysis for water allocation and in equitable pricing of water resources. Pricing will in turn encourage users to economize on the use of water. It will also ensure cost recovery. In addition, it will encourage companies to invest in water resources, since economic evaluation will help come up with a pricing system that will ensure that profits accrue in water projects. Increased investment will enable more Zambians to access water for longer hours and thereby improving their living standards. Increased access to safe drinking water will enable Zambia achieve the millennium development goals of halving the number of people without access to safe water and adequate sanitation by the year 2015.

1.7 Study Area

The study took place at Sable farms situated in Chakunkula ward of Lusaka District (Figure 1).

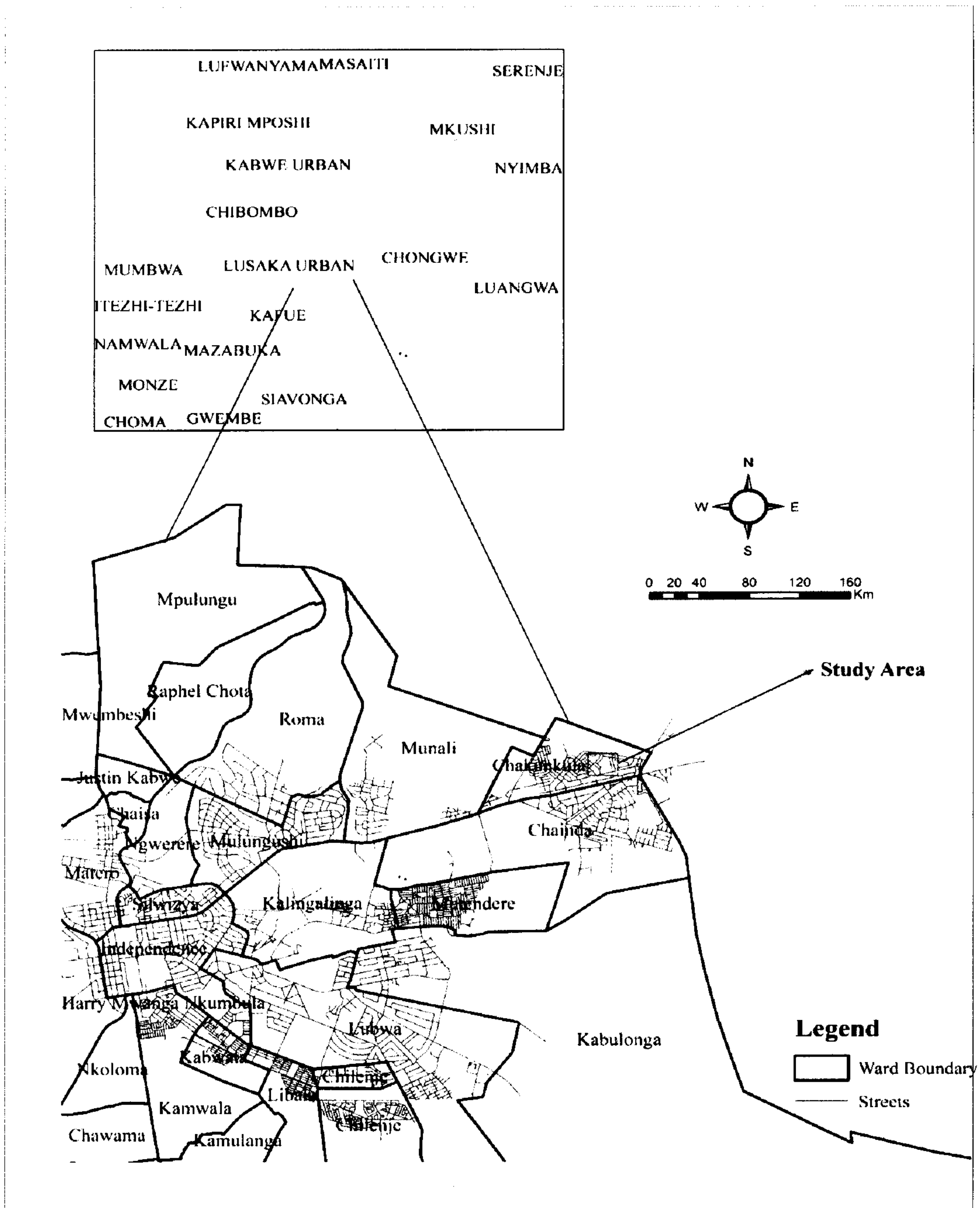

Figure 1: Map of Lusaka District showing the study area, Lusaka Province, Zambia.

It has a total size of 350 hectares of which a total cleared land of 240 hectares is suitable for irrigation. It abstracts water from Chingamuti Creek, a tributary of Ngwerere Stream which is a tributary of Chongwe River in Lusaka District. The reference for the point of direct abstraction is S 15° 20’ 55.1° and E 28° 24’ 1.82’’.

The land is relatively flat with sandy loamy soils. It is also characterized with grass interspaced with shrubs. The major crops grown on the farm are sugar cane, wheat, and tobacco and soya beans. The farm also keeps some beef cattle.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews current knowledge including substantive findings as well as theoretical and methodological techniques existing in the literature. An evaluation of previous research has been done through various secondary sources.

2.1 Agriculture and Irrigation in Zambia

Zambia's agriculture is currently dominated by the production of maize. Other important crops include cotton, rice, sorghum, cassava and wheat (MACO, 2004). Nyambe & Feilberg, 2009, state that agriculture plays an important role in the development of the Zambian economy and will be the engine of growth for the next decade and beyond. Agriculture sector generates between 18% and 20% of the Gross Domestic Product (GDP) and provides livelihood for more than 50% of the population. The sector absorbs about 67 percent of the labour force and provides more than 80 percent of the national food requirements (CSO, 2000).

Agriculture is dependent on rainfall than irrigation. Out of the total land area of 752 614Km^2, 420,000Km^2 is suitable for arable use. However, only 14% or 5,800,000 hectares is presently cultivated. The land suitable for irrigation is estimated at 423,000 hectares (MACO, 2004). Despite the many benefits of irrigation, only about 100,000 hectares is currently under irrigation comprising approximately 52,000 hectares under formal (commercial) and 48,000 hectares under informal (subsistence) farming (MACO, 2004) this may be due to attitudes and perceptions that it is very expensive, lack of information on the benefits of irrigation, cost of irrigation equipment and poor water distribution in the land.

2.2 Economic Significance of Wheat in Zambia

Wheat is the most important crop among all irrigated cereal crops in Zambia with many varieties in different agro-Ecological zones. The total production, cultivated area, and yield (irrigated) of wheat in Zambia in 2010 year reported about 172 252 tons, 27 190 (ha) and 6335 kilograms per hectare respectively. The range in wheat yield for irrigated crops in the provinces is from 4730 to 6980 kilograms per hectare (MACO, 2010).

The most irrigated cultivation area and production amount reported 14 562 hectares and 89 682 tones by Central Province of Zambia respectively (Table 1). The total of irrigated production under consideration year (2010) was reported to be around 172 252 and the gross income from wheat sales was about 46 million US dollars.

Table 1: Irrigated Area, Irrigated Production, Irrigated Production and sales of wheat per province in 2010 in Zambia (MACO, 2010).

Province	Irrigated Area in hectares *	Irrigated Production (metric tones)*	Irrigated yield/Ha*	Sales in tones*	Price Per tone US dollars**	Income in US dollars
Central	14562	89 682	23	91 268	300	27 380 400
Copper belt	2306	16 445	15	21 789	300	6 536 700
Eastern	34	143	4	143	300	42 900
Luapula	0	0	0	0	300	
Lusaka	6522	42 075	12	21 789	300	42 900
Northern	0	0	0	0	300	0
North-western	120	840	7	840	300	252 000
Southern	3646	23 071	27	18 555	300	5 566 500
Western	0	0	0	0	300	0
Country	27 190	172 256	89	154 383	300	46,314,900

2.3 Agricultural Policy and Competition for Water Resources

Although Zambia is considered to have abundant water resources, development in the sectors of irrigated agriculture, tourism, hydropower generation and drinking water supply and sanitation coupled with a rising and predominantly urban population is exerting heavy pressure on the available resources base (Nyambe and Feilberg, 2009; MACO, 2004).

Zambia has experienced a recurrence of droughts in 1991/1992 and 1994/1995 and 2000/ 2001 resulting in lower than average rainfall and reduced agricultural productivity. It is therefore recognized that the availability of water may not match the spatial pattern of demand, needing to put in place an integrated approach towards management of water resources in the country (MACO, 2004).

The government's promotion of irrigated agriculture will further increase competition for the available resource base. The Ministry of Agriculture and Cooperatives (MACO) has indicated that the irrigation potential for Zambia is substantial, in the order of 423 000 ha. A total of 85 areas suitable for irrigation have been identified countrywide. The commercialization of agriculture lands development initiative has identified nine viable farm blocks in each province involving not less than 100 000 ha per block (Table 2), (MACO, 2004).

Table 2: Proposed commercialization of agricultural lands (farm blocks) in Zambia (MACO, 2004)

No.	Farm Block	Approximate area	Province
1	Nansanga-Munte	155, 000	Central
2	Kalumwange	100, 000	Western
3	Luena	100, 000	Luapula
4	Manshya	147, 750	Northern
5	Solwezi	100, 000	North-Western
6	Simango	100, 000	Southern
7	Machiya	100, 000	Copperbelt
8	Mungu	100, 000	Lusaka
9	Mwase-Mphangwe	100, 000	Eastern

Estimates of growth for irrigated production as determined by FAO (FAO, 2003) in its agricultural trends 2030 report point to a significant demand led growth in irrigated wheat as population changes from 9.9 million in 1999 to projected 21.3 million in 2030. The analysis also point out some marginal growth in rice and in sugar cane as in Table 3.

Table 3: Projected growth for irrigated agriculture in Zambia by the year 2030 (MACO, 2004).

Crop	year	rainfed land			irrigated land			Total	
		area	yield	prod	area	yield	prod	Area	Prod
Wheat	1998	0	0	0	11	6 608	75	11	75
	2015	0	0	0	19	7 672	143	19	143
	2030	0	0	0	25	8 595	215	25	215
Rice	1998	10	0.626	6	3	1.826	5	13	11
	2015	11	0.751	8	3	2.219	7	14	15
	2030	12	1.008	12	4	3.025	12	16	24
sugarcane	1998	0	0	0	15	104444	1567	15	1567
	2015	0	0	0	19	126.91	2465	19	2465
	2030	0	0	0	24	150124	3603	24	3603
vegetables	1998	28	6.321	177	9	9	81	37	258
	2015	33	8.686	285	9	11.881	113	42	398
	2030	38	11.235	427	10	14998	150	48	577
Fruit	1998	13	43	43	5	10	50	15	93
	2015	18	6 202	109	5	12714	70	23	178
	2030	27	8 553	231	6	15996	96	33	327
Cotton	1998	42	1.19	50	4	3.25	13	46	63
	2015	46	1 303	60	5	3448	18	51	78
	2030	53	1 397	74	7	372	26	60	100

2.4 Valuing and Pricing of Water

The challenges policymakers face in managing the supply and demand of water in a developing country, with water shortages, is enormous. There are not only massive human and health costs to pay for in the mismanagement of water, but the implementation of any successful management programme requires public consensus and acceptance of the inherent social and economic rights people have to water (Moore et. al, 1994).

It is now a widely accepted view that water is an economic good and, therefore, must have a value assigned to it. The value of water to a user is the maximum amount the user would be willing to pay for the use of the resource. While that might sound like a platitude it was not a stated view until 1992, when it was articulated in the fourth principle of the "Dublin Statement" at the United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro. In order for water to be managed effectively its economic value must be treated as mutually exclusive with its non-economic human value (ICWE, 1992). Like all goods, therefore, water must have an economic price assigned to it but that price must also reflect its human value. Water pricing is the policy of assigning value to water in order to manage its demand and, by extension, its supply.

There are three well known economic effects of pricing policy. The first is that it reduces demand for water - when users have to pay for their consumption, they do not consume more than they need to. This initiates behavioural change that encourages conservation and changes consumption habits. The second effect, a direct result of a reduction in demand, is that it increases the supply of water - users have an economic incentive to reduce water use and water loss. The third effect is an efficient, market-driven reallocation of water across sectors - household, agricultural and industrial; the reallocation occurs as a result of higher prices which make waste expensive and encourage more responsible distribution, thereby removing from the system any inefficiency (Moore et. al, 1994).

2.5 Methods for the Economic Valuation of Water

Regardless of how water is allocated and managed, under conditions of scarcity, its use in one activity for productive or consumptive purposes implies that it is not available to other uses. That is, the use of scarce water resources entails an opportunity cost for society. This basic fact applies to all water uses, including those only indirectly or distantly related to economic activity, such as when water support habitat for fish that are ultimately harvested for sport, food or commercial use. Economists have long used a variety of valuation approaches to understand and estimate the value of natural resources – More recently; these methods have been applied to value ecosystem services and biodiversity (Aylward *et. al,* 2010). A summary chart of the full range of methods is provided in Table 4.

Table 4: Economic Valuation Methods by Category (Aylward *et. al,* 2010).

	Observed behaviour	**Hypothetical Behaviour**
Direct	**Market Prices** **(Direct Observed)**	**Stated Preferences** **(Direct Hypothetical)**
	Competitive market prices Shadow-pricing	Contingent Valuation (dichotomous choice, willingness-to-pay, bidding games)
Indirect	**Revealed Preferences** **(Indirect Observed)**	**Choice Modelling** **(Indirect Hypothetical)**
	Productivity methods	Contingent referendum
	Avertive (defensive) expenditure	Contingent ranking
	Travel cost	Contingent behaviour
	Hedonic pricing	Contingent rating
	Substitute goods	Pair wise comparisons

The principal economic valuation methods can be grouped into four different categories based largely on two criteria. The first grouping criteria is based on the whether observations of behaviour take place via participant behaviour within 'real' markets or whether the behaviour is elicited as a hypothetical response to constructed market scenarios. The second criteria is determined by whether monetary values derived from the technique are observed directly in markets or merely inferred from behaviour and preferences. These two grouping criteria create four categories: market prices, stated preferences, revealed preferences, and choice modelling. Within this framework, economists have selected a number of specific methods that are useful in assessing the value of the traditional extractive uses of water explored in this paper, specifically water used for agriculture, domestic purposes, and industrial production (Young, 2005).

2.5.1 Valuation Methods based on Observed Behaviour

Under this section each of the methods of Table 4 is briefly reviewed for its application to these water values.

2.5.1.1 Market Value

Occasionally, values associated with water can be observed directly through market activity. As regulatory and institutional frameworks for water trading evolve in various countries and jurisdictions, the movement of water-related goods and services between willing buyers and sellers is increasing. Somewhat, obviously creating a well defined and enforceable property right to water – if only for its use – and making this right tradable is essential enabling conditions for such market values to be observable in a given jurisdiction (Aylward *et. al*,2010).

As with all active markets, those associated with the sale of water are at times susceptible to various market distortions and failures that may lead to inefficient allocation through trade. In these cases of failure, unfettered market prices are not expected to lead to an optimal distribution of resources to their highest social use. There are many causes of these market failures, including but not limited to externalization of certain costs and benefits, information failure (i.e., lack or unequal distribution of information), low income level undermining ability to pay, high transaction costs, and subsidy distorting incentives. Subsidies and other distortions can also alter prices from those that would be expected in an efficient market. More specifically, artificial inflation of prices owing to speculative demand for water has been a primary concern in emerging markets for water rights. There are multiple causes for this distortion, some of which are psychologically and sociologically based. The speculative stockpiling of water rights is a factor affecting inflation via the creation of artificial scarcity. Further, physical limitations to the scale of water markets, including limited conveyance capacity, can result in thin, illiquid markets where very few sellers can meet a particular buyer's water need. In these cases, insufficient competition may leave the buyer no recourse but to purchase a water right at an enormous premium to its value in an alternative use, even in cases where other sellers would be willing to sell but are unable due to lack of conveyance/transfer infrastructure. On the supply side, many potential sellers take a decidedly uneconomic approach to the marketing of water rights given the long status of such rights as family heirlooms rather than tradable assets. Economists describe the 'endowment effect' that takes place when such sellers enter emerging markets. They focus on the loss they will incur in selling the asset as opposed to the gain in welfare resulting from its sale, even when the gains from sale (i.e. prices) are substantial. Price premiums over what would normally be considered the productive value of the asset may then be required to wrest it from the seller through markets (Aylward *et. al,* 2010)

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Some have criticized using market prices to value water, arguing that these rarely account for values associated with environmental goods and services and therefore do not capture water's "complete" value. This criticism is valid insofar as not all uses of water are expressed as demand in water markets. The implication is that as markets evolve to include environmental purchasers and others, so too will the values of water (Aylward *et. al,* 2010).

For all of these reasons, it is important to carefully scrutinize the "market" before concluding that observed prices represent efficient market prices that accurately gauge value. As such, it is often proposed that any estimate of the value of water based on market prices be modified – just as with any observed market price – to reflect conditions and distortions, possibly requiring the incorporation of other valuation techniques. However, for many uses of water and in many jurisdictions secure property rights over water do not exist and therefore there are no markets in which values for water can be directly observed. Hence, the resort to other valuation methods as described below (Aylward *et. al,* 2010).

2.5.1.2 Productivity Approaches

Productivity approaches to valuation are employed where water is an input, or intermediate good, in the production process of some good. Techniques included within this category of approach include but are not limited to income capitalization/change in net income methods, cost/input-response functions, farm budget models, and residual imputation methods. Water's primary extractive use worldwide is as an intermediate good in agriculture and industry. Conceptually, values derived from these productivity methods represent the marginal increase in welfare (or revenue) per additional increment of water. These methods can generate a wide range of water values because they are highly dependent on cost-based production factors such as procurement, application, reuse, non-water input values, level of use, technology, etc. When applied to agricultural use, the results of productivity methods of valuation are also affected by crop response (fertilizer, climate, etc.), acreage, and crop species. The advantage of productivity approaches to valuation is the relative ease of acquiring data, robustness derived from a foundation in economic theory, and the ease with which the concept of 'with or without water' analysis can be understood. The drawback of these techniques is their reliance on cost estimates of non-water inputs. If these are not adequate (i.e. other costs are excluded) or inaccurately represent economic costs (such as where other inputs are subsidized) then this approach may under or over state the value of water's contribution to the production being analyzed (Mendelsohn et al, 2009).

2.5.1.3 Hedonic Pricing

Hedonic valuation is rooted in the principal that the price paid for an asset reflects the value of a bundle of attributes of that asset, whether or not these separate attributes explicitly marketed or marketable. For example, one attribute that may in part determine the value of a piece of real estate is access to water, which is typically assessed in terms of a claim or right for irrigation. Contrasting the values of real estate with varying access to water is one approach to deriving the value of water. In the absence of market information on the value of each separate attribute of an asset, the hedonic method relies on a statistical understanding of how the price of the asset changes with different levels of the set of attributes of the asset. In its simplest form, this approach amounts to an evaluation of like properties, one "with" water and one "without" water. Whether conducted with large property transaction datasets or as limited "with and without" comparisons, the method is used to identify the implicit value associated with a particular single attribute based on the sale price of the entire asset. From an economic standpoint, this method's use in property transactions implies that willing buyers and sellers are completely informed about the relevant attributes and that asset markets are efficient. Valuation through hedonic pricing can be difficult to implement when attributes where variation is difficult to express or measure, e.g. quantity and quality. This technique may also difficult to apply in developing countries where institutional and regulatory constraints can prevent optimal market activity and data pertaining to property transactions may be difficult to acquire. Hedonic valuation approaches are more accurate when used with large data sets from comparable sales; however ideal data is often difficult to come by in water markets. In water rights markets, the use of comparable sales data (from prior water right sales) to appraise the value of a water right represents the use of hedonic pricing for the purpose of forecasting the likely value of some water right. Where water rights are heterogeneous in terms of water quality, reliability, quantity, delivery cost or other factors, market prices of other water sales are in effect used to estimate the value of these various separate attributes of a water right, from which an expected value of the entire water right can be estimated (Mendelsohn et al, 2009).

2.5.1.4 Avertive Expenditure

Derived from theories of consumer and household behaviour, the avertive expenditure valuation method seeks to find and quantify observed responses to environmental changes, i.e. the avertive behaviour. In this context actual expenditure displayed through avertive/defensive behaviours can represent the benefits to the consumer or household of avoiding negative effects of environmental changes. These behaviours are most frequently associated with a reduction in exposure to contaminated waters, e.g. boiling, chemical treatment, and acquisition from another source. Many aspects of this method are rooted in the concept of substitutability and as a matter of course can be difficult to apply to water quantity given that there are few substitutes for water as a commodity. More likely is the application to water quality (Aylward *et. al,* 2010).

2.5.2 Valuation Methods Based on Hypothetical Behaviour (Contingent Valuation)

In the absence of observable behaviour, contingent valuation (CV) methods are often utilized in an effort to extract data from surveys based on constructed markets. These surveys are intended to convey WTP/WTA values for existing or hypothetical conditions pertaining to specific goods and/or services. CV surveys are questionnaires that ask respondents to choose the value to them of some contingent (potential) action and are arranged in an open-ended, dichotomous choice, discrete choice, and/or bidding game format. Values derived from this method are often extrapolated across larger populations which the respondent sample was intended to represent. In the context of water valuation, the purpose of such surveys is to elicit individuals' preferences pertaining to changes in water quality and quantity. The contingent valuation technique is the most prevalent approach to valuing the domestic use of water by households. This approach is often necessary because the price paid for water in many locations is subsidized and reflects neither its true cost of production nor its value to households purchasing it. Values derived from CV methods should be considered an upper bound of WTP if the respondents do not provide a range associated with the provision of the good or service. CV tends to be one of the most dynamic valuation methods due to its applicability to a wide array of circumstances, including the valuation of environmental services aside from that of water. CV methods are especially useful for assessing values in developing countries given that access to scare market data (and indeed scare market activity) along with other constraints can impede or prevent the use of methods requiring substantial amounts of price information (e.g. property sales and complementary/substitute good prices). In addition, other assessment challenges imposed by conditions in developing countries such as illiteracy and poor communication infrastructure can be mitigated through the use of face-to-face CV surveys. Throughout the academic valuation material, CV methods tend to be controversial and as a result have been subject to extensive debate. The most prominent issue is sourced in the risk of strategic bias on behalf of the respondents, who may intentionally understate their WTP in an effort to 'free ride' or increase the likelihood of any improvements in quantity and/or quality. Alternatively, respondents may intentionally exaggerate the value they place on a resource in order to prevent its reallocation to an alternative use. In addition, other issues associated with surveying such as sampling errors, survey design, and yea-saying have been identified. While practitioners have found approaches to mitigate these sources of bias, the technique remains subject to widespread scepticism in the public realm. Lastly, CV surveys can be time-consuming and expensive to undertake (Mendelsohn *et. al*, 2009).

Although several methods have been devised to ascertain the value of water in private, commercial and environmental uses, young, 2005 conceded that water value assessment is not easy since markets for ground water services either do not exist or are highly imperfect. In this research, residual method will be employed. The residual imputation approach is one of the most prominent and most comprehensive exposition to-date of the application of nonmarket economic valuation methods to proposed water resources investments and policies (Howe, 1985). Ashfaq *et. al,* (2005) estimated the full financial and economic value of irrigation water for different crops using this method. Ahmad *et. al*, (2010) also concluded that the method is clear and easy to use in valuing water. Williams *et. al,* 2000 also made use of this method valuate water in Namibia.

CHAPTER 3: METHODOLOGY

This section of my dissertation provides the methods and procedures used during the research study.

3.1 Data Collection

Raw data was collected from a commercial farm called Sable farms which irrigate wheat. It was selected randomly out of the six farms producing wheat within Chakunkula area in Lusaka District.

3.2 Types of Data

To make sure that the aim of this study is achieved, both primary and secondary data were used.

3.3 Methods of Data Collection

Primary data was collected from the selected farms using structured questionnaires (Appendix 1). Secondary data was obtained from Ministry of Agriculture and Cooperatives, Meteorological Department, Bank of Zambia, Zambia Revenue Authority and Central Statistics Office using qualitative methods, through the use of semi-structured interviews.

3.3.1 Primary Data

An interview schedule was designed. Selected farms were then visited and primary data was obtained using a structured questionnaire. The questionnaire asked about quantities and costs of inputs used in production (capital, variable and overhead), quantities and value of output, and the quantity of water consumed.

4.3.2 Secondary Data

Secondary data and information from 2006 to 2010 was obtained using semi-structured interviews from the various sources indicated in Section 3.3.

3.4 Data Analysis

Data was analyzed using Microsoft Excel and residual imputation method. The analyzed data was then presented in tabular form.

3.5 Limitations of the study

During this study, the following limitations were encountered: The farmers were hesitant to releasing information on their farm budgets. It seems they were afraid of the unknown or maybe they are over exploiting certain resources.

CHAPTER 4: AN ESTIMATION OF THE ECONOMIC VALUE OF IRRIGATION WATER FOR WHEAT PRODUCTION AND DISCUSSION

In this section, data analyzed and results obtained are tabulated or presented in form of narrative descriptions of observations and interpretation is then given.

4.1 Characteristics of Respondents

Analysis of the questionnaire showed that targeted respondents who were farm managers had different levels of formal education. For primary data, managers in high management positions had qualifications as high as a bachelor's degree while those in lower management positions had at least reached grade twelve level of education. All respondents were conversant with the official language, English.

4.2 The quantity of water needed for the production of wheat at Sable farms

The farm uses 1,026,000 m^3 of water each year to irrigate 200 hectares of wheat (approximately 5130m^3 per hectare).

4.3 Income, Expenditure, Financial Analysis and Economic Analysis

This section gives the total income and expenditure for wheat production at Sable farms. It also provides the profits and project worth of irrigating wheat through financial and economic analysis respectively.

4.3.1 Income, Expenditure and Financial Analysis

Farm costs were divided into three components, namely fixed costs, variable costs and total costs. The fixed cost (FC) portion included rent of land and farm machinery whereas variable cost (VC) included labour, both family and hired, seed, fertilizer, farm yard manure pesticides, draught power and irrigation service. The FC and VC were added up to arrive at the total cost (TC). All costs were estimated on a per hectare basis.

The financial returns (FR) were estimated by taking the average yield times the farm gate prices (FGP), and adding up the by-product times the prices received by the farmers. The financial net returns were obtained by subtracting the total cost from the gross returns. The financial returns FR were also estimated on a per hectare basis (Table 5).

Table 5: Financial analysis on a per hectare basis for Sable farms Zambia for the year 2010.

Item	**Expenses**	**Income**
Sales	ZMK	ZMK
wheat		8, 460, 000
wheat brand		1, 000, 000
financial gross income		9,460, 000
Less cost of sales		
Cost of land preparation and planting	753,333	
Cost of weeding	200, 000	
Fertilizer	1, 200, 000	
Harvesting expenses	282, 000	
Packaging	240, 000	
Transportation	1,494,594	
Farm rent	1, 000	
Depreciation of machinery	50, 000	
Wages	100, 000	
Total cost of sales		4,320,927
Net financial income		5,139,073

The income per hectare was found to be ZMK 9,460,000 and total expenses were ZMK 4,320,927 giving a net financial income of ZMK 5,139,073 per hectare of wheat. Since 5130m^3 of water is needed per hectare, it means that a farmer gets about one thousand kwacha per cubic meter of water used and in a similar manner looses the same amount if for any reason fails to use that same unit of water. The farmer is therefore willing to pay up to as high as ZMK1000 for every cubic meter of water used for irrigation of wheat. Considering the current water charges as stipulated in the 1949 water act of the laws of Zambia, the maximum price a farmer is paying for using $500m^3$ of water is only ZMK5000 (approximately ZMK10 for every cubic meter of water used for irrigation). This value is very low compared to a ZMK1000 gain by the farmer for every unit of water used. This means that at the moment, farmers are using water at almost no cost and therefore are earning a rent which could have been for the government if water was appropriately priced. Such lower prices do not encourage economisation of water use by farmers.

Provided the other conditions needed for normal growth of wheat are optimal, there is a linear relationship between quantity of water used and yield. This means that up to a certain level, the more water used the more the profit for the farmer.

4.3.2 Economic Analysis

The economic returns (ER) were obtained by valuating wheat grains at economic prices (EP). Economic prices are also referred to as social prices or efficiency prices. By-product prices are the same as used for estimating gross returns. The input costs were also estimated at world prices. World prices of inputs and outputs are the cornerstone for estimating the efficiency prices.

The costs of production were separated into tradable and non-tradable components. World prices are the prices for tradable commodities, which can be traded in the world market. To obtain economic prices, the market prices of the tradable inputs and outputs have been adjusted by applying a standard conversion factor (SCF) i.e. 0.86. The SCF has been derived by taking into account, CIF (cost insurance freight) value of imports and FOB (free on board) value of exports, net value of taxes on imports and on exports. Shadow pricing was used to convert financial prices into economic prices.

The use of shadow pricing was to ensure that values applied to inputs and outputs reflect their real scarcity in society (i.e. the cost to society of their being used or produced in the specific activities).

Seeds, fertilizers and materials for plant protection (pesticides, insecticides, sprays, herbicides etc.) can be traded internationally, so prices of these inputs also were adjusted by applying SCF to arrive at economic prices. For hired labour, actual wage rate is the private price. To estimate the economic price of the hired labour, wage rate were multiplied by SCF (Table 6).

Table 6: Economic Analysis on a per hectare basis for Sable farms Zambia for the year 2010.

Item	Expenses	Income
Sales	ZBK	ZBK
wheat		8, 460, 000
wheat brand		1, 000, 000
Economic Gross Income		9,460, 000
Less cost of sales		
Cost of land preparation and planting	647,866.38	
Cost of weeding	172, 000	
Fertilizer	1,032, 000	
Harvesting expenses	242520	
Packaging	206,400	
Transportation	1285350.84	
Farm rent	860	
Depreciation of machinery	43, 000	
Wages	86, 000	
Economic Costs		3715997.22
Net Economic Value Added		5744002.78

The financial costs were converted to economic costs by applying the standard conversion factor of 0.86 to all costs in order to get farm get prices (economic costs). The economic returns were ZMK 5744002.78. This means that each cubic meter of water used for production of wheat provides a benefit of ZMK1120 to society. Again looking at present water charges of at most

ZMK10, it means the society has little benefits for using the water in agriculture. This may mean that water used in agriculture and in particular wheat production is not very profitable to the society.

4.4 Marginal Product Value of Water

The marginal value product of water was then estimated using the residual imputation method developed by 5in 2006. Using residual imputation method, accurate results are guaranteed only if the quantities and prices of production, excluding water, are determined correctly at their marginal values. The technique requires that all non-water factor inputs be deducted from the total value of the products produced by an agricultural activity. Using this method, the additional contribution of each input in production process is determined. According to Young (2005), the residual imputation value can be derived by using a production function with four factors of production: capital (K), labour (L), land (R), and water (W). Assuming that the value of the marginal product of a production factor equals its price, the residual value of water used in agriculture can be computed by using the following equation:

$$P_w = \{TVP - [(PK * QK) + (PL*QL) + (PR*QR)]\}/Q_w \qquad (1)$$

Where:

Pw = the shadow price of water or marginal value product (MVP) of water or the imputed value of water used in the production of the four crops in the specific season.

TVP = the industry's total value product (value added).

P&Q= the prices and quantities of the non-water factor inputs.

Q_w = the quantity of water used.

Using equation 1 above the financial and economic prices of water were calculated as follows:

4.4.1 Financial Price of Water

The farm uses 1,026,000 m^3 of water each year to irrigate 200 hectares of wheat (approximately 5130m^3 per hectare). From equation (1) of chapter 4.4:

$$Pwt = \{TVPt - [(PK \times QK) + (PL \times QL) + (PR \times QR)]\}/Qwt$$

P_{wt} = {9460000 – [4320927]}/ 5130m^3 =ZMK 1001.768616.

The financial marginal value product of water is therefore ZMK 1000 (US$ 0.21) per m^3.

4.4.2 Economic Value of Water

Using the above methodology for economic costs and benefits:

P_{wt} = {9460000 – [3715997.22]}/5130 = ZMK 1119.688651

The economic or marginal value product of water is therefore ZMK 1120 (US$0.23) per m^3. It indicates the net present worthy of the project. It is this value that may be used in cost benefit analysis for the project. The main result of this study show that, the price of agriculture water for production of wheat at Chakunkula farms is below its economic value (ZMK 1120/m^3). The present charges for water rights by Water Board as per 1949 Water Act of the laws of Zambia are as low as ZMK 2 per cubic meter of water used in excess of 500m^3/ day and a maximum of ZMK 5,000 for every 500m^3 of water used per day for irrigation (which is approximately in the range of ZMK 2 to ZMK 10). Farmers pay very little for the water they use despite huge financial returns of ZMK5, 139,073 per hectare, which is about ZMK1, 000 from each cubic meter of water used for irrigating wheat. This cheapness of water (ZMK10) compared to its economic value of ZMK1, 120 can disadvantage the agriculture sector as a water user when it comes to allocation decisions as priority in terms of allocation is given to a user which generates the highest net benefits at present. It may also discourage investment in the sector as there is little profit accrued after heavy investments for construction of dams and buying of irrigation equipment. Under these circumstances, an inappropriate use of water and the lack of incentives in investing in water saving technology are expected. This may indicate that Sable farms have no incentive to conserve water.

The results were however, consistent with the values found in literature. Ahmad *et. al,* (2006) found the economic value of water used in the production of wheat to range from $ 0.07 to $0.32 depending on the place. Williams *et. al,* (2000) found the economic value of water used in the production of wheat in Namibia to be $0.10. On the other hand, Ashfaq *et.al,* (2005) calculated the economic value of irrigation water used in the production of wheat in Pakistan to be $0.013.

The method is simple and, under certain specified conditions, is applicable for estimating the value of resources used in production.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Sable farms make a profit of ZMK 5,139,073 per hectare of wheat after using 5130m^3 of water. Through Residual Imputation Method, the financial and economic values of irrigation water for wheat were estimated to be ZMK1000/m^3 and ZMK1120/m^3 respectively. These results show that a farmer gets ZMK1000 per cubic metre of water he uses. The wheat irrigation project at Sable farms is worthy ZMK1120 per cubic meter used. This value can help to price and in decisions concerning allocation of water to different users according to its contribution in the production process. Pricing of water can assist in water demand management which in turn may reduce shortages of water especially in cities like Lusaka.

5.2 Recommendations

Based on the results, the following recommendations are made:

i) The present flat rate policy is neutral; therefore water charges could be levied on the basis of at least some percentage of economic value of water;

ii) The Government should strengthen monitoring and enforcement mechanisms in the commercial farming sector; there is a good possibility of inefficient practices (both economically and environmentally) existing, and land uses being sub-optimal;

iii) The Government should also investigate water-saving technologies for farmers in Zambia;

iv) The University of Zambia through IWRM Centre should carry out a more detailed research on this farm to analyze whether the information the farmer gave is correct.

v) The Government should come up with policies which will encourage water audits for all commercial farms in Zambia;

vi) The University of Zambia through IWRM Centre should encourage research to determine and compare the economic values for various crops and also determine the economic value for all other water users in Zambia; and

vii) This study points to the possibility of water pricing, but the University of Zambia should undertake further detailed studies so as to come up with an accurate economic value of water in Zambia.

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APPENDIXES

Appendix 1: ESTIMATING THE ECONOMIC VALUE OF IRRIGATION WATER FOR PRODUCTION OF WHEAT AT SABLE FARMS.

THE UNIVERSITY OF ZAMBIA
IWRM CENTRE
SCHOOL OF MINES

Purpose of collection

This survey will collect information on the size of land quantities and costs of inputs used in production, quantities and value of outputs, size of land irrigated, quantity of water used and variety of wheat used. The information that will be generated after analyzing the data is very useful for planners and policy makers especially those involved in water.

Collection authority

You are kindly requested to assist with the filling in of this form especially in time. The information is required as fulfilment for the award of the Post Graduate Diploma in integrated water resources management (IWRM) of the University of Zambia.

Confidentiality

Your completed form remains confidential as it will just be used for academic purpose only.

Due date

Please kindly complete this form and I will personally collect in a week's time from date of receiving the form. Should you need any clarification, do not hesitate to contact me on:

Cell #: 0966 704252.

Name: Mr. Chitete Client.

Instruction

Please fill in your information in the spaces provided.

Name ....

Position of interviewed person..

Location of farm..

Farm number..

Date..

Survey number..

What is the size of the area planted with wheat and irrigated?.......................................

What quantity of water did you use per hectare...

How much did you spend on each cubic meter of water (ZMK/ M^3).................................

What variety of wheat did you plant?...

Why did you choose this variety?

i. ....

ii. ....

iii. ....

How much seed did you use per hectare (Kg/Ha)...

How much did you spend in Zambian kwacha per hectare on this seed...............................

How much did you spend on planting labour per hectare...

What type of implement did you use for land preparation?...

How much did you spend on land preparation...

Which type of weed control did you use?...

How much did it cost you per hectare?...

Did you use any pest control method?..

How much did it cost you per hectare?...

Did you apply any fertilizer?...

What type of fertilizer did you use?..

What is the cost per hectare of each type of fertilizer used?..

What did you use to harvest your wheat?..

How much did it cost you to harvest each hectare of wheat..

How many tones of harvest did you get per hectare……………………………………………..

Did you bag your wheat?...

How much did you spend on bags per hectare?...

How many tones did you actually sell?..

How many tones didn't you sell and why………………………………………………………

What was the cost per tone of transporting your wheat to the market……………………..…

What was the price per tone of wheat………………………………………………………….

Thank you for your cooperation

If there is any additional information and comments please write them on the space below.