INVESTIGATION OF THE ECONOMICS OF WATER AS USED BY SMALLHOLDER IRRIGATION FARMERS IN SOUTH AFRICA

By

Stanley Conficious Bartholomew Yokwe

Submitted in partial fulfilment
of the requirements of degree:

M. Inst. Agrar, Rural Development Planning and Management

Faculty of Natural and Agricultural Sciences
(Department of Agricultural Economics, Extension and Rural Development)
at the
University of Pretoria

Promoter:
Prof. Sylvain R. Perret

PRETORIA

NOVEMBER, 2004

Declaration statement

I declare that this thesis hereby submitted by me for M. Inst. Agrar. Degree at the University of Pretoria is my own independent work conducted under the skilful guidance and supervision of a study leader and has not been previously submitted at any other University or Faculty.

Signature: **--------------------------------------**

Stanley Conficious Bartholomew Yokwe

Acknowledgement

A number of persons have made direct contributions to the successful completion of this research. My sincere thanks and gratitude go to my study leader Prof. Sylvain Perret of the Department of Agricultural Economics, Extension and Rural Development, and Senior Researcher at CIRAD - France research organisation. On many occasions you had to go out of your way to ensure that the study remained focussed, and that all components necessary for success were available. *Merci beaucoup Professeur* for your skilful and humane guidance and for allowing me to make mistakes sometimes and learn from you. Meriting special acknowledgement is Professor Rashid Hassan, Director, Centre for Environmental Economics and Policy in Africa (CEEPA), for seminal ideas and insightful suggestions.

This study would not have been possible without financial assistance from South Africa Water Research Commission (WRC), at Pretoria. To Dr. Gerhard Backeberg, Research Director WRC, *Baie dankie* for the generous financial support and for allowing me to benefit from your black empowerment initiative.

Ms Melanie Lavigne and Mr. Nicolas Stirer (French students for internship at University of Pretoria) have also made a wonderful contribution. Your work on data coding have guided me so much that I was able to build up crop and farmer typologies for the case study without difficulty. Therefore, your inputs are highly appreciated and acknowledged. Mr. Njokweni Ntsonto was also in this vanguard, thank you so much for allowing me to use your raw data from Zanyokwe scheme. But over all, thanks a lot for your superb company.

It would also be appropriate to thank the staff members of the Limpopo Department of Agriculture, at Thulamahashe and Thabina, as well as the staff members of the Water Users Association at Thabina. Thank you all for your hospitality, logistic support and interpretation. You have made it possible for us to obtain the information needed in this study. Last but not the least; I owe a considerable debt to my beloved wife Margaret and my little angels Murö and especially Erika who was born during the hectic moment of this work. Your moral support and prayers were all that made the difference.

Finally, to my beloved deceased parents Mr. Conficious Lomude Bartholomew and Mrs. Enike Meling Barnaba whose efforts to invest part of their meagre resource in my education had laid a base for me to

reach where I am today. Although you had decided to run your race so early, your parenthood qualities are still remembered. To both of you I dedicate this work.

Investigation of the economics of water as used by smallholder irrigation farmers in South Africa

By

Stanley Conficious Bartholomew Yokwe

Degree: M. Inst. Agrar., Rural Development Planning and Management

Department: Agricultural Economics, Extension and Rural Development

Supervisor: Professor Sylvain R. Perret

ABSTRACT

This study investigates the economics of water as used by smallholder irrigation farmers in South Africa. The productivity and value of water were estimated with data from two smallholder irrigation schemes: Zanyokwe and Thabina. Production parameters such as fertilisers, seeds, pesticides, equipment, transport, labour, and water were treated as inputs. Various methodologies used to estimate water value, including cost-based approaches, were thoroughly reviewed. The aim was to select the ones with more justification for use in smallholder irrigation sector and also to compare a number of approaches. On a case study basis, three methods were applied: residual valuation method, willingness to pay and cost-based approaches (i.e. accounting costs of O&M). Water productivity and values were then evaluated as per crop, farmer, and scheme. Also, cross-section regression analysis was used to investigate the effect of some key socio-economic factors of production on gross margin and willingness to pay.

The results indicated that on average, the value of water varies according to methods, crops, farmers and schemes. In the Zanyokwe scheme, water value estimated by the residual method in cabbage is higher (R1.64 per m^3) than the one in dry maize (R0.35 per m^3), if intensive and high yield irrigated crops are grown per year. Also, in Thabina, water value for cabbage (R1.14 per m^3) outperforms water value for dry maize (R0.02 per m^3). This means that there is greater potential in vegetable crops than food grain crops, although the two schemes have different irrigation systems, and such analysis is based on one-year data, which may lack accuracy. Low water valuation is ascribed to low yield and extensive cropping systems, because gross margin per hectare is very low. This signifies the need for expansion in high value crops rather than low value crops.

At farm and scheme level, the results were derived by using the Smile database and simulated platform. The Smile platform is a data capturing and a calculation tool. It calculates a number of indicators,

economic figures, at scheme and individual farm level, allowing for evaluation of the current situation. The results suggested that at present, the Zanyokwe scheme requires about 1 739 255 m^3 of irrigation water per year. The total operational costs (accounting costs of O&M) are about R146 097.42. In other words, supplying 1 m^3 at farm level will cost R0.084. This implies that if irrigation charges are levied so as to cover O&M costs of the Zanyokwe scheme, the current costs (R0.084) will form only 23% of the average gross margin of R0.37 per m^3 used at scheme level. Furthermore, in the Zanyokwe irrigation scheme, the results revealed that the most active and efficient farmers (specialized farmers) can make an average gross margin of R4 105 per ha per year, also achieving the highest water productivity R0.69 in gross margin per m^3 consumed. However, in the Thabina scheme, the results indicated that, to supply 1 m^3 will cost R0.062. Thus, the current water supply costs cover about 56 % of what is earned (i.e. R0.11 per m^3 used) at scheme level. Again, the most active farmers (commercially oriented pensioners) are more efficient, with average gross margin of R3 092 per ha per year, also achieving the highest water productivity (R0.53 in gross margin per m^3 used). These results suggested that certain smallholder farming systems seem capable of paying for irrigation charges of their respective schemes if they are obliged to do so.

As far as willingness to pay (WTP) and cost-based approaches (CBA) are concerned, the results clearly show that the active farmers in the Zanyokwe scheme have lower WTP per m^3 (R0.03) than the GM of output (R0.69) per m^3 of water used. Also, the accounting cost (R0.084 per m^3 of water used) is lower than the GM gained. However, in the Thabina scheme, the situation is quite different. The active farmers are willing to pay R0.19 per m^3 of water used. This implies that, if farmers are to pay for the charges in order to cover O&M costs, the farmers in Thabina are ready to pay as much as three times the proposed costs of O&M (R0.062 per m^3 of water used), although both the WTP and the accounting cost are lower than GM gained. In these results, it is significant that both the accounting cost and the willingness to pay are lower than the GM per m^3 of water used at least in the Zanyokwe scheme. Even though the data were drawn from a sample for one year only, this finding on the perception of farmers has implications for extension and training to improve future productive use.

Regarding the findings from cross-section regression analysis, the results for GM (as dependent variable) in general indicated that in the Zanyokwe scheme, only credit affects output positively and significantly. Production costs have significant effect on output, but with a negative correlation. It is striking that all the other factors of production including hired labour show negative and insignificant effects on output. In the Thabina scheme, the most important factors of production in the model are land size (hectare) and production costs (Rand per ha). These two variables influence output positively and significantly.

As far as WTP (as dependent variable) is concerned, the results indicated that in the Zanyokwe scheme, it is striking that in all the investigated factors, only credit affects WTP positively and significantly. All other factors are insignificant. Also, gross margin of output per m^3, unexpectedly, has displayed a negative and insignificant effect on output. In the Thabina scheme, the results show that the land size per hectare, and gross margin of output per m^3 affect WTP positively and significantly. Such results are consistent with the assumptions made in the conceptual framework that a farmer with high gross margin gained at farm level is more likely to pay for water costs than those with poor gross margin.

On the basis of these findings, the following recommendations were formulated. Specific policies should include promotion of high value crops and improved varieties of seed for food grain crops (e.g. maize) and vegetables (e.g. cabbage). While improved agronomic practices remain important, there is also potential to increase productivity and profitability of the crops by improving water management practices at the canal-system level, such as better timing of water delivery and increased overall canal-water supplies at the farm level. Finally, from a cost recovery point of view, government should develop a program of cost sharing for capital costs of irrigation development.

With regard to inter-sectoral competition, these results highlight that, if inter-sectoral competition is left to uncontrolled market forces may result in smallholder farmers' selling their water rights to sectors which value water at higher levels. To avoid a “liberal trap” such as in the example of Chile (where smallholder farmers "en masse" sold their water rights, resulting ultimately in deeper rural poverty), some form of control/management of water rights transaction involving smallholder farmers is necessary.

Finally, the findings of this study can be used in various ways. Since, these values determine the farmer’s ability to pay for water now or in the future, the incentive to use water judiciously will be governed by these values. Secondly, the results can be used to evaluate whether the costs estimated and gross margin per m^3 gained at farm level, are in line with the farmers’ willingness to pay. Further work is recommended to clarify these conclusions and provide more policy clarification on the better use of water by smallholder irrigation farmers in South Africa.

Key words: Smallholder irrigation; water productivity; water value; cropping systems; farmer typologies; willingness to pay.

Table of Contents

Chapter three: Methods of the study

Chapter four: Results and discussions

Chapter 5: Summary of findings, conclusions, limitations and recommendations for further research

Appendices

List of Tables / Figures

Figures

Acronyms

ARDC	Agricultural Rural Development Corporation
CBA	Cost-based Approaches
CMS	Catchment Management Agencies
CS	Cost of Supply
CVM	Contingent Valuation Method
DBSA	Development Bank of Southern Africa
DWAF	Department of Water and Forestry
FAO	United Nations Food and Agriculture Organization
GM	Gross Margin
GPW	Global Water Partnership
IMT	Irrigation Management Transfer
IWMI	International Water Management Institute
MPP	Marginal Physical Product
MRW	Marginal Return to Water
MVP	Marginal Value Product
NWA	South Africa National Water Act
OECD	Organisation for Economic Co-operation and Development
O&M	Operation and Maintenance
PTO	Permit to Occupy
RVM	Residual valuation Method
SAPWAT	A computer program used to calculate crop water requirement (CWR). In calculating SAPWAT takes into account the seasonal length, irrigation method (efficiency), etc).
SIS	Smallholder Irrigation Sector
SMILE	Sustainable Management of Irrigated Land and Environment
TVP	Total Value Product
UNCED	United Nations Conference on Environment and Development
WRC	Water Research Commission
WP	Water Productivity is defined as crop yield or gross margin (dry matter of the crop produced) per unit of water consumed
WTP	Willingness to Pay
ZIS	Zanyokwe Irrigation Scheme

Chapter one: Introduction

1.1 Background to and motivation for the study

This study is motivated by two main concerns: the economic and financial viability of the South African smallholder irrigation management transfer (IMT) program, and the feasibility of water markets in South Africa. These two issues define the research problems to be addressed.

1.1.1 The economic and financial viability of the South African IMT program

South Africa has an estimated 1.3 million ha of land under irrigation for both commercial and subsistence agriculture (Perret, 2002a; Bembridge, 1996). Irrigated agriculture consumes more than 60 percent of the water (Backeberg, 1997) and contributes almost 30 percent of the total agricultural production (Backeberg and Groenewald, 1995). According to Perret (2002a) the smallholder irrigation sector (SIS) alone accounts for about 4 to 5 percent of irrigated areas in South Africa. It is estimated that two thirds of the South African SIS is dedicated to food plots which support the livelihood of 300 000 black people (Perret, 2002a). Most smallholder irrigation schemes however, have been inactive for many years (Bembridge, 1986; Crosby et al., 2000). The major problems are infrastructure deficiencies emanating from inappropriate planning and design (Perret and Touchain, 2002), poor operational and management structure, inappropriate land tenure arrangements and lack of technical know-how and ability of extension officers.

In finding ways to mitigate these problems, both the central and provincial governments have developed an ambitious reform program aimed at revitalising smallholder irrigation schemes and reducing the financial burden of their maintenance and operational costs. Smallholder irrigation farmers are now exposed to the IMT program, which includes a cost recovery and institutional change principle in South Africa (DWAF, 1999b). This supposes that irrigation water is to be priced, and farmers will have to pay for the cost of water supply and related services, by forming water users associations. While such arrangements are important, crucial questions remain: What are these costs? Do the farmers' production systems allow them to pay? If so, are they willing to pay? It becomes important to have an idea of the value that is given to water through a number of approaches or methodologies.

1.1.2 The feasibility of water markets in South Africa

Demand for water is increasing in the world especially in developing countries. Growing water scarcity implies that options for water resource development are becoming exhausted, hence a need for efficient water allocation among competing uses. The apportionment of water resources among different sectors has become a critical issue of concern. Such is the case in South Africa where a variety of sectors such as domestic users, industry, mining and agriculture demand their share of the country's water resources (Olbrich and Hassan, 1999). This increased demand on water supply may in part be due to population and economic growth, industrialisation, urbanisation, provision of water and sanitation services to previously disadvantaged people and environmental concerns (DWAF, 1999b; Perret, 2002b). Hence, there is pressing need to address both equity in water allocation (social justice) and water use efficiency (environmental integrity).

To satisfy this need, the new National Water Act of 1998 has provided the broad policy framework for measures to finance the provision of water resource management services and the development of water resources, as well as financial and economic measures to support the implementation of strategies aimed at water resource protection, conservation and the best use of water. The Act also has provided for water marketing (NWA, 1998; Armitage, 1999; Louw and Van Schalkwyk, 2000). Although stated vaguely, it makes provision for water rights trading (the legal transfer of water use licenses) as an option for water allocation (Armitage, 1999; Farolfi and Perret, 2002). Under the previous legislation, sectoral water rights trading did occur and still exists between commercial farmers. It has proved efficient in certain instances (Armitage et al., 1999; Farolfi and Perret, 2002). It appears that water rights trading may also be easily implemented within Water Users Associations. However, since the majority of the rural poor in South Africa depend on water for irrigation, and even more for subsistence farming, the issue of marketing of water remains contentious.

It has been argued by various authors (Armitage, 1999; Louw and Van Schalkwyk, 2000; Farolfi and Perret, 2002) that implementing water markets has a number of possible implications, such as water re-allocation from agriculture to non-agricultural use (low value to high value uses). For example, irrigated agriculture and especially smallholder irrigation is a high-volume water user, but with low return, whereas mining and industry uses water at low volume, but with high return. According to Farolfi and Perret (2002) the productivity of water (WP) in mining is far higher than in smallholder irrigation. Therefore, in a scenario where a water rights market is established, total re-allocation of water from smallholder irrigation to the mining sector may occur, as happened in Chile (Gazmuri and Rosegrant, 1994; Thobani, 1995). This study, therefore attempts to evaluate water productivity and value in smallholder irrigation sector and to examine the effects these values may have, especially in terms of irrigation charges and inter-sectoral water transfer.

1.1.3 Development questions

As presented in the preceding section, the challenge that irrigated agriculture is likely to face in the coming years is how to find a solution to questions such as:

- How to maintain and increase production and enhance water productivity in the face of growing water scarcity and limited access for its use in agriculture?
- How can this situation be overcome at a relatively affordable cost?
- Who should pay for irrigation water supply?
- Are farmers capable of paying and are they willing to pay?
- What are the prospects and potential for changes and improvement in cropping systems?

For each of these issues, valuation of water resource is important for correcting pricing, cost recovery measures, allocation decisions and policy support.

1.2 The Problem setting

The need for this study arises from two existing facts: South Africa is an extremely water scarce country (Backeberg, 1997; DWAF, 1999b; Louw and van Schalkwyk, 2000; Tewari, 2003) and secondly the new national water law advocates that water is to be used to achieve efficiency and long-term environmentally sustainable social and economic benefits for the society from its use (Principle 7 of water law) (DWAF, 1996). With the exception of providing water for basic human needs and ecological reserve, water is no longer a free good and every user is expected to pay for water so that the rule of efficiency can be applied. The smallholder irrigation sector is no exception to this rule and estimation of water productivity and value in the sector is therefore required.

Also, owing to the current conditions of growing scarcity, water pricing may be a key incentive to improve irrigation water use efficiency and to encourage smallholder farmers to conserve and reallocate water to high value uses (i.e. from subsistence oriented kind of farming to high value cropping systems). It therefore appears necessary that this study is undertaken, in order to assist those authorities responsible for designing water pricing policy in the smallholder sector, creating water markets, charging for water supply (O&M at least) and creating incentive for water conservation.

1.3 Research objectives

The overall objective of this study is to investigate the productivity of water and value in smallholder irrigation contexts in South Africa, on a case study basis.

The more specific objectives of the study are to:

- Investigate and compare various methods for evaluating water productivity, and identify the most relevant.
- Assess water productivity on a case study basis by crop, farming systems and at scheme level, and compare such figures or values with supply costs and willingness to pay.
- Analyse discrepancies and introduce some analytical tools in order to investigate factors influencing irrigation water productivity.
- Evaluate the implications of the findings, especially in terms of water charges/cost recovery, and inter-sectoral competition.

1.4 Conceptual framework for evaluating water productivity and value in SIS context

The concept of water productivity can be defined at different levels and in different contexts. In agronomic terms, it is defined as crop yield (dry matter of the crop produced) per average water consumed (Van der Hoek, 2001). Further consideration includes improving non-water inputs in association with irrigation strategies that can increase the yield per unit of water consumed (Molden et al., 2001). These definitions refer to a crop-response to water application. However, from an economic point of view, such "crop per drop" may be transformed into a "gross margin of output per drop", while monetizing the crop through marketing or self-consumption. In both cases the problems are to evaluate properly water consumption / demand; and to evaluate properly the contribution of water to yield / gross margin, among a lot of other inputs.

The following conceptual framework is therefore proposed to evaluate water productivity and value in smallholder irrigation context. In this conceptual framework the water productivity is calculated at total gross margin of output (Figure 1). This is due to the fact that smallholder farmers do not take into account external factor costs such as taxes, land fees, interest rates, depreciation of capital, and the like, when calculating their farm income or budgets. It is thus assumed that an increase in farm gross return may positively affect both water value and farmer's willingness to pay (both represented by positive signs), and conversely that a decrease which may possibly occur due to lack of farmer's skill or other inputs, may have a negative effect.

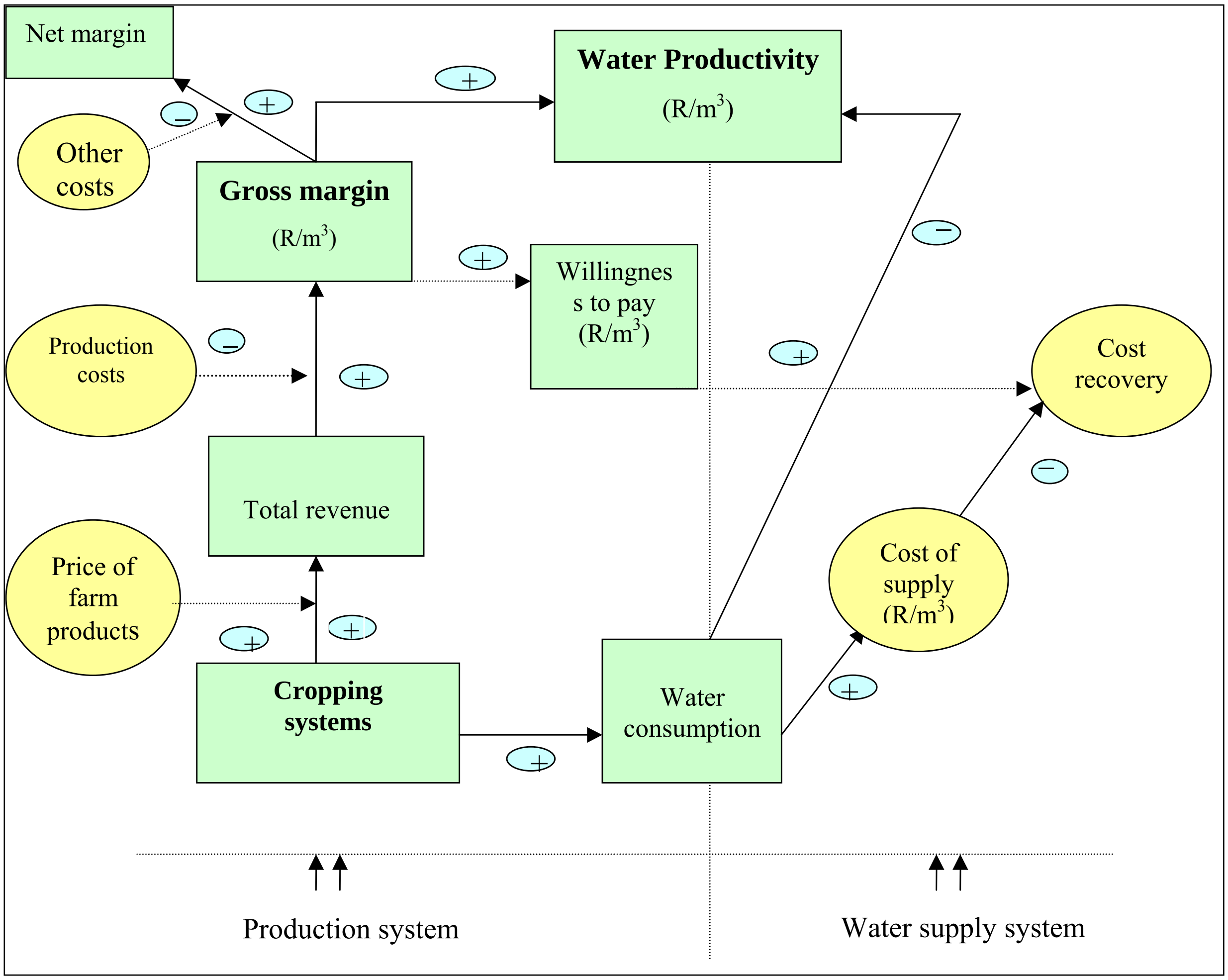

Figure 1. Conceptual framework for evaluating water productivity and value in SIS context

1.5 Hypotheses

(i) There are a number of methodologies and approaches to assess water productivity and value, but few of them are readily applicable for use in smallholder irrigation context.

(ii) There is variation in water productivity and value according to evaluation methods, crops, farmer's strategies and schemes.

(iii) In SIS, a series of socio-economic factors, including livelihood strategies, have influence on water productivity and value, gross margin of output and farmers' willingness to pay.

1.6 The choice of research methods

The method and approaches used in this study are descriptive, theoretical, and with some empirical observations. In considering the specific traits and constraints attached to the smallholder irrigation sector, various existing methods were critically evaluated. These include the Willingness to Pay (WTP), Residual Valuation Method (RVM), Production Function Method (PFM), Water Demand Functions (WDF) and Cost-Based Approaches (CBA). The aim was to identify those methods (with strong justification) that would be applicable for measuring the water productivity and value in smallholder irrigation sector. Three sources of data (i.e. water use, crop yield and the economic return) were obtained by the use of structured questionnaires from two government smallholder irrigation schemes i.e. Zanyokwe in the Eastern Cape and Thabina in the Limpopo Province. It must be stressed that the water data have been obtained from standard SAPWAT computer program (SAPWAT, 1999). Also, data on supply costs (at least the accounting costs of O&M) were used for comparison purposes.

1.7 Structure of the study

The study is presented in five chapters. Chapter two presents a review of the literature on economics of water uses especially by smallholder irrigators. Chapter three describes the material and methods, as well as the description of the case study sites. Chapter four presents and discusses the results on water productivity and value. Chapter five provides a summary of findings, conclusions, limitations and recommendations for further research.

Chapter two: Literature review on the economics of water uses

2.1 Introduction

Water resources provide important benefits to human kind, both commodity benefits and environmental values. For physical, social and economic reasons, water is a classic non-marketed resource. Even for commodity uses, market prices for water are seldom available or when observable, often are subject to biases. However, because of the increasing scarcity of water for both its commodity and environmental benefits and scarcity of the resources required to develop water, economic evaluation plays an increasingly important role in public decision on water projects, reallocation proposal and other water policies (Young, 1996).

This chapter reviews the economics of water uses. Section 2 focuses on the economic concepts, issues and definitions. Section 3 provides a review of evaluation techniques used for estimating the water productivity and value in irrigation. Section 4 discusses the role of economic incentive in improving water use in irrigated agriculture. Section 5 briefly describes the effect of water transfers. Section six gives a summary of the chapter.

2.2 Concepts, issues and definitions

2.2.1 Water scarcity

Water scarcity is a situation whereby the quantity of water required by farmer for producing output exceeds available quantity (Young, 1996). According to Saleth (2002), water scarcity can be defined either as absolute or relative water scarcity in terms of its severity. When water is absolutely scarce, it limits the survival of the irrigation project, and/or development of an individual, a population, a society or an ecosystem. If it is relatively scarce, its limiting character can be overcome with technical, economic or institutional measures, usually at higher costs (Dosi and Easter, 2000).

2.2.2 Social equity

Social equity refers to whether the costs and benefits associated with changes in the allocation of water are equitably distributed among affected parties, which affects their acceptability to change (Hellegers, 2002). In South Africa, in past, apartheid policies distorted the provision of water supply services, so that in 1994 an estimated 12 million people did not have adequate supplies of potable water (DWAF, 2002, 2003). According to DWAF (1999) apartheid also generated a biased approach to water resource management, and allocation was never merely an economic matter, but a socio-political one. Government water policy, and in particular the provision of subsidies (including those associated with the provision of irrigation water), resulted in considerable advantages to large, mainly white commercial farmers at the expense of emerging black farmers and smallholders.

In order to re-address the imbalance created by the previous water allocation systems, the pricing strategy for water use charges coupled with the granting of financial assistance may be an option to achieve social equity both with respect to equitable access to water supply services and with respect to direct access to first tier water (DWAF, 1999). However, to safeguard social equity and future water uses in smallholder irrigation; water management should not be carried solely through a market process or through a purely bureaucratic process. What is really required is a system that reduces conflict over transfers and promotes equality (Howe and Goodman, 1995). In smallholder irrigation, water resource allocation should occur through administrative devices with the purpose of serving social justice and equality requirements.

2.2.3 Economic value

Economists base the concept of economic value on decision framework within which rational individuals make the best use of resources and opportunities (Young and Gray, 1985; Gibbon, 1986; Young, 1996). The framework assumes that the individual members of the economy react systematically to perceived changes in their situation. Such changes can include in addition to the quantity and quality of the water resource of primary interest, prices, costs, institutional constraints and incentives, income and wealth (Young, 1996). In utilitarian approach, a commodity has economic value when users are willing to pay for it rather than do without (Hassan and Lange, 2004). According to Hassan and Lange (2004) the economic value of the water is the price a farmer would pay for it (or, on the other side of the transaction, the amount a farmer must be paid in compensation to part with it). Economic values can be observed when farmers make choice (reveal preference) among competing products available for purchase (or for barter trade – values need not be expressed only in monetary units). In competitive markets, the process of exchange establishes a price that represents the marginal economic value, that is, the value of the last (marginal) unit sold.

In smallholder irrigation, analysis of economic values for water-related decisions is seldom an easy task. Because, the analysis of the demand side of water management decisions require as much specialised skills as is required by our colleagues from engineering and hydrology to perform their supply-side studies. An economically efficient allocation of water therefore occurs when the marginal value of water is equalised across all uses because this allocation maximises the net social benefit from water use (Pareto efficient) (Hassan and Lange, 2004). However, water is rarely supplied by competitive markets, and the price, if any, charged for water usually does not reflect its economic value.

To recapitulate, the economic value of water resource is thus measured by the summation of many users' willingness to pay for the water and service in question. According to Young (1996) willingness to pay is a monetary measure of the intensity of individual farmers' preferences. Therefore, economic valuation is the process of expressing preferences for beneficial effects or preferences against adverse effects of policy initiatives in a money metric.

2.2.4 Economic efficiency

Economic efficiency can be defined as an organisation of production and consumption such that all unambiguous possibilities for increasing economic well-being have been exhausted (Young, 1996). As stated by Briscoe (1996) economic efficiency in irrigation usually measured in terms of cost-benefit ratio, has long been used in investment decision making, which seeks to derive maximum return from an irrigation system over the project life period. The definition of water use efficiency itself is rooted in the concept of economic efficiency. The economic efficiency (termed as Pareto optimality) is satisfied in a perfect functioning competitive economy (Young, 1996).

According to Young (1996) Pareto optimality is said to occur when the marginal benefits of using water or service are equal to the marginal cost of supplying the water. Pareto optimality however, rests on several judgements (Young and Gray, 1985). The first of these is the judgement that individual preferences count; the economic welfare of society is based on the economic welfare of its individual citizens. Second, the individual is the best judge of his/her own well being. The third, highly restrictive, value judgement is that a change, which makes everybody better off with no one becoming worse off, constitutes a positive change in total welfare.

The term economic efficiency thus needs to be considered in a broader perspective and should include factors involving opportunity costs of water, and externality costs generated by the irrigated agriculture (Tewari, 1998). To ensure optimum resource allocation, it requires that goods be priced at their opportunity cost, meaning that this same water can be used for high-value purposes.

2.2.5 Allocative efficiency

Allan (1998) described allocative efficiency as a way to increase the return to water, which is based on the notion of a rational choice as to which activity would bring the highest return to water. Allocative efficiency can be understood as being 'more jobs per drop' (Turton, 1999). In theory, there are two distinct types of allocative efficiency, which represent two different levels of political risk: inter-sectoral allocative efficiency and intra-sectoral efficiency. Inter-sectoral allocative efficiency can be defined as allocating water away from an economic sector (usually agriculture) because of an inherent low return to water, to another (usually industry or mining) because of an inherently higher return to water. This is politically very risky (Turton, 1999). According to Mohamed and Savenije (2002) intra-sectoral allocative efficiency can be defined as allocating water within a given sector, usually away from production that has a low return to water to production with a higher return to water. In the smallholder irrigation sector, it appears reasonable to promote intra-sectoral allocative efficiency especially in the case of South Africa where the nation desires to address issues of food sufficiency, rural employment opportunity and poverty alleviation.

2.2.6 Productivity of water (WP)

Water productivity is the amount of food produced per unit volume of water used, and is a vital parameter to assess the performance of smallholder irrigated agriculture (FAO, 2003). Improving water use productivity is often understood in terms of obtaining as large quantity of crop as possible per cubic meter of water – 'more crop per drop' (IWMI, 1996). Financially astute farmers may prefer to target a maximum income per cubic meter i.e. 'more rand per drop'. This may also mean deriving more benefit, or achieving more welfare, for every unit of water withdrawn from natural water bodies. From the perspective of a national economy, a key goal for water use productivity may also refer to improved net economic returns per rand invested in water use, but this may favour investment in the mining and industrial sectors. Also such a view may not adequately recognise the social and environmental benefits derived from smallholder agriculture.

2.3 A review of evaluation techniques regarding productivity and value of irrigation water

Theoretically, the value of water for irrigated agriculture can be estimated from the area under the water demand curve. In practice, this can be operationalized in various ways, depending upon data availability and other constraints. Water valuation can be quite complex. Data are often not available and expensive to collect. In smallholder sector the volume of water consumption is usually not measured. Water values are usually very site-specific and benefits transfer (a method of applying values obtained from one study site to other sites) is not well developed for many aspects of water (Hassan and Lange, 2004). Methods and assumptions are not standardised, and uncertainty may be quite high.

As presented in the previous chapter, the value of irrigation water therefore can be addressed from a number of perspectives: (1) how much yield or gross margin (GM) a unit of irrigation might give; (2) how much money are farmers ready to pay to acquire that input; (3) how much does it cost to supply a unit of water; and (4) how these estimated values (i.e. GM per m^3 and willingness to pay) can be compared with what farmers actually pay? In view of these questions, this section discusses the strengths and limitations of the various evaluation techniques, taking into account the above mentioned constraints attached to smallholder irrigation sector.

2.3.1 User Benefit approaches

2.3.1.1 Willingness to pay for water (WTP)

Willingness to pay (WTP) for irrigation water is a monetary measure of the value an individual farmer would pay to have a specific change in quantity of water and service (Young, 1996). Farmers' gross income in smallholder irrigation sector is a determinant of the WTP (see the conceptual framework). According to Rogers et al. (1998) WTP is represented by a demand curve relating the quantity of water demanded by farmers at a series of prices.

Determining WTP for water can be carried out in two approaches, both of which are based on user surveys of actual or hypothetical behaviour (Young, 1996). One approach is termed the "revealed preference method", relying on observations of actual expenditure choices made by consumers. This method infers net willingness to pay from the differences in expenditures observed with levels of environmental amenities. Such approach however, is not applicable to our study. A second approach is represented by what are often termed the Contingent Valuation Method (CVM). This approach does not rely on market data, but asks individuals about the value they placed on something, i.e. by asking them how much they would be willing to pay for water (Hassan and Lange, 2004; Hanemann, 1991).

According to Hassan and Lange (2004) CVM surveys often take the form of a binary-choice instrument (open-ended surveys can be more difficult to analyse). Individuals are given a choice between two quantities of services, usually the status quo and an alternative that requires a payment. Different levels of payment are randomly assigned to different individuals in the sample and the response is analysed in the same way that behaviour in actual markets is analysed. A demand curve measuring total economic value is derived by econometric analysis of the results along with other variables such as income and other factors that influence willingness-to-pay (demand). A CVM survey however, requires that survey respondents are well informed of an improvement of water benefits and its substitute, a large sample, and face-to-face surveys. These requirements make good CVM studies rather expensive. For example, developing materials that inform the sample population about the issue often requires the use of photographs and other means of visual display, focus groups, in-depth interviews and pre-testing of surveys.

Applicability of this method to use in the case study

Since this method does not rely on market data, it would be useful in estimating the marginal value of water in SIS. The problem is that smallholder irrigation farmers do not consider the value of water as a relevant unit. They may express WTP with regard to other units that make sense with regard to cropping systems i.e. average and/or time, thus the need to apply this method to investigate the link between consumption, gross margin gained from irrigation water used, and accounting cost (O&M costs at least).

2.3.1.2 Residual Valuation Method (RVM)

Residual Valuation Method is used for measuring the value of an input used to produce output (Young, 1996). Similar to the production function approach, residual value method is applied to water used as an intermediate input (water in irrigation) to production. In this case however, neither data on price and quantity of water for direct estimation of water demand functions nor data on physical quantities of inputs (including water) and output to support production function estimation are available. Instead, data on production cost or revenue are available. Such data can be used to indirectly estimate a marginal value of water based on the principles of cost minimisation or profit maximisation (Hassan and Lange, 2004). The simplest of firm models employ a budgeting approach, where the valuation process involves subtracting forecast costs of non-water inputs from forecast crop gross income (Young, 1996). This is expressed mathematically as:

RVM = Gross margin of output under irrigation - Gross margin of output under rain-fed

Assuming that all other conditions are equal (i.e. input supply, crop calendar, biophysical conditions, product prices, etc.). The remaining surplus of income over non-water costs is imputed as the benefit or value of water to the firm. This implies that residual effect can be very small when there is enough rainfall (e.g. maize in summer) and visa versa in drought seasons (e.g. vegetables in winter).

The derivation of this model requires two principles. First, competitive equilibrium requires that the prices of all resources be equated to returns at the margin. Profit-maximizing farmers are assumed to add productive inputs up until the point that values of marginal products are equal to opportunity costs of the inputs. The second condition requires that the total value of product (TVP) can be divided into shares, so that each resource is paid according to its marginal productivity and the total value of product is thereby completed exhausted (Young, 1996).

This technique has the advantage of being relatively easy to implement, but is quite sensitive to small variations in the specification of the production function and assumptions about market and policy environment. If an input to production is omitted or underestimated, its contribution (value) is wrongly attributed to water. Some major inputs, like the labour of the farmer and his/her family, are often unpaid in both developed and developing countries and a shadow price must be estimated, usually in terms of the opportunity costs of workers. Unless the value of labour input is estimated and fully accounted for, the value of water will be overestimated. Farm management is a distinct contribution of the farmer and sometimes less easy to value unless there are comparable farms, which hire managers. Another problem related to labour is the cost of paid labour. In many developing countries unemployment is high, and farm wages may be set by government regulation rather than the market. These wages may be substantially higher than the marginal value of labour (Hassan and Lange, 2004**;** Young, 1996; Young and Gray, 1985).

Applicability of this method to use in the case study

This method can be applied to evaluate water productivity in smallholder irrigation schemes e.g. in Zanyokwe scheme, where data on rain-fed and irrigation are provided. Also RVM can be based on the premise that water is paid after all other inputs in the production process of smallholder irrigation scheme are paid-off. The value of water is thus computed by subtracting total costs from total revenue and then dividing the residual value or the gross margin by the quantity of water used.

However, Young (1996) stresses that although valuing irrigation water using RVM is a relatively straight forward task from the accounting perspective, inaccuracies or biases can arise from either the quantities of all inputs and the associated outputs or the pricing of inputs. Another biases relating to pricing is that over- or under pricing inputs induces corresponding but opposite effects on the estimated value of the residual.

2.3.1.3 Production Function Method (PFM)

A production function, which mathematically represents the relationship between inputs and output(s) in a production process, serves as a basis for describing, explaining and predicting the output expected from a specific level of inputs (Dinwiddy and Teal (1996). For irrigation water valuation, water-crop production functions play an important role in serving as building blocks for models of farmers' response to alternative water management policies (FAO, 2003). According to Whittington et al. (1987) production function can provide data needed to determine the use of resources and the pattern of output, which maximises firm's profit. For example, the effects of irrigation water on crop production are usually quantified by using a crop water production function, which relates crop output to the amount of water applied.

According to Hassan and Lange (2004) this approach is applicable to situations where input demand for water is not directly observable (no information on sale price and quantity of water bought as is the case in this study), but data on quantity of water W (and other inputs X) used and corresponding output levels (Q) realised are available to support estimation of production or yield response functions. Such data are usually obtained from producers' surveys or experimental data (irrigation agriculture) and can be used to indirectly derive a marginal value of water. First, the data are used to estimate production function parameters (vector β) measuring the technical relationship between output and input use, including water.

$$Q = F\,(X, W, \beta)$$

This information is then used to derive the marginal physical product of water (MPP_w), where:

$$MPP_w = \beta_w = \delta\, Q / \delta\, W$$

The first order conditions for profit maximisation require that the value of marginal product (VMP_w) is equated to the price of water (P_w):

$$VMP_w = P_Q * MPP_w = P_Q * \beta_w = P_w$$

When the price of water P_w is not observable but the price of output P_Q is, and β_w can be obtained from the production function F, one can use that information to calculate an estimate of the marginal value of water indirectly as $P_Q * \beta_{w.}$

Applicability of this method to use in the case study

One major problem limiting the application of this method in smallholder irrigation sector is the lack of data on actual quantities of water used. As presented earlier, in this study, irrigation water is not metered. Data on water consumption are only estimates from SAPWAT computer program, which provide a fixed total crop water requirement (mm).

2.3.1.4 Water Demand Functions (WDF)

Under the right circumstances, consumer and industry demand functions for water can be derived from the econometric analysis of water sales (Hassan and Lange, 2004). The conditions under which a demand curve can be derived are rather stringent and are often not obtained, even in developed countries (Walker et al., 2000; Hassan and Lange, 2004). According to Briscoe (1996) water use in irrigation must be metered to provide accurate data about volume consumed and water charges must be based on volume consumed, not a lump sum for services. As indicated at the inception of the chapter, in irrigation agriculture, water provision and use are not metered. The reason being that in South African SIS, as in the rest of Africa devices for measuring flow volumes (as distinct from flow rate) especially in gravity-based systems or open channels are not available at the scales and costs required are extremely high (Abernethy et al., 2000). When consumers pay a lump sum, the marginal cost is zero and their consumption does not reveal marginal value.

Applicability of this method to use in the case study

As stated already, where there is no measurement of actual water consumption, it is difficult to know the marginal value of water. This is exactly the situation encountered in this case study. Apparently, in SIS water consumption is not measured. What is currently available is fixed water consumption or volume derived from SAPWAT computer program. According to Hassan and Lange (2004) demand curves cannot be estimated where water is rationed or where a single marginal price is charged to all consumers. Where a single price is charged, a less reliable alternative sometimes used is to trace the real tariff over time and changes in water consumers. Thus, this method is not applicable to be used in the case study.

2.3.2 Cost-based approaches

2.3.2.1 Full supply cost (FSC)

These are the costs, which are associated with the supply of water to a consumer without considering either the externalities imposed upon others or the alternate uses of the water (Global Water Partnership - GWP, 2000). Full supply costs are composed of two separate items: Operation and Maintenance (O&M) costs, and Capital Costs (charges), both of which should be evaluated at the full economic cost of inputs.

O&M costs: these costs are associated with the daily running of the supply system (DWAF, 1999b). Typical costs include purchased raw water, electricity for pumping, labour, repair materials and input cost for managing and operating storage, distribution, etc. In practice, there is typically little dispute as to what are considered O&M costs and how they are to be measured. Unlike other costs (mentioned above) the O&M costs are included in water prices and they are supposed to be recovered annually through implementation of the water use charges at government water schemes (Rogers et al., 1998).

In smallholder irrigation, recovering O&M costs may be difficult, especially when the marginal benefit is lower than the marginal cost. In such circumstances, they require that the government and external donor subsidy should be estimated at the full cost of supply (Briscoe, 1996). According to DWAF policy with regard to cost recovery or charges in SIS, the idea is that O&M charges will be phased in over 5 years after water users association (WUA) is established and a contract is set up with DWAF; operational subsidies by DWAF on O&M costs will be phased out (DWAF, 1999b; Perret et al., 2003).

Capital charge: In terms of section 56 (2)(b) of the National Water Act, 1998, water resource development costs can include the related costs of investigation, planning, design and construction of water schemes, which constitute the capital cost of the project. There are three common financial approaches that can be used for determining the capital portion of the unit cost of water; they are the funding approach, the depreciation and the rate of return (DWAF, 1999b) associated with reservoirs, conveyance and distribution systems.

- *Funding approach*. In funding approach it is required that revenues should be sufficient to cover debt service obligations (interest charges) and the redemption of loans. This approach has been historically used by DWAF and as it is generally more easily understood in the public sector because of the cash-oriented budgeting and accounting system traditionally used by this sector. This method was based on "notional loan", where it is assumed that the State raised loans to fund schemes and that these "loans" then had to be repaid through water use charges (DWAF, 1999a).
- In the *depreciation approach,* asset values (composed of water infrastructure assets and other fixed assets) are depreciated over their useful economic lives. Depreciation is normally calculated on a straight-line basis over the life of the asset. In an inflationary environment, it is prudent to depreciate assets on the basis of current replacement cost. Depreciation cost recovery is used to ensure sustainable water supplies from existing assets (DWAF, 1999a).
- According to DWAF (1999a) the *rate of return (or interest rate) approach* allows for fixing a charge to earn a specific rate of return on either the total capital employed (fixed assets based or total assets)

or the total financial investment used to finance facilities to supply water. Typically, this approach would be applied in conjunction with depreciation accounting.

Applicability of this method to use in the case study

This section in particular is applicable for use in the case study, at least accounting O&M costs, which can be compared to benefit-based figures. For example, in Thabina scheme, all beneficiaries would be able to pay a fixed component per ha owned, regardless of what is done (e.g. R10 per ha per month). The farming beneficiaries would pay an additional variable component per ha cropped (e.g. R40 per ha per month).

2.3.2.2 Full Economic Cost (FEC)

The full economic cost of water is the sum of the full supply cost, the opportunity cost associated with the alternate use of the same water resource, and the economic externalities imposed upon others due to the consumption of water by a specific actor (GWP, 2000; Hellegers, 2002).

Opportunity Cost: This cost addresses the fact that by consuming water, the user is depriving another user of the water, if that other user has a higher value for the water, then there are some opportunity costs experienced by society due to this misallocation of resources. The opportunity cost of water is zero only when there is no alternative use (Young, 1996; Briscoe, 1996). Ignoring the opportunity cost undervalues water, leads to failures to invest, and causes serious misallocations of the resource between users.

Economic externalities: According to GWP (2000), the most common externalities are those associated with the impact of an upstream diversion of water or with the release of pollution on downstream users. There are also externalities due to over-extraction from or contamination of common pool resources such as lakes and underground water (Briscoe, 1996). There may be also production externalities (Rogers et al., 1998), for example, the agricultural production in irrigated areas damaging the markets for upland non-irrigated agriculture, or forcing them to change their inputs. According to Winpenny (1996), the standard economic approach to externalities is to “internalise the externalities.”

The externalities may be positive or negative. With *positive externalities*, for example, when surface irrigation is both meeting the evapotranspiration needs of crops, and recharging a groundwater aquifer, irrigation is then effectively providing a “recharge service.” However, the net benefit of this recharge service will depend on the overall balance between total recharge (from rainfall and surface irrigation) and the rate of withdrawal of water.

However, *negative externalities*, as discussed in Briscoe (1996) may impose costs on downstream users if the irrigation return flows are saline, or where return flows from towns impose costs on downstream water users. One method used to account for these kinds of externalities is to impose a levy on users, depending on their water use patterns. This method is used in the Australian State of Victoria, and the surcharge is determined by the cost of restoring the saline water to its original condition (and generally greater than the abstraction costs which users have to pay). Where return flows are from towns, which impose costs on downstream users, the method is to levy a charge on urban consumers for restoring the wastewater to an acceptable condition (in the German Ruhr and French systems, Briscoe, 1995). According to Rogers et al. (1998) these negative externalities should result in additional costs to users who impose these externalities on others.

Applicability of this method to use in the case study

As presented earlier, it is not easy to measure full economic costs at this particular study as it does not take into account the impact of an upstream diversion of water, the irrigation return flow, the damage of the markets by agricultural production in irrigated areas, and the like. Besides, this needs data and surveys that do not exist anyway.

2.4 Role of economic incentive in improved water use in irrigated agriculture

The increasing demand for water, growing scarcity and rising cost of augmentation have led to the realization that water has to be allocated and used efficiently (Grimble, 1999). In the past, economic measures such as water charge and taxes have mainly been introduced with the aim of generating revenue to partially cover the cost of supplies (OECD, 1999). The use of incentive-based measures for improving efficiency in the resource use is very rare in practice. It is precisely secure property rights, which provide incentives for efficient resource allocation. This applies specifically to smallholder irrigation farmers who require predictable outcomes of decisions before expanding farming activities or intensifying their production methods, etc. In this context, there is a need for conceptualising on the role of economic incentive measures and resource use efficiency, producers' cost and economic variables. The rest of the section provides a brief description of the role of economic incentive measures in motivating improved water use in irrigation at various levels of policy intervention.

2.4.1 Water charging and cost recovery

Water prices denote any charge or levy that farmers have to pay in order to obtain access to water in their fields (OECD, 1999) and is based on the user pays principle that those who benefit from the use of scarce resource should pay (Dommen, 1993). The adoption of the user pays principle provides a basis for pricing and allocating scarce water among different uses, which could help improve water use efficiency and reduce conflicts in sharing scarce water (Tewari, 1998). Water charging and cost recovery refers also to that issue but also to others, as there are a number of approaches to pricing or taxation. However, in practice, there are several issues involved in the pricing of irrigation water for achieving different aspects of water use efficiency.

In some developing countries, irrigation water is also charged on the basis of output per area, i.e. irrigators pay a certain water fee for each unit of output they produce (Johansson, 2000). The basic concept is that farmers' should pay the charge according to the crop productivity or value of output they derived per unit of water used e.g. gross margin gained per m^3. For example, in Pakistan, Philippines, Mexico and India the output pricing system is based on the type of crops grown, which somewhat reflects the charging system according to the amount for water used (Yoduleman, 1989; Tewari, 1998; Johannson, 2000). Another basic concept is that of farmers willingness-to-pay based on pricing: how much users are ready to pay? And cost based approach to pricing: how much does it cost to supply water to the user? As indicated earlier, in smallholder irrigation sector in South Africa, when existing, charging systems are more often based on a cost recovery principle, at least for O & M (Perret et al. 2003).

2.4.2 Subsidies

Subsidy on irrigation water is considered as the difference between what farmers actually pay per unit of irrigation water and the marginal cost of supply or full cost price of water. In South Africa smallholder irrigation water has been highly subsidised in the past, and even at least the capital costs are still being subsidised (Perret et al., 2003). As farmers receive irrigation water at a relatively lower price, it provides no economic incentives to them for using water more efficiently (Backeberg, 1996). Elimination of existing subsidy in the smallholder irrigation sector and re-investment of the resulting fiscal savings in efficient water use technologies could thus improve WUE and result in large monetary benefits. In the South African context, as presented in the preceding section, DWAF charging policy entails the idea that the operational subsidies (O & M costs) will be phased out over 5 years after the WAUs is established and contract is set up by DWAF. This means that ultimately after 5 years farmers should pay for additional costs under the current water consumption (Perret, et al., 2003).

Removal of the existing subsidy for eliminating the existing inefficiency in smallholder sector, and making a shift from 'negative' to 'positive' subsidies, for improving efficiency in water use however, involves several issues such as:

- first, the investment subsidy is considered as the most politically acceptable means for pleasing the farmers in the rural areas, though major beneficiaries of such subsidy schemes such as for irrigation water have been the agribusiness people in the past rather than the small farmers (DWAF, 1999b);
- second, subsidies aimed at providing economic incentives to farmers, if not designed well and not specifically targeted to the specific group, that promote WUE, then it may result in misallocation of resources and also, lower efficiency in water use (Tewari, 2003);
- third, subsidy needs to be implemented only for the transitional period required for making a shift towards the adoption of water productivity. Otherwise, it could also result in over-dependency of farmers on such grants and credits, and would be difficult to modify the farmers' behaviour; and
- finally, using subsidy as an economic incentive measure should thus be carefully implemented with evaluation of the impacts of existing subsidy and potential impacts of elimination of such subsidy on the poor households and rural employment opportunities.

Different types of subsidies such as grants (as in Zanyokwe scheme) or payments to WAUs (as in Thabina scheme), provision of extension services, etc. could be implemented depending upon their effectiveness and suitability to a particular region or scheme such as:

- Subsidies that constitute payment for part of the investment cost (e.g., O&M costs) on water conservation practices to be paid to the farmers on the basis of per unit water saved or designated types of water saving technologies;
- Conservation subsidies for crop diversification to be paid on the basis of water saved per unit crop area, or loss in productivity or incremental cost of production (e.g., for making a shift from low yield cropping systems to high yield cropping system);
- Research grants for undertaking the research on efficient water application technologies, and management practices.

2.5 The effect of inter-sectoral water transfers

Inter-sectoral allocation of water refers to reallocation of water from low value uses (irrigation) to high-value uses (mining). Also, it refers to the issue of allocative efficiency i.e. what is the best allocation of one unit of water, for it to ensure maximum return, welfare, jobs, etc (Turton, 1999). In this context, it's the return to water use that counts, per sector and also externalities, which we don't address here.

According to Shiffler (1996) there are two ways to reallocate water from agriculture to non-agricultural sector: through administrative decision or through the markets. If water is administratively reallocated to non-agricultural sector (say mining or municipal), income and employment losses in rural areas are inevitable and remain uncompensated for. Also, in inter-sectoral allocation, if organised through markets, but if not controlled whatsoever, will result in smallholder farmers selling their rights to sectors which value water at higher levels, as it has happened in Chile (Gazmuri and Rosegrant, 1994).

In South Africa context, intra-sectoral water transfer can be seen as a panacea for improving water use efficiency of SIS especially in the case where the nation desires to address issues of food sufficiency, rural employment opportunity and poverty alleviation. The advantage with this approach is that it provides a wider basis for water use efficiency as greater attention is paid to policy issues such as pricing and decentralisation that extend beyond the context of individual projects (Saliba and Bush, 1987). The sectoral approach involves policy intervention directly to productive sector, productive infrastructure and social infrastructure (World Bank, 1993; Ghooprasert, 1990).

2.6 Conclusion

This chapter has provided a description of key concepts, issues and definitions in relation with the research. Also, it discussed the strengths and limitations of the various evaluation techniques, taking into account the current features and constraints attached to smallholder irrigation sector. On a case study basis, only three methods were chosen. This includes residual valuation method, willingness to pay and cost-based approaches. Drawing from these discussions, it becomes clear that in the conditions where water use is to be charged to users: looming water charging systems are also a challenge (low productivity); and looming water market put smallholder irrigation sector at risk (since it is a high volume, low productivity sector).

Chapter three: Methods of the study

3.1 Introduction

As presented in the preceding chapters, the "productivity" of irrigation water is a measure of the net economic contribution of water to the value of agricultural production. For a number of reasons, the accurate evaluation of irrigation water values and costs is of special interest and concern. According to the conventional theory of the distribution of factor incomes, the value of a resource is an upper bound on the farmers' ability to pay (Young, 1996). Empirical estimates of the productivity of irrigation water provide important evidence on the farmers' ability to pay in implementing cost recovery programs for development projects, and for long-term sustainability purposes.

This chapter presents: (1) a description of the methods and materials used in section two, (2) a brief description of case study sites in section three; and (3) a conclusion in section four.

3.2 Materials and methods

This section is to describe the criteria of selection for the study areas; methods employed in data collection; and how farmers responded to the survey. It also presents the method employed in data analysis, and the study sites in terms of biophysical aspects, land, infrastructure, social and institutional aspects.

3.2.1 Selection of study areas

The two schemes were primarily selected, because they are considered reasonably representative of the diversity of SIS existing in South Africa. It is worth mentioning that the selected schemes are part of two different projects.

The generic criteria of selection of the schemes are based on: (i) some form of diversity in production features that are occurring in the schemes; (ii) the diversity in farming orientation and style (from subsistence to commercialisation); (iii) the diversity of crop management style (production cost, water supply and yield - from low to high yield); (iv) the diversity in local institutional settings (PTO, WUA, Trust & etc.); (v) the diversity in bulk water supply (dam and river); and (vi) the diversity in irrigation system (from gravity to pressurised systems).

3.2.2 Methods employed in data collection

Surveys have been conducted in the two schemes between February to May 2003. The purposes were to assess the economic and technical circumstances and to calculate economic figures at individual farm and scheme level. Before the individual farmers were interviewed in each of the selected schemes, group discussions were held with scheme management committees, staff of WUA and agricultural department staff to get background and general information about each of the schemes.

A well-structured (long and comprehensive) questionnaire has been used to interview the farmers who were mostly the household heads (a specimen of the questionnaire is supplied in the Appendices). Information captured in the questionnaire include household characteristics, land, crop systems, market, equipment, sources of off-farm income, credit, water management aspects, and problems associated with agricultural practices in general.

A stratified sampling procedure was used to draw a representative sample of 124 household heads - 60 household heads in Thabina scheme and 64 in Zanyokwe scheme. Due to unavailability of suitable respondents during successive rounds of data collection, the effective sample in Zanyokwe scheme was reduced to 55 households. It is worth noting that the interviews in Thabina scheme were conducted by a number of research teams including the author of this study. Whilst, the one in Zanyokwe scheme has been carried out by Mr. Ntsonto, whose aim was to collect data for his independent study.

A stratified sampling procedure was adopted because:

- it allows for dividing the population into sub-population that are less variable than the original population; different parts of the population can be sampled at different rates when this seems advisable;
- it takes into account the peculiarities found within the schemes and adapts to local circumstances (Perret et al. 2003);
- in the stratified sampling the size of sample to be taken from any ward or cluster can be chosen separately. This freedom of choice provides scope for an efficient allocation of resources to the sampling of the wards (Leedy and Ormrod, 2001).

3.2.3 Response of farmers to the survey

The initial reaction of farmers to the survey in the two different schemes for the case study was encouraging. However, in Thabina scheme, following the first round of the interview, some inaccuracies and deficiencies have been identified within the questionnaires, hence a second round of interviews has been carried out by internship students (Lavigne and Stirer). Also, in Zanyokwe scheme successive rounds of data collection were carried out.

3.2.4 Method employed in data analysis

A database has been established based on data collated at the two smallholder irrigation schemes. On case study basis, five steps were used to analyse the data.

The first step:

The first step of the analysis was to evaluate water productivity by crop types in Zanyokwe case study scheme. The Residual Valuation Method (adapted) was used to measure the return to water out of the gross margin obtained from all the production inputs employed. In this step, the starting point was to select the most representative and common crops grown from crop management style (typologies) constructed by Ntsonto (2003) to use in crop budget analysis. A table of variable costs for each crop makes explicit each step required for crop production, its resource requirement and the resulting outputs (see appendices).

The next point was to amalgamate (or assemble) a unit crop budget to calculate and display the gross margin over variable costs per unit land (ha) for each crop type. It is worth noting that the "Variable Costs" here refer to the costs associated with production, which include the costs of fertilisers, pesticides, seeds, plant, land preparation, labour, transportation, harvest, marketing costs, etc (see page 66 in the appendices). At this step, the residual return to water is thus; computed by subtracting the gross margin "with" rain-fed from the one "with" irrigation and then dividing the residual gross value of output by the quantity of water used (m^3). It must be highlighted here that the quantity or volume of water used here was derived from SAPWAT computer program, which uses data from the closest weather station (see the definition of SAPWAT in the Acronym).

The second step:

The second step of the analysis was to evaluate water productivity at crop level in two case study schemes, but using 'only crop data under irrigation'. The reason being that some of the major crops, lack information from "rain-fed" situation. At this step, also a series of typical and reasonably homogenous cropping systems were chosen from two separate crop typologies (i.e. crop typology constructed by Lavigne and Stirer, 2003; and the one by Ntsonto, 2003). The Residual Valuation Method also has been used. The residual method used was based on the premise that water is paid after all other input (excluding the capital assets) in the production process of crops are paid-off. Similar procedures as in step one were followed.

The third step:

The third step of the analysis was to estimate water productivity at farm and scheme level. Smile model was used to calculate a number of indicators, economic figures, at scheme and individual farm level, allowing for evaluation of the current situation (Perret and Touchain, 2002; Perret et al., 2003). Smile stands for Sustainable Management of Irrigated Land and Environment (Perret, 2002b). It is a model for data capturing by users and consists of five input modules that form the basis of the information system. Each cost-generating item was listed in the "Cost module". This model generated output variable that reckon the costs incurred by the scheme and its management (e.g. operation costs, etc.). Such information answers the question as to how much does it cost to operate the scheme in a sustainable manner (regardless of who is going to pay for it) (Perret, 2002b).

In the "Crop" module, each potentially productive and water-consuming crop was listed with its technical and economic features (e.g. management style, cropping calendar, water demand, yield, production and marketing costs). This then generated micro-economic output variables (e.g. gross and net margin per ha, and per cubic meter) that allow comparative evaluation of crops in terms of profitability, land productivity, and water productivity.

In the "Farmer" module data were captured at different farmers' types, with their cropping systems (combination of crops that have been documented in the crop module), average farm size, percentage of the scheme's size, willingness to pay for irrigation water service. This then generated type-related output variables (e.g. aggregated gross margin per type, crop calendar) and scheme-related output variables (e.g. number of farmers, aggregate water demand) when combined with the "scheme" module. A "Water" module deals with water balance at scheme level (rainfall and resource –availability patterns, crop consumption). It must be underline here that water module was not applied in this case study, water consumption used in the case study was taken from SAPWAT computer program.

The "Farmer" and "Cost" modules were then amalgamated and used within the water charging system" module, and generated output variables on cost recovery rate as per type. This allows answering the question as to who may pay, and how much, for water services. It also generated some social and equity-related indicators, and resource related indicators (e.g. total number of farmers, area per type, number of farmer per type, gross margin per type, gross margin at scheme level, total water consumption (see appendices for used in this study).

The fourth step:

The fourth step of the analysis was to calculate water values from what the farmers were willing to pay for a unit of water. Contingent Valuation Method (CVM) was used to obtain the data needed for determining the willingness to pay per cubic meter of water used. During the sampling survey, a contingent valuation question was posed for the farmers to evaluate and disclose their possible financial contribution to water supply and related services. As stated in chapter 2, different levels of payment were randomly assigned, and the respondents were given a choice to indicate what they are willing to pay. It must be emphasised that survey respondents were informed of an improvement of water benefits and its substitute. The figures obtained were then transformed as average rand per m^3 (i.e. average rand per ha per year divided by total irrigation water demand per ha). Such figures are important for investigating the link between consumption, cropping and farming systems, and possible charging for irrigation (Cost-Based Approach).

The fifth step:

The fifth step of the analysis was to introduce the cross-section regression model in order to investigate explanatory factors related to gross margin and willingness to pay. The analysis of implications of findings, especially in terms of water charges and inter-sectoral competition was also made in this step.

3.3 Brief description of the case study sites

3.3.1 Thabina irrigation scheme

Bio-physical aspects: The Thabina irrigation scheme is located by latitude 30^{o}18 E and longitude 23^{o}58 S. It lies at an altitude of about 560m along the Thabina River, which runs east towards the Great Letaba. The scheme is located 24km southeast from Tzaneen (along the R36). It benefits from sub-tropical, frost-free conditions and fairly good alluvial soils. Annual rainfall averages around 790mm, yet with drastic inter-annual variation (20-30%), recurrent and severe droughts, and a long dry season (about 90 percent of rainfalls occurs between October and February) (Perret et al., 2003). The scheme started in 1962, to promote development and food security in impoverished rural areas of former Gazankulu and Lebowa homelands (Crosby et al., 2000).

Land: The scheme composes of 234 ha with 149 farmers, who are living in the surrounding villages (Lifara, Burgersdorp, Khopo, Mhlaba Kraal and Head-Kraal, Mafarane, Shwapane, Sasekane, Lenyenye, Zanghoma, etc). Initially each farmer was allocated one hectare, but re-allocation occurred afterward. Some farmers now hold more than 1 hectare. A striking fact is that about 40 percent of the land lies unused in Thabina, the plot holders not being interested in farming.

Infrastructure: According to Perret et al. (2003), infrastructures for water supply include the initial gravity fed system (weir, dams and a main canal), now combined with 4 pumps (2 diesel engines and 2 electric ones), which have been installed later to increase water supply to the main canal. The weir has been recently refurbished and upgraded, in the frame of the rehabilitation program. The canal started at a weir along the Thabina River downstream from the dam. The length of the main canal is 7000m. About 5000m of it lies outside the scheme, where it used to be almost entirely covered with concrete plates, although now broken from place to place. The Thabina dam was initially developed for irrigation purpose, but it now serves the communities around for domestic water. The scheme is about 2000m long. The main canal supplies secondary canals within each irrigation ward. Water bailiffs control each ward's water supply. Irrigation is scheduled on a turn basis among wards. There are four wards, and within each ward some farmers are allowed to irrigate while the rest are to wait for the next turn according to the schedule. According to Perret et al. (2003), farmers commonly admit that all wards experience water shortages, with ward D being more exposed.

Social and institutional aspect: The Thabina scheme was one of the first three former homeland irrigation schemes that were revitalized by the Limpopo Province Department of Agriculture, Land and Environment. It was also the first emerging farmer Water User Associations (WUA) that was established by Department of Water Affairs and Forestry (DWAF). The Thabina farmers' population is composed of two ethnic groups, Shangaans and Sothos, who go along and cooperate with no major problem. Currently, the management committees for the WUA in collaboration with staff members of the Limpopo Province Department of Agriculture (extension branch) are the ones running the daily management of the scheme. Membership to the WUA is restricted to PTO holders, within the scheme. Yet, other people from neighbouring communities use water from the same resource.

3.3.2 Zanyokwe irrigation scheme

Bio-physical aspects: Zanyokwe irrigation scheme is situated in the district of Keiskammahoek, about 30km west of King William's Town. It lies at an altitude ranging between 440m to 640m above sea level. The area is characterized by a temperate to warm and sub-humid climate, with an annual average summer rainfall of 590mm per annum. Frost occurs from mid-June to mid-August (Van Averbeke et al., 1998;

Rural Urban Consultants, 2001). Rainfall is of showery nature and thunderstorms are quite frequent and are occasionally accompanied by hailstorm. Zanyokwe irrigation scheme started in 1983, to improve standard of living, and to create job opportunity (Rural Urban Consultants, 2001).

Land: Zanyokwe irrigation Scheme covers approximately 635 hectares but only 535 hectares is irrigated. The scheme comprises of 66 individual small farms ranging from 0.5 to 10 hectares. The balance of land is yet to be developed and irrigated. The scheme also includes an additional 78 communal plots. 42 communal plots in Lenye are occupied, and the 36 at Burnshill are not currently occupied and have not been irrigated.

Infrastructure: The Sandile Dam that has adequate storage capacity to serve the entire area serves the Zanyokwe Irrigation Scheme. The scheme consists of piped irrigation systems with valve chambers and ancillary pipes serving the area of the irrigated land. The land consists of relatively small islands of irrigated land, stretched from Lower Nqumeya in the East to Kama Furrow in the West. All irrigated land is intended for crop production (Van Averbeke et al., 1998).

Social and institutional aspects: The demographic size settled around Zanyokwe is roughly 402 inhabitants (households), who are directly benefiting from the schemes. Land tenure in the Eastern Cape in general and Zanyokwe Irrigation Scheme in particular is very diverse. This diversity was added to by new legislation that provided for a new form of tenure and modifications to existing tenure (Scogings et al., 1998). According to evidence collected by van Averbeke et al. (1998), in Keiskammahoek District, the chiefs were responsible for choosing the form of tenure that would apply to their people. Three forms of tenure are: communal tenure, freehold and leasing agreement. In the scheme, 44 percent of the land is held under freehold title, 40 percent under PTO and the remaining 16 percent leasing agreement. These forms of tenure accord the owner full entitlement with the freedom to alienate and use the land at will subject to statutory restrictions (Van Averbeke et al, 1998).

3.4 Conclusions

This chapter has attempted to provide material and methods used for data analysis. The way in which data has been analysed is also presented in this chapter. Furthermore, the chapter has provided a brief presentation of the case study site on the basis of bio-physical aspects, land, infrastructure and social and institutional aspects.

Chapter four: Results and Discussions

4.1 Introduction

This chapter presents and discusses the results on water productivity and value on a case study basis in Zanyokwe and Thabina scheme. The first section briefly outlines the basic assumptions and economic terminologies used in the analysis. The results on water productivity at both crop and farmer type level are presented and discussed in section two. Water values (calculated from the farmers' willingness to pay), and the costs of supply (accounting the O&M costs) are presented and discussed in section three. The investigation of explanatory factors related to 'gross margin of output' and 'willingness to pay' are then presented in section four. Analysis of implications of findings, especially in terms of water charges and inter-sectoral competition is made in section five, followed by summary of the chapter in section six.

4.2 Basic assumptions and economic terminologies used in the analysis

In computing water productivity and values, the following assumptions and terminologies were used:

- Total revenue TR = Product price * output (average yield). Thus, gross margin of output GM = TR minus Variable costs VC (or production costs).
- GM differs from economic returns for it does not consider implicit costs such as the opportunity costs associated with employing the resources in their current use rather than using these resources in their next best alternative (meaning that some income is forgone). Thus, TR and GM apply at crop level, but also at farm and scheme level through simple amalgamation of crops (Perret et al., 2003).
- In smallholder irrigation context, GM should not be seen as net income gained at farm level, since it does not take account of further external factors or charges possibly shouldered by farmers such as taxes, interest rates, depreciation, capital costs, and so on. Thus, for the purpose of this study water productivity has been evaluated in terms of GM of output per volume of irrigation water consumed (assuming that actual water consumption is known).
- It must be highlighted that a better measure of capital cost, labour, land, and the like, would have been the optimised rate of net irrigation (which maximizes output) obtained from yield response. But due to inadequacies of the data, it was not possible to follow the optimisation approach.
- Also, it should be noted that the residual valuation method used is based on the premise that the residual value obtained as total revenue minus total production cost, excluding the compensation for capital assets and management, is totally attributed to irrigation water.

4.3 Water productivity

4.3.1 The residual return to water

Table 1 provides some of the data at crop level, which can be used to evaluate the return to water (Rand per m^3) out of the gross margin gained when all the variable costs are deducted. As indicated earlier, the residual return to water has been derived from crop output with irrigation and those with rain-fed, over the entire production cycle. Dry maize, which is one of the major and most commonly practised crops, has been chosen for the analysis. The total revenue with irrigation is estimated at R6 370 per hectare, while the one with rain-fed is estimated as R5 460 per hectare. Thus, irrigation enables the farmer to increase the total revenue by R910 per hectare when high-yield dry maize is grown per year. However, the cost of inputs including the cost of fertilisers, pesticides, seeds, labour, equipment, water, and marketing costs, account for R4 569.39 per hectare. This leaves only R1 573.32 per hectare as the residual gross margin of water.

Table 1. Estimates of the residual return to irrigation water (Rand per m^3) in Zanyokwe scheme (Source: author's work; Ntsonto raw data)

	Grain maize*			Potatoes*			Butternuts*		
	Irrigated	Rain-fed	Δ	Irrigated	Rain-fed	Δ	Irrigated	Rain-fed	Δ
Total revenue (Rand per ha)	6 370.00	5 460.00	910.00	1 1985	3 630.34	8 354.66	11 655	3 495.00	8 160
Production costs (Rand per ha)	4 569.39	5 232.71	-663.32	9 630.34	3 360.00	6 270.34	8 145	3 374.76	4 770.24
Gross margin (Rand per ha)	1 800.61	227.29	1 573.32	2 354.66	270.34	2 084.32	3510	120.24	3 389.76
Irrigation water used (m^3 per ha)**	5 150	0	5 150	5 670	0	5 670	4 700	0	4 700
Return to water (Rand per m^3)	0.31			0.37			0.72		

Δ= *Change in output. All figures are expressed as per ha. All figures are average obtained from both rain-fed and irrigated (data collected in summer and winter of 2002 – 2003 excepted**from SAPWAT). *Summer high yield crop types*.

In view of the low rainfall in the semi-arid region of Eastern Cape, and the high evapotransportation needs of crops, the estimated irrigation water requirements for maize is 515 mm (Source: SAPWAT, 1999). This is equivalent to 5 150 m^3 of water diverted for maize per hectare. Thus, the return to water for dry maize in Zanyokwe has been calculated as R0.31 m^3 (R1 573.32 / 5 150 m^3 used). With similar method, the return to water (Rand per m^3) of potatoes has been calculated at R0.37 per m^3 and butternut R0.72 per m^3 of water used.

Interestingly, the picture that emerges out of these results is a higher proportion of the return to water out of the gross margin of all production inputs. The proportion percentage of the return to water for dry maize is estimated as high as 87 percent, potatoes 89 percent and butternut 97 percent, somewhat higher than might have been expected. Such results can be explained by the very arid conditions of the scheme, which make irrigation a crucial input of production. Another, picture that can be seen in the results is the higher production cost of dry maize in rain-fed conditions. The high production costs seen in maize under rain-fed can be attributed to the fact that the collated data in SIS was directly from farmers themselves, not from farm records, hence over-estimation of inputs might have occurred. To solve such problem in future, it is important that crop output, hence inputs costs should be calculated as standard deviation.

The pitfall of such analysis is that it is based on one-year data, hence may not be accurate. Another limitation of such analysis is that certain elements remain dubious e.g. high production costs seen in maize under rain-fed conditions. Thus, further investigation may require data compiled from more than one year, but such still may yield a direct estimate of non-irrigation benefits, which presents the main requirement for further research.

4.3.2 Water productivity of crops under irrigation

The evaluation of water productivity has also been undertaken based only on crops under irrigation. As mentioned in the preceding chapter, some of the major crops do not have data on rain-fed conditions. Thus, water productivity has been computed by subtracting variable costs from total revenue and then dividing the residual gross margin by the quantity of water (m^3) used. It must be underlined however, that the previous results show that residual return to water forms large proportion of gross margin under irrigation in semi-arid conditions. For the sake of this study, Thabina scheme has been introduced to compare various water productivity at scheme level. Table 2 sums up the results of water productivity for the various crops investigated in Zanyokwe and Thabina scheme.

According to the results, cabbage produces higher gross margin per m^3 than the dry-maize if intensive irrigated crop type is grown per year across the two schemes. Although, the gross margin per m^3 in cabbage in general is higher across the two schemes, these figures are not comparable as the irrigation systems used are different (Dragline sprinkler vs. Gravity-based system). However, for comparisons of crops inside the schemes, in Zanyokwe, dry maize and potatoes show the lowest gross margin per m^3 of water used as compared to cabbage and butternuts which indicate higher gross margin per m^3, when high yield irrigated crops are grown. Also, in Thabina schemes, cabbage, and tomatoes outperform dry-maize. This implies that there is a greater potential in vegetable crops farming than food grain crops.

Table 2. Summary of irrigation water productivity for the various crops in Zanyokwe and Thabina scheme (Source: author's work; Ntsonto raw data; Lavigne and Stirer, 2003)

	Zanyokwe			Thabina		
	GM (Rand per ha)	Water consumption (m^3 per ha)**	GM per m^3	GM (Rand per ha)	Water consumption (m^3 per ha)**	GM per m^3
Dry maize-High yield*	1 800.61	5 150	0.35	1 162.80	5 840	0.20
Tomatoes-Intensive	-	-	-	8 455.00	3 910	2.16
Cabbage-Intensive	5 155.37	3 140	1.64	4 208.00	3 700	1.14
Dry maize-Low yield*	211.14	5 150	0.04	-374.40	5 840	0
Tomatoes-Extensive	-	-	-	1 957.00	3 910	0.50
Cabbage-Extensive	409.44	4 610	0.09	3 377.00	3 700	0.91
Butternut – High yield	3 510.00	4 700	0.75	-	-	-
Butternut– Low yield	101.43	4 300	0.02	-	-	-

*Data collected in summer and winter 2002-2003. All figures are averages obtained from different farmers (except ** from SAPWAT). * Summer crops.*

As expected, higher gross margin, hence higher water productivity in general is more likely to be attained in irrigated crops using sprinkler system as compared to gravity-based system, which has higher water losses through evaporation and un-lined channels. However, it is important to emphasis that the measure of water productivity is of little value in comparing the two schemes, as high gross margin may not necessarily mean high economic returns when especially capital costs and opportunity costs are not taken into account.

As far as low yield and extensive cropping systems are concerned, in general the results indicate very low gross margin per ha, hence low irrigation water productivity (or gross margin per m^3). This signifies that in future, those farmers growing low yield crop types should move to high yield cropping systems. As presented in previous section, the pitfall with this analysis is that it's based on one season data.

4.3.3 Irrigation water productivity at farm level

The productivity of water at farm level has also been computed for Zanyokwe and Thabina scheme. The idea is to reflect the diversity and situations that exist inside these schemes. For the purpose of this study, the most common crop types representing the current farming systems in Zanyokwe and Thabina, in coherence with the farmer types are provided in table 3, and the details of which are presented in appendix C. It is important to highlight that the figures used here were annualised average gross margin per farm based on total revenue from combined crops and production costs of inputs for summer and winter of 2002-2003.

As indicated in chapter three, it is worth mentioning that all the figures used were captured in the Smile database and simulation platform (Perret, 2002b; Perret et al., 2003). In the current situation, and assuming that the figures captured into Smile reflect the reality, the following results were obtained from the two case study schemes.

In Zanyokwe scheme, the total annual farming revenue is R2 497 511.50, although the gross margin at farmer level just amounts R642 924.28. According to Perret et al. (2003) such difference represents all the variable costs relating to services as provided by the surrounding agri-business and labour sectors, i.e. inputs purchased, mechanization contracts, labour hired). Also, such difference can be ascribed to lack of proper marketing channels, and low price. The average farmer annual gross margin per ha is R1 524.56 (which indeed is very low as compared to what the old-age pensioners and the normal labourers in other sectors are getting per annum). The average gross margin per farm per year is estimated at R8 481.78, whereas the irrigation water consumption per farm is 22 945 m^3 per year. Thus, the irrigation water productivity at scheme level is calculated as R0.37 per m^3.

The total annual water consumption including losses amounts to 1 739 255 m^3. The current costs incurred by O&M are about R146 097.42 (i.e. accounting the costs of irrigation). In other words, the supply of 1 m^3 costs R0.084 per m^3. For comparison sake, if irrigation charges are levied so as to covered O&M costs of irrigation scheme, these charges will form (about 23 percent) proportion of scheme's gross margin (R0.37 per m^3 used) from irrigation water. However, if the farmers have to pay O&M costs plus annualised capital costs (which are not accounted for here) as irrigation charges, the charges can be much higher than the gross margin per m^3 gained by using irrigation.

In Thabina scheme, the annual farming revenue is R191 634 while the gross margin at farmer level just amounts R73 930. The farmer annual gross margin per ha averages R675, which also is comparatively low. The gross margin per farm averages R1 080. This implies that Thabina scheme valued water at R0.11 per m^3. The total annual water demand including losses amounts 668 147 m^3. The cost of supply has been estimated at R0.062 per m^3. Again, if irrigation charges are levied so as to cover the O&M costs, these charges will form more than a half (56 percent) of what is earned at scheme level. Meaning that smallholder farmers, whose consumption of crop products depends on their own output, will be adversely affected since they will have to produce more per units of land and water used, probably through increased use of inputs and acquisition of skills.

Table 3 sums up the results on the current situation, at farmer type level in both Thabina and Zanyokwe. In Thabina scheme, the results indicate that, irrigation water valuation by farmers is very low, because gross margin of output gained is very low. The subsistence farmers valued water at R0.01 per m^3; full-time commercial farmers R0.34 per m^3; while commercial pensioners at least valued water

Table 3. Estimating the productivity of water across the two case study schemes (source: authors data; Ntsonto raw data; Perret et al., 2003; Lavigne and Stirer, 2003)

	Thabina					Zanyokwe				
Farmer type	Cropped area (ha)	GM per ha	GM per farm	W_C (m^3 per farm)	GM per m^3	Cropped area (ha)	GM per ha	GM per farm	W_C (m^3 per farm)	GM per m^3
Subsistence Farmers	0.67	56	37	6 884	0.01	-	-	-	-	-
Specialized Farmers	0.54	-443	-239	5 904	0	1.40	2 932	4 105	4 235.86	0.69
Pensioners - commercial farmers	0.45	3 092	1 391	2 611	0.53	-	-	-	-	-
Transition Farmers	-	-	-	-	-	6.60	1 772	11 695	5 556.83	0.32
Full-time Commercial	0.5	2 379	1 189	3 467	0.34	9.00	2 146	19 314	4 917.17	0.44
Dry-land plot users	-	-	-	-	-	-	-368	0	0	0

W_c = Water consumption in m^3 per farm.

R0.53 per m^3. As compare to Thabina, in Zanyokwe scheme, the valuation of water, hence GM of output is quite higher. The specialised oriented farmers make R0.69 per m^3; transition oriented farmers make R0.32 per m^3, while full-time commercial farmers R0.44 per m^3. Again, such difference reflects the fact that both schemes have different water consumption. Interestingly, in these results, there is no subsistence farmers' observed in Zanyokwe scheme, meaning that the current participating farmers are more market oriented.

4.3.4 Farmers willingness to pay (WTP) and the costs of supply (CS)

Also water values have been computed from what the farmers are willing to pay for a unit of water. Table 4 summarises the results for GM, WTP (i.e. actual contribution a farmer can offer), and the costs of supply (i.e. accounting costs of O&M at least in Zanyokwe and Thabina).

The results indicate that in Zanyokwe scheme, the specialised farmers are ready to pay amount of R0.03 per m^3 of water used; transition farmers show that they are willing to pay R0.02 per m^3; whereas, full-time commercial farmers are willing to make R0.01 per m^3 used. Looking at these results, the most active and willing farmers' type here is the specialised oriented farmers who are willing to pay at least 3 cent per m^3 used. For comparison sake, if farmers are to pay in order to cover the O&M costs; these costs will be almost three times what they are willing to pay per a unit of water used. But interestingly, if the O&M costs are to be covered through the gross margin per m^3 used, these costs can only form a small proportion. For instance, for the specialised farmers these costs will form only a small proportion (12 percent) of the gross margin of output per m^3 used. Such results indicated that in Zanyokwe scheme farmers do not really make a direct link between the water they used (volume) and the money they gained from farming. In other words, farmers have not idea of how much water they use. Again, in Zanyokwe scheme, if we compare WTP (Rand per m^3), the gross margin of output (Rand per m^3) and the accounting cost per m^3 of water used, the results indicated that both the accounting cost and the willingness to pay are lower than GM per m^3 of water used. Even though the data are qualified as a sample for one year only, this finding on perception of farmers has implications for extension and training to improve productive use in future.

In Thabina scheme, the situation seems different. According to the results, subsistence farmers indicated that they are willing to incurred R0.02 per m^3 for the costs of supply. Specialized oriented farmers indicated R0.03 per m^3. Pensioners' commercial farmers are willing to pay R0.19 per m^3, whereas, full-time commercial farmers are willing to incurred R0.03 per m^3. As can be seen in the results, the most active and willing farmers in these groups are the pensioner-commercial oriented ones. Thus, again, if farmers are to pay for the costs of supply (O&M costs), these costs will be about 44 percent proportion of what the pensioner commercial farmers are willing to pay. Again, if we compared the WTP (Rand per m^3) and the gross margin of output (Rand per m^3) gain from irrigation water, the results indicated that farmers do value water as important input (e.g. the WTP is higher in Thabina than in Zanyokwe). Because, their willingness to pay per m^3 can form about 63% proportion of the gross margin of the output (R0.30 per m^3) gained from irrigation water.

Table 4. Comparison between gross margin per farming system and willingness to pay (source: author's data; Ntsonto raw data; and Lavigne and Stirer, 2003)

Farmers' types	Zanyokwe			Thabina		
	GM per m^3	WTP Rand per m^3	Acc. Costs of O&M (Rand per m^3)	GM per m^3	WTP Rand per m^3	Acc. Costs of O&M (Rand per m^3)
Subsistence farmers	-	-	0.084	0.01	0.02	0.062
Specialized farmers	0.69	0.03		0	0.03	
Pensioners -commercial farmers	-	-		0.30	0.19	
Transition farmers	0.32	0.02		-	-	
Full-time commercial	0.44	0.01		0.29	0.03	
Dry-land plot users	0	0		0	0	

Acc. = Accounting costs of operation and maintenance (figures obtained electricity bills from Eskom and salaries e.g. Thabina).

4.4 Investigation of factors of production related to GM and WTP

This section has attempted to make estimates of quantitative relationships between output and some key factors of production for the two case study schemes. The idea is to see the response of output to various factors of production. The results are obtained from estimating a cross-section regression model. The dependent variables were "gross margin of output per m^3" and the "willingness to pay per m^3" of water used. While, the explanatory variables used to explain gross margin are land size, livelihood strategies (in terms of access to off-farm income), credit, gender, labour and production costs. The ones to determine WTP are land size, livelihood strategies, credit, gender, labour, and GM per m^3. The results are then estimated using the following mathematical representation (Saito, 1994):

$Y = f(X_1, X_2, X_3, X_4, ...X_n)$

Where Y = log of value of output (in this case GM and WTP);

X_1 = log of land;

X_2 = log of labour;

X_4 = log of credit

X_n = log of water used in the production process.

It is assumed here that the equation will specify the average magnitude of the expected change in output given a change in explanatory variables (X_1, $X_2....X_n$). There would be a non-linear relationship between input and outputs variables. It is important to note that the variables are estimated at 5 percent level of significant. Also it is worth mentioning that the production costs used here entail cost of seeds, fertilizers, pesticides, equipment, water, and marketing cost.

4.4.1 The impact of the factors of production on GM per m^3 of irrigation water used

Table 5 recaps the results obtained by regression model. In Zanyokwe scheme, the coefficient of multiple determinations adjusted for degree of freedom (adjusted R^2) indicates that only 74 percent of the variation in the farm gross margin per m^3 used is associated with the factors of production specified in the model. The results show that, among the six estimated explanatory variables in the regression equation, only credit affects output positively and significantly. Also, production costs have indicated significant effect on output, but with a negative correlation. All the other variables including livelihood strategy do not affect output significantly. Hired labour also shows a negative and insignificant effect on output, such is to be expected anyway, given that family members working on a plot are more likely to be knowledgeable about their farming operations than hired labour (Yokwe, 2002).

As can be seen in the results the estimated elasticities are as follows: credit (0.461), and production costs is (-0.242). Given these elasticities, a 5 percent increase in credit results in about 5 percent increase in the gross margin of output per m^3 used, whereas a 5 percent increase in production costs results to about 3 percent decrease in gross margin of output, which again is amazing, unless farmers are already over-using production input (e.g. fertilisers) and that more application become harmful to crops (law of diminishing return applies).

In Thabina scheme, the adjusted R^2 indicates that 85 percent of the variation in farm gross margin of output per m^3 is associated with the factors of production specified in the model. The results show that the most important inputs variables in the model are the cultivated land size and production costs. These two variables influence output positively and significantly. However credit, including livelihood do not affect output significantly. As indicated already, production costs impact can be explained quite straight forward. It is a bit trickier about land size which probably reflect more on a commercial and production orientation by the farmers, given the fact that when farmers are commercial oriented, they manage to get more land and intensify it, hence, increased GM of output per m^3 used.

Table 5. Estimating the cross-section regression model for the two schemes (Dependent variable: Gross margin per m^3 (Source: author's work; Ntsonto raw data)

Explanatory parameters	Zanyokwe		Thabina	
	Coefficient	T-statistics	Coefficient	T-statistics
Land size (ha)	0.166	0.895	0.457	2.968*
Farmers livelihood strategies (0-1)	0.106	0.543	-0.022	-0.160
Credit (0-1)	0.461	3.110*	0.001	0.005
Gender (0-1)	-0.145	-0.843	-0.054	-0.352
Labour (0-1)	0.095	0.520	-0.051	-0.373
Production costs (Rand per m^3)	-0.242	-2.720*	0.274	2.049*
Constant	1.201		3.653	
Adjusted R^2	0.74		0.852	
Number of observation	52		52	

*Significant at 5-percentage level. Dummy variables are gender (0=female and 1=male); labour (0=family labour and 1=hired labour); credit (0=farmer without access to credit, 1 = farmers with access to credit); Livelihood strategies (0= farmers without income, 1 = farmers with income).

4.4.2 The impact of factors of production on WTP per m^3 of irrigation water used

Table 6 summarises the results, which can be used to explain the farmers' willingness to pay per a unit of water used. In Zanyokwe scheme, the adjusted R^2 indicates that 62 percent of the variation in willingness to pay at farm level is associated with factors of production specified in the model. It is striking that in all the investigated factors, only credit affects WTP positively and significantly. All other factors are insignificant. Also, GM of output per m^3, unexpectedly, has displayed a negative and insignificant effect on WTP. The estimated elasticity of credit is (0.341), meaning that a 5 percent increase in credit results in 3 percent increase in WTP.

In Thabina scheme, adjusted R^2 indicated that 73 percent of the variation in farm level (WTP per m^3 used) is associated with the factor of production specified in the model. The results show that land size per hectare, and gross margin of output per m^3 of water used, affect WTP positively and significantly. Such results are consistent with the assumptions made in the conceptual framework that a farmer with high gross margin gained at farm level is more likely to pay for water costs than those with poor gross margin.

Again, land size refers to commercial orientation of farmers in Thabina scheme. Thus, GM of output per m^3 obviously reflects successful farming in the scheme. Such results clearly indicate that farmers in Thabina make a link between water use and successful commercial farming.

Table 6. Estimating the cross-section regression model for the two case study schemes (Dependent variable: WTP per m^3 (Source: author's data; Ntsonto raw data)

Explanatory variables	Zanyokwe		Thabina	
	Coefficient	T-statistics	Coefficient	T-statistics
Land size (ha)	0.082	580	0.592	4.342*
Farmers livelihood strategies (0-1)	-0.091	-0.609	-0.047	-0.400
Credit (0-1)	0.341	2.003*	-0.119	-0.952
Gender (0-1)	0.076	0.538	-0.133	-1.028
Labour (0-1)	0.021	0.104	0.025	0.218
GM of output per m^3	-0.097	-0.692	0.207	2.104*
Constant	1.488		1.489	
Adjusted R^2	0.62		0.73	
Number of observation	53		52	

**Significant at 5-percentage level. Dummy variables are gender (0=female and 1=male); labour (0=family labour and 1=hired labour); credit (0=farmer without access to credit, 1 = farmers with access to credit); Livelihood strategies (0= farmers without income, 1 = farmers with income).*

4.5 Implications of findings especially in terms of water charges and inter-sectoral competition

4.5.1 Water charges and cost recovery

The results of this study can be used in various ways. Among others, the results can be used to evaluate whether the costs estimated and the GM per m^3 gained from irrigation water, are in line with the farmers' willingness to pay per m^3 used. For example, in Thabina scheme, the O&M costs are calculated at R0.062 per m^3 used. The active farmers are willingness to incur R0.19 per m^3. Whereas, the gross margin gained per unit of water used is R0.30. This indicates a direct link between the irrigation water they use (volume) and the GM per m^3 used. However, in Zanyokwe scheme, the willingness to pay by the active farmers is very low (R0.03 per m^3 used) as compared to what they get back from the farm (R0.69 per m^3). This indicates that farmers in Zanyokwe do not really make a direct link between the water they use and the GM gained from irrigating. For example, they get higher gross margin, but incur very low WTP per unit of water used. Thus, if farmers are to pay charges in order to cover O&M costs, this means that they will have to produce more per units of land and water used, probably through intensifying farming (increased use of inputs) and acquisition of skills.

4.5.2 Inter-sectoral water rights transfer

Above all, the results highlight the risks of massive transfer from SIS who value water at low levels towards higher water productivity and willingness to pay sectors (e.g. mines and domestic). These results clearly indicated the difference in economic power between the smallholder and those sectors with water productivity and higher willingness to pay. Inter-sectoral competition if left to uncontrolled market forces may result in smallholder farmers' selling their water rights to sectors which value water at higher levels. To avoid a “liberal trap” such as in the example of Chile (where smallholder farmers "en masse" sold their water rights, resulting ultimately in deeper rural poverty), some forms of economic control or regulatory policy, at catchment management agencies (CMA) level, as alternatives towards a more balanced allocation of water.

4.6 Conclusion

The results in this chapter highlight a few general conclusions. Firstly, the findings strongly indicated that the estimated water value in smallholder irrigation schemes varies according to methods, crop, farmers, and scheme. The estimated water value by the residual valuation method showed that there is a very small difference between the ‘return to water’ and the ‘gross margin of output’ of all the production inputs. An estimated proportion of the return to water for maize in Zanyokwe is as high as 87 percent, potatoes 89 percent and butternut 97 percent, such figures are somewhat higher than might have been expected. This can be explained by the very arid conditions of the scheme, which make irrigation a crucial input to production.

Secondly, the water values estimated by residual valuation method (with only data from irrigation) indicated that water value in dry maize is far below the value estimated for cabbage and tomatoes, when high or intensive crop types are grown per year. For example, the average water value for maize estimated in Zanyokwe is R0.35 per m^3 and in Thabina is about R0.20 per m^3, as compared to Cabbage which has exhibited high water value (R1.64 per m^3) and (R1.14 per m^3) respectively. Although, maize being a key crop in terms of food supply to households, it does not value water very well, as compared to vegetable crops.

Thirdly, at farmer level, the results clearly show that the active farmers in the Zanyokwe scheme have lower WTP per m^3 (R0.03) than the GM of output (R0.69) per m^3 of water used. Also, the accounting cost (R0.084 per m^3 of water used) is lower than the GM gained. However, in the Thabina scheme, the situation is quite different. The active farmers are willing to pay R0.19 per m^3 of water used. This implies that, if farmers are to pay for the charges in order to cover O&M costs, the farmers in Thabina are ready to pay as much as three times the proposed costs of O&M (R0.062 per m^3 of water used), although both the WTP and the accounting cost are lower than GM gained. In these results, it is significant that both the accounting cost and the willingness to pay are lower than the GM per m^3 of water used at least in the Zanyokwe scheme. Even though the data were drawn from a sample for one year only, this finding on the perception of farmers has implications for extension and training to improve future productive use.

Chapter five: Summary of findings, conclusions, limitations and recommendations for further research

5.1 Introduction and objectives

For many years, South African smallholder irrigation schemes have been struggling and are said to be inactive. The major problems are infrastructure deficiencies emanating from inappropriate planning and design, poor operational and management structure, inappropriate land tenure arrangements and lack of technical know-how and ability of extension officers. In finding ways to mitigate these problems, smallholder farmers in irrigation are now exposed to irrigation management transfer (IMT), which includes institutional changes and a cost recovery principle. This supposes that irrigation water will be priced, and farmers will have to pay for the cost of water supply and its related services, by water users' associations. It becomes important to have an idea of the value that is given to water through a number of approaches and methodologies.

The overall objective of this study is to investigate the productivity and value of irrigation water in smallholder irrigation contexts in South Africa, on a case study basis. The specific objectives are (i) to investigate and compare various methods for evaluating water productivity, and identify the most relevant; (ii) to assess water productivity by crop, farming systems and at scheme level, and compare such figures or values with supply costs and willingness to pay; (iii) to analyse discrepancies and introduce some analytical tools in order to investigate factors influencing irrigation water productivity; and (iv) to evaluate the implications of the findings, especially in terms of water charges and inter-sectoral competition. A summary of the achievements that were realised through the specified objectives as well as the conclusions and recommendations for further research are presented below.

5.2 Summary of findings

5.2.1 Methods of analysis

Theoretically, the value of water for irrigated agriculture can be estimated from the area under the water demand curve. In practice, this can be operationalized in various ways, depending upon data availability and other constraints. In a smallholder irrigation context, major problems are the lack of records at farm level, and the lack of actual water consumption measurement. This therefore necessitated a review of existing techniques used to estimate the value of water in irrigation in order to choose those most compatible for use in smallholder irrigation context. On a case study basis, three methods were then chosen: the residual valuation method (RVM), willingness to pay (WTP) and cost-based approaches (CBA). Also, Smile database and simulated platform was used to calculate a number of indicators, economic figures, at scheme and individual farm level. It must be emphasised that RVM first starts from crop budgets, but also can be amalgamated at crop, farm and scheme level. WTP refers to a farmer's point of view (i.e. at farm level) and CBA refers to the whole scheme, since we rely only on O&M costs incurred by scheme management.

5.2.2 Estimated water productivity and values

On average, the values of water vary according to methods and levels of analysis. At crop level, in the Zanyokwe, water value estimated by the residual valuation method is higher for cabbage (R1.64 per m^3) as compared to the dry-maize which valued water at the lowest level (R0.35 per m^3), if high yield or intensive irrigated crops are grown per year. Also, in Thabina, water value for cabbage (R1.14 per m^3) outperforms water value for dry maize (R0.02 per m^3). This means that there is greater potential in vegetable crops than grain maize, although the two schemes have different irrigation systems. As far as low yield and extensive cropping systems are concerned, in general the results indicate very low water valuation, because gross margin of output gained per hectare is very low. This signifies the need for expansion of high value crop system, to replace low value crop.

At farm level, in the Zanyokwe scheme, the results indicated that it costs R0.084 to supply 1 m^3 of water at plot or farm level. If irrigation costs are to be paid so as to cover O&M costs of the irrigation scheme, these costs will form a proportion (about 23 percent) of scheme's gross margin (R0.37 per m^3 of water used). By contrast, in Thabina scheme, the O&M costs (R0.062 per m^3) can form about 56 percent of what is earned (i.e. R0.11 of gross margin per m^3 of water used) at scheme level. This means that smallholder farmers, whose consumption of crop products depends on their own output, will be adversely affected since they will have to produce more crops per units of land and water used, probably through increased use of inputs and acquisition of skills.

As far as WTP and cost-based approach are concerned, one important finding is the relative value of water productivity obtained from the comparison made between gross margin (GM) per m^3 of water, willingness to pay per m^3 and accounting cost per m^3 of water used. It is significant that the accounting costs are lower than the GM per m^3 of water used, but that the willingness to pay is also lower, at least at the Zanyokwe scheme. Even though the data used are from a sample for one year only, this finding on the perception of farmers has implications for extension and training to improve future productive use.

Regarding the findings from cross-section regression analysis, in general the results indicated that in the Zanyokwe scheme, only credit affects GM (per m^3 of water used) positively and significantly. Also, production cost has indicated significant effect on GM per m^3 of water, but with negative correlation. In Thabina however, the most important factors of production in the model are the land size (hectare) and production costs (Rand per ha). These two variables influence GM per m^3 of water positively and significantly. However credit, including livelihood does not affect output significantly. As indicated already, the impact of production costs can be quite easily explained, but that of land size is a bit trickier. This depends more on a commercial and production orientation by the farmers, given the fact that when farmers are commercially oriented, they manage to get more land and intensify it, hence, increased GM of output per m^3 used.

As far as WTP (as dependent variable) is concerned, the results indicated that in the Zanyokwe scheme, it is striking that in all the investigated factors, only credit affects WTP per m^3 of water positively and significantly. All other factors are insignificant. Also, GM of output per m^3 (as explanatory variable here) unexpectedly has displayed a negative and insignificant effect on WTP. In the Thabina scheme, the results show that the land size per hectare, and gross margin of output per m^3 of water used, affects WTP positively and significantly. Such results are expected, given the fact that farmers with high gross income gained at farm level are more likely to pay for water costs than those with poor gross margin.

However, it is worth noting that the water values estimated in this study are site specific and indicate the efficiency of water use more than the scarcity of water per se.

5.3 Conclusions and recommendations

Against the above findings, it is important that conclusions are delineated based on the three formulated hypothesis about the productivity and value of water in smallholder irrigation sector.

- The first hypothesis is that there are a number of methodologies and approaches to assess water value and productivity, yet few of them are applicable to smallholder developing irrigation. In this study, eight different methods used to estimate water value and productivity were thoroughly reviewed on the basis of the current features and constraints attached to SIS. The findings revealed that most of the methodologies are not compatible to use in smallholder irrigation sector. On a case study basis, the residual valuation method, willingness to pay, and cost-based approaches were chosen to use in SIS.
- The second formulated hypothesis is that there is variation in water productivity and value, between evaluation methods, crops, farmers, and schemes. The study has supported this hypothesis. The

results indicated that the value of water varies according to methods, crops, farmers and schemes. At crop level, the value of water in dry maize (the most commonly grown crop) estimated by RVM is very low in both Zanyokwe and Thabina, as compared to cabbage and tomatoes, which display high water values, when high yield or intensive crops are grow per year. However, low water valuation, hence low gross margin of output is attained when low yield or extensive crops are grown per year. At farmer and scheme level, the results also show that the value of water varies according to farmer type and scheme. For example, in the Zanyokwe scheme, the most active farmers (specialized farmer) values water at R0.69 per m^3 of water used, whereas in Thabina the active farmers (Pensioners-commercial) can achieve water productivity at R0.53 of gross margin per m^3 of water used.

- The third hypothesis is that there is a series of socio-economic factors, including livelihood strategies influencing water gross margin per m^3 and WTP for cost of water supply. In respect to gross margin of output (as dependent variable), the findings indicated that land and production costs are the only variables that have recorded a positive and significant effect to output in the Thabina scheme. Also, for the willingness to pay (as output variable), gross margin per m^3 (as input variable) has indicated positive and significant effect to the farmer's willingness to pay for water supply in Thabina. In the Zanyokwe scheme, only credit and production costs influence output positively and significantly, although production cost has indicated a negative correlation. Thus, the findings of this study support the third hypothesis.

All in all, these results indicate that to some extent, the more commercial farmers are, the more willing to pay they would be. In the context of current water scarcity, strategies to increase water productivity are required. The paragraph below provides specific strategies that may enhance smallholder water productivity.

An improved farming practice is the key to mitigating the problem of both farm GM and water productivity. This is especially important in the context of water scarcity. Specific policies that lead to better farming practices should include promotion of high value crops and improved varieties of crop seeds (e.g. maize and cabbage). While improved agronomic practices remain important, there is also potential to increase productivity and profitability of the crops by improving water management practices at the canal-system level, which may include better timing of water delivery and increased overall canal-water supplies at the farm level. Furthermore, smallholder irrigation farmers should be supported with access to markets, because it is useless to promote a shift away from low yield if markets are not in place for high yield crops.

With regard to costs recovery, the current policy for financing irrigation development is that it occurs with minimum government subsidy. All the operational and maintenance costs are to be borne by the farming beneficiaries of irrigation schemes, especially when DWAF subsidy is phased out after 5-years. Besides getting this right, the government should develop a program of cost sharing for capital costs of irrigation development. In developing this program, consideration would be given to matching grants, in-kind contributions from the beneficiaries, cost sharing for materials, equipment and labour. Also, in developing the cost-sharing program, the farmer’s ability to pay would be taken into consideration. Furthermore, emphasis would be placed on the willingness of farmers to organize themselves and be ready to take full responsibility for the operation and maintenance of the water works right from the dam to the canal level.

5.4 Limitations and recommendations for further research

- This study highlights the need to improve water productivity in the smallholder irrigation context, but still more physical data are needed particularly on actual water consumption at the study sites and sufficient data on capital and maintenance. For instance Zanyokwe’s data are of poor quality and are based on one-year only; further study with a longer time frame is required.
- In order to properly assess the residual return of irrigation water, there is a need for some form of monitoring of GM/crop budgets over longer periods and also of rain-fed crops under similar conditions and over several years.
- Very few farmers appear to be economically efficient and so policy needs to take greater account of the wide variation in opportunities and constraints facing different smallholder farmers. Further studies are needed in this area.
- Efficient techniques that provide potential for investigation on water productivity in the smallholder irrigation sector need to be developed, taking into consideration variables such as labour, energy, water and time efficiency.

References

ABERNETHY, C.L., SALLY, H., LONSWAY, K. AND MAMAN, C. (2000). Farmer-based financial or operations in the Niger Valley irrigation schemes. *Research report no. 37, International water management institute,* Colombo, Sri Lanka.

ALLAN, J.A (1998). Productive efficiency and Allocative efficiency: Why better water management may not solve the problem. In *Agricultural Water Management,* No. 1425; 1-5.

ARMITAGE, R.M. (1999). An economic analysis of surface irrigation water rights transfers in selected areas of South Africa. *Water Research Commission, report no. 870/11/99*, Pretoria, South Africa.

BACKEBERG, G.R., AND GROENEWALD, J.A. (1995). *Lessons from the economic history of irrigation development for smallholder settlement in South Africa.* Agrekon, 34 (4) 160-171.

BACKEBERG, G.R. (1996). Policy proposal for irrigated agriculture in South Africa. Discussion paper. *Water Research Commission, report no. KV96/96*, Pretoria.

BACKEBERG, G.R. (1997). *Water Institutions, Markets and Decentralized Resource Management: Prospected for Innovative Policy Reforms in Irrigated Agriculture.* Presidential Address, 35th Annual Conference of the Agricultural Economics Association of South Africa, Osner Conference Centre, East London.

BEMBRIDGE, T. J. (1986). Irrigation development in some African countries. *Journal of contemporary African Studies 3* (½): 102-103.

BEMBRIDGE, T.J. (1996). Small-scale farmer irrigation schemes in South Africa. Appendix to Backeberg et al. 1996. Policy proposal for irrigated agriculture in South Africa, 1996. *Water Research Commission,* Pretoria.

BRISCOE, J. (1996). *Water as an economic good: The idea and what it means in practice.* International Commission on Irrigation and drainage, Special Congress, Special Session R. 11, Cairo, 1996.

CROSBY, C.T., DE LANGE, M., STIMIE, C.M. AND VAN DER STOEP, I. (2000). A review of planning and design procedures applicable to small-scale farmer irrigation projects. Report no. 578/2/00, *Water Research commission,* Pretoria.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (2002, 2003). Document of the department's water charging strategy, (website: www.dwaf.gov.za).

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (1999a). A pricing strategy for raw water charges. *Government Gazette no*. 1353. Pretoria

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (1999b). *National water Act news* (information pamphlets on the principles and implementation of the new Water Act (http:www-dwaf.pwv.gov.za).

DINWIDDY, C. AND TEAL, F. (1996). Principles of Cost-Benefit Analysis in developing countries. Cambridge University press.

DIXON, J.A. SCURA, L.F., CARPENTER, R.A, SHERMAN, P.B. (1994). *Economic analysis of environmental impacts*. Second edition. London: Earthscan Publications Ltd.

DOMNEN, E. (1993). The four principles of environmental policy and sustainable development: an overview, in *fair principles of sustainable development: Essays on environmental policy in developing countries,* E. Dommen (ed.), Edward Edgar press, England.

DOSI, C. AND EASTER, K.W. (2000). *Water scarcity: economic approaches to improving management.* International For and Agricultural policy, WP00-2, St. Paul.

FAO (1997). Assessment of the socio-economic impact of smallholder irrigation development on smallholder farmers in Zimbabwe: A report prepared by R. Dhlodhlo for FAO.

FAO (2003). Unlocking the Water Potential of Agriculture. Rome: Food and Agriculture Organization of the United Nations (ftp://ftp.fao.org/agl/aglw/docs/unlocking_e.pdf.)

FAROLFI, S. AND PERRET, S. (2001). *Inter-sectoral competition for water allocation in rural South Africa: Analysing a case study through a standard environmental economies approach.* In: XXXIX Convegno SIDEA, Firenze, Italy, 12-14 September 2002.

GAZMURI, R.G., AND ROSEGRANT, M.W. (1994). *Markets in tradable water rights: the Chilean* *experience.* Mimeo (Washington, DC: International Food Policy Research Institute).

GHOOPRASERT, W. (1990). Management of water projects, *Environmentally sound water management,* N.V. Thanh and A.K. Biswas (eds.), Oxford University Press, Delhi, India.

GIBBONS, D.C. (1986). *The economic value of water. A study from resources for the future, Washington*, D.C.

GRIMBLE, R.J. (1999). Economic instruments for improving water efficiency: theory and practice. *Agricultural water management,* 40:77-82.

GWP (GLOBAL WATER PARTNERSHIP) (2000). *Integrated water resources management.* Technical Advisory Committee, GWP, Paper no. 4, Stockholm.

HASSAN, R. AND LANGE, G.M. (2004). The Economics of Water Management in Southern Africa: An Environmental Accounting Approach. In Lange, G. and R. Hassan (eds.), Edward Elgar (forthcoming).

HELLEGERS, P. J. (2002). *Treating water in irrigated agriculture as an economic good.* Paper submitted for the conference on irrigation water policies, Agadir, Morocco, 15 – 17 June, 2002. Agricultural Economics research Institute, The Hague, The Netherlands.

HOWE, C.W. AND GOODMAN, D.Y. (1995). *Resolving water transfer conflicts through changes in the water market process and economic analysis*. In: Dinar, A and Loehman, E.T. (eds) Water quantity/quality resolution, London.

IWMI (1996). *Mission statement of the international irrigation management institute.* Colombo, Sri Lanka. International Water Management Institute.

JOHANNSON, R.C. (2000). *Pricing Irrigation Water: A Literature Survey*. The World Bank, Washington, D.C.

LAVIGNE, M. AND STIRER, N. (2003). *Transfert de gestion et durabilité des périmétrès irrigués en agriculture familiale noire en Afrique du Sud.* Unpublished Masters thesis. 170p, ENSAIA-UP-CIRAD, Montpellier, France.

LEEDY, P. D., ORMROD, J.E. (2001). *Practical Research: Planning and Design, 7th edition.* Upper

Saddle River, N.J.: Merrill, Prentice Hall, Columbus, Ohio.

LOUW, D. AND VAN SCHALKWYK, H. (2000). *Water markets an alternative for central water allocation.* Paper prepared for AEASA annual conference, Sun City, South Africa 28-29 Sept. 2000.

MOHAMMED AND SAVENJE, H.H.G. (2000). *The socio-economic value of water: knowledge gaps and research questions in integrated water resources management.* Paper presented at the UNESCO – WORTRO Conference on Water for society, 8 – 10 November, 2000, Delft.

MOLDEN, D., SAKTHIVADIVEL, R. AND HABIB, Z. (2001). *Basin-level use and productivity of water: examples from South Asia.* Research Report 49. Colombo, Sri Lanka: International water management institute.

NATIONAL WATER ACT (NWA OF 1998) (1998). Government of RSA: Pretoria, SA.

NSTONTO, N. (2003). Zanyokwe smallholder irrigation scheme: Raw Data, Pretoria.

OECD (1999). Agriculture water pricing in OECD countries, unclassified, ENV/EPOC/GEEI (98) 11/FINAL Or Eng. OECD, Paris.

OLBRICH, B.W. AND HASSAN, R. (1999). A comparison of the economic efficiency of water use of plantations, irrigated Sugarcane and Sub-tropical fruits: A case study of the Crocodile River Catchment, Mpumalanga province. *Water Research Commission report no. 666/1/99,* Pretoria.

PERRET, S., LAVIGNE, M., STIRER, N., YOKWE, S., AND DIKGALE S. (2003). *The Thabina irrigation scheme in a context of rehabilitation and management transfer: Prospective analysis and local empowerment.* Final report: DWAF, CIRAD-IWMI-UP, Pretoria.

PERRET, S. (2002a). Water policies and smallholder irrigation schemes in South Africa: A history and new institutional challenges. *Water Policy,* 4(3): 282-298.

PERRET, S. (2002b). *Testing scenarios on the viability of smallholding irrigation schemes in South Africa: participatory and information-based approach*. In: 17th Symposium of the International Farming Systems Association, November 17-20, 2002, Lake Buena Vista, Florida, and USA.

PEERET, S. AND TOUCHAIN, E. (2002). *A simulation-based approach to assess the economic viability of smallholding irrigation schemes in South Africa: conceptualisation and first implementation.* CIRAD

Tera / UP research report, CIRAD-Tera, no. 02?02, Pretoria, SA.
ROGERS, P., BHATIA, R., AND HUBER, A. (1998). Water as a Social and Economic Good: how to put the principle into practice. *Global Water Partnership Technical advisory Committee (TAC) background paper. n*o. 2, 5-31.

ROSEGRANT, M.W. AND RINGLER, C. (1998). Impact of food security and rural development of transferring water out of agriculture, *Water Policy*, 1:567-586.

RURAL URBAN CONSULTANTS (2001). Transforming and Integrated Communities." Provincial Land Reform Office. Department of Land Affairs, South Africa.

SAITO, K. A. (1994). *The raising of the productivity of women farmers in Sub-Sahara Africa.* Background papers Volume 1 and II (Mimeo).

SALETH, R. M. (2002). *The management of water resources: Water resources and economic development*, Edward Edgar publishing limited, UK.

SALIBA, B.C. AND BUSH, D.B. (1987). *Water markets in theory and practice: market transfers, market values and public policy.* Studies in policy and management 12, Boulder West view press, London.
SAPWAT (1999). Website: www.sapwat.org.za

SCOGINGS, P.F., VAN AVERBEKE, W. (1999). *The effects of policy and institutional environment on national resource management and investment by farmers and rural households in East and Southern Africa.* ARDRI, Fort Hare.

SHAH, T., VAN KOPPEN, B., MERRY, D., DE LANGE, M. AND SAMAD, M. (2000). *Farmer management of irrigation systems: Can Africa's smallholder black farmers do it?* International Water Management Institute, Colombo, Sri Lanka.

SHIFFLER, M. (1996). Inter-sectoral water markets: A solution for the water crisis in arid areas. In: Kay et al. (eds) (1997). *Water: Economics, management and demand.* E & FN Spon. Publisher, London, UK.

THOBANI, M. (1995). Tradable property rights to water: How to improve water use and resolve conflicts. Public policy for the private sector. The World Bank, Washington D.C.

TEWARI, D.D. (1998). Determining Economic Value of Irrigation Water: Comparison of Willingness to Pay and other Conventional Approaches, *CSERDGE Working paper No. 1998-05,* University College, London, UK.

TEWARI, D.D. (2003). An estimation of the value of water in the commercial forestry sector in selected areas in South Africa: a case study of Kwazulu-Natal. *Water Research Commission report No. 1133/1/03*, Pretoria.

TURTON, A. R. (1999). Water scarcity and social adaptive capacity: Towards an understanding of the social dynamics of water demand management in developing countries, *MEWREW Occasional Paper No. 9,* Water Issues Study Group, School of Oriental and African Studies (SOAS).

VAN AVERBEKE, W.M., MARETE, C.K., IGODAN, C.O., AND BELETE, A. (1998). An investigation into food plot production at irrigation schemes in the Central Eastern Cape, ARDRI, Univ. of Fort Hare.

VAN DER HOEK, W., SAKTHIVADIVEL, R., RENSHAW, M., SILVER, J.B., BIRLEY, M.H. AND KONRADSEN, F. (2001). *Alternative wet/dry irrigation in rice cultivation: a practical way to save water and control malaria and Japanese Encephalitis.* Research Report 47, Colombo, Sri Lanka: International Water management Institute.

WALKER, I., ORDOÑEZ, F., SERRANO, P., AND HALPERN, J. (2000). Pricing, subsidies and the poor: demand for improved water services in Central America. World Bank: Washington, D.C.

WINPENNY, J. (1996). The economic appraisal of environmental projects and policies: A practical guide. Paris, Organization for Economic Cooperation and Development, France.

WHITTINGTON, D.J., BRISCOE, AND MU, X. (1987). *Willingness to pay for water in rural areas: methodological approaches and an application in Haiti*. WASH project, field report No. 213. Washington, D.C.

WORLD BANK (1993). The demand for water in rural areas: determinants and policy implications. *World Bank Research Observers* 8(1), 47-70.

YODULEMAN, M. (1989). *Sustainable and Equitable Development in irrigated Environments, in Environment and the poor: Development strategies for a common agenda*, H. Jeffrey (ed.), US Third World Policy perspectives, No. 11, Overseas Development Council, Washington, D.C.

YOKWE, S.C. (2002). *The adoption of cash crop technologies by small women farmers: Qwaqwa case study*. Unpublished Master theses, University of Free State, Bloemfontein.

YOUNG, R. A. (1996). Measuring Economic benefits for water investments and policies, World Bank Technical Paper No. 338.

YOUNG, R. A. AND GRAY, S.L. (1985). Input-output models, economic surplus and the evaluation of State or regional water plans. *Water Resources Research,* 21 (12:1819-1823).

Appendices

Appendix A. Crop management style (typology) for Thabina and Zanyokwe scheme (Source: Lavigne and Stirer, 2003; Perret et al., 2003)

First, it must be emphasized here that it is often impossible to reflect the diversity of crop management styles or practices in the existing cropping systems practiced in South Africa (and even per a given scheme). Hence, it is important that typology of cropping system must be undertaken in this study. An attempt therefore is made to identify a series of typical and reasonably homogenous cropping systems, so as to address this reality. Two main criteria were taken into account in building the crop management style in the Thabina and Zanyokwe scheme. These include: (1) the average yield (2) the level of inputs for a given crop, and crop budget. Table A1 and A2 summarise the crop management style in the two schemes, including water productivity measured in terms of gross margin of output per volume of irrigation water used.

It is worth mentioning that each product has been given a monetary value (even those used for family consumption) according to the market prices for equivalent products. These data refer to farmers' sayings and remembrance of their cropping systems and performances during the last cropping season (i.e. winter and summer 2002-2003). According to Perret et al. (2003) such information however, should not be taken as generic and over-standing. It highly depends on circumstances that took place during the given cropping seasons.

Finally, all these figures are averages. Choice has been made in terms of differentiating the main modes of management for given crop. All crops in the schemes, except green maize which management style looks quite homogenous among farmers, can be splitted into two management styles. This sometimes refers to 'Low yield' and 'High yield', since yields are significantly different whereas management style seem homogenous otherwise. Lack of skills, lack of information or specific failure on that given cycle may explain such difference. In other instance the difference refers more directly to a strategy by the farmers, in terms of level of intensification ('Intensive' to 'Extensive'), hence resulting in significantly different yields. Such distinct management styles and performances are interesting from a support point of view. According to Perret et al. (2003) CMS that are labelled 'Low yield' resulting from a poor performance by farmers can be spotted for training and technical advice. CMS that are labelled 'Extensive' may rather refer to poor access to markets by farmers; hence the resort to an extensive strategy, which does not, supposes that those farmers are unskilled.

Appendix B: Farmers' typology in Thabina and Zanyokwe (Source: authors work; Lavigne and Stirer, 2003; Ntsonto, 2003; Perret et al., 2003)

Historically, in South Africa, smallholder farmers had been perceived as a one-dimensional entity. Holding size, for a long time has been the most common basis for classifying farmer in South Africa and previous models have followed this modality by classifying smallholder rural farmers according to holding size classes (Bembridge, 1996). It must be recognized however that this needs to be developed to take greater account of the different opportunities and constraints facing different smallholder farmers in this country, and which reflect into their strategies and practices. This can be a useful tool for strategic development policy planning. The section below attempts to highlight this difference, and see whether smallholder farmers are diverse or otherwise.

In the data collected from Thabina and Zanyokwe schemes, farmers are regrouped on the basis of the following criteria: (1) the level of marketing (as opposed to subsistence); (2) the level of diversification (number of crop sold); and (3) the livelihood system (source of income). In the analysis, 9 types of farming households have been identified in Thabina, and 5 in Zanyokwe irrigation schemes. Table B1 recaps farmers' typologies for Thabina and Zanyokwe.

It must be underlined here however that attempting to generalize data onto each of the scheme refers to the assumption that the sample of interviewees is representative of the schemes. Although the main trends are likely to be properly reported, there might be some difference and uncertainty attached to some figures (for example number of farmers per type).

As can be seen in Table B1, major types of farmers have been identified from the two schemes. However, since these schemes vary from one another, there is a need to describe each type separately.

1. Thabina scheme (Perret et al., 2003)

- *Type 1: Non-farming occupiers* - Farmers who do not cultivate any more their land (land left unused or fallow). This type of farmers occupies a large portion of the scheme. The estimated proportion of 42% out of 149 farmers is believed to form this type. This explains why the management and the farmers 'committee felt a need for reallocation of some land to the interested and committed farmers. It is probable that if farmers are supported (e.g. access to support service such as credits and inputs), more non-farming beneficiaries will make use of the lands. If such supported will be rendered however, greater attention should be paid as to who will really benefit from such support.

- *Type 2: Subsistence oriented farmers* - Farmers who are cultivating their land (under irrigation) mainly for self-consumption. They are in the most insecure position because of low yield production. About 5 % farmers come from this type as compared to the rest of the types in the scheme. Most of them have no chance to work for off-farm activities, since they consist mostly of pensioners.
- *Type 3: Specialized farmers* - Farmers who are growing only one type of crops (mostly low yield maize). Some do grow crops other than maize crops in smaller part of their land. This result shows that this type is not viable. Also, 7% farmers form this type.
- *Type 4. Diversified farmers* – These are farmers with non farm income grow high yielding maize and groundnut (intensive); it looks as if the non-farm incomes allows them to invest more in production (large areas, more intensive). This type consists of 11 % proportion of farmers in the scheme.
- *Type 5. Full-time diversified farmers* – These farmers composed of 3 percent. They grow high yielding maize, spinach and cabbage (both extensive); maize surplus is sold, as well as vegetables, on order to secure income.
- *Type 6. Pensioners-commercial farmers* – These group of farmers grow onions (extensive) and green beans (intensive); it looks as if they can take some risks growing these non traditional crops, which transport and marketing are quite easy and profitable; skills probably contribute significantly here. This type composes only about 3 % of farmers.
- *Type 7. Commercial farmers with non-farm income* – These farmers grow low yielding maize (that is for self-consumption); onions (extensive) and tomato (intensive); they also produce several high value vegetable cropping. They make up of 8 % of the farmers.
- *Type 8. Full-time commercial farmers* – Grow spinach and cabbage (both intensive and tomato (extensive); most of them have quite growing maize and have turned to profitable vegetable cropping. They made up of 7% farmers' proportion.
- *Type 9. Large-scale commercial* - These farmers make up of 10 percent. They grow a wide combination of crops, sometimes non-traditional or even exotic ones (e.g. okra, avocado); their core crops are cabbage and green beans (both intensive); tomato and onions (both extensive) and dry maize (low yield). It must be emphasised here that such farmers are very few in Thabina, yet very diverse in their features (e.g. area, crops).

2. Zanyokwe irrigation scheme (Ntsonto, 2003)

- *Type 1: Dryland involved farmers* - Farmers within the scheme but don't have access to water, hence depend entirely on rain-fed cropping. The reason being that after the withdrawal of DBSA (funder) and Ulimocor (management) from ZIS, the hydrants which were mounded in the plots (meant to be shared by plot owners) were claimed by those plot owners where the hydrants have been mounded in their plots. These are the most vulnerable farmers to drought and diseases. Although this type is made up of smaller number of farmers as compared to the rest of the types in the scheme, urgent solution is required for access to water to all farmers within the scheme.
- *Type 2: Non-farming plot users* - Farmers owning land without using it. A small proportion of farmer in this type occupied the larger portion of the schemes (see table 10).
- *Type 3: Specialized subsistence farmers* - Farmers under irrigation who are planting one crop without diversifying, mostly for self-consumption. Unlike in the other schemes, some do sell a smaller quantity of the products, but below the minimum to be considered here.
- *Type 4: Diversified commercial oriented farmers* - Farmers who grow at least two or more crops at a time. Mostly maize and some grow summer and winter crops. They sell most of their products. In future development, this type will be merged with the type 5 in order to be self-sufficient and stable.
- *Type 5: Diversified transitions* - Farmers who do grow more than four of different type of crops. They use most of the land available to them. Also, they sell most of their products.

Table A1. Crop budget in Thabina scheme by crop type per ha (Source: authors work; Lavigne and Stirer, 2003; Ntsonto, 2003; Perret et al., 2003)

Crop Name	Yield Unit	Av. yield per ha	Price (R)	Total revenue (Rand/ha)	Production Costs (R/ha)	GM (Rand)	Water used (m^3/ha)	GM per m^3
Dry maize - High Yield	Bag	18.18	154.00	2802.80	1640.00	1162.80	5840	0.20
Green maize - Average	Cob	1694.2	0.76	1284.00	1170.00	114.00	6520	0.02
Dry maize - Low Yield	Bag	6.60	166	1095.60	1470.00	-374.40	5840	-0.06
Onion - Extensive	Box	78.5	22.00	1727.00	520.00	1207.00	2640	0.46
Onion - Intensive	Box	287.5	16.22	4592.00	1180.00	3412.00	2640	1.29
Spinach - Intensive	Bundle	1007	3.80	4040.00	1820.00	2220.00	3020	0.74
Spinach - Extensive	Bundle	564.55	4.00	2128.00	585.00	1543.00	3020	0.51
Tomatoes - Extensive	Box	131.85	22.90	2977.00	1020.00	1957.00	3910	0.50
Tomatoes - Intensive	Box	507.22	23.50	11985.00	3530.00	8455.00	3910	2.16
Cabbage - Intensive	Head	1960	3.30	6468.00	2260.00	4208.00	3700	1.14
Cabbage - Extensive	Head	1287.2	3.30	4257.00	880.00	3377.00	3700	0.91

Table A2. Crop budget in Zanyokwe scheme by crop type per ha (Source: authors work; Lavigne and Stirer, 2003; Ntsonto, 2003; Perret et al., 2003)

Crop name	Yield Unit	Av. yield per ha	Price /unit	Total revenue (Rand/ha)	Production Costs	GM (Rand)	Water used (m^3/ha)	GM per m^3
Dry maize – High yield*	Bag	91	70.00	6370	4569.39	1800.61	5150	0.35
Cabbage – High yield	Head	8508	1.00	8508	3352.63	5155.37	3140	1.64
Butternut – High yield	Bag	777	15.00	11655	8145.00	3510.00	4700	0.75
Beetroot – High yield	Bundle	5510	1.00	5510	1359.27	4150.73	3040	1.36
Potatoes - High yield	Bag	799	15.00	11985	9630.34	2354.66	5670	0.42
Green maize– High yield	Cob	12666	1.00	12666	7905.80	4760.20	5150	0.84
Cabbage – Low yield	Head	1440	2.00	2880	2470.56	409.44	4610	0.09
Butternut – Low yield*	Bag	113	15.00	1695	1593.57	101.43	4300	0.02
Beetroot – Low yield	Bundle	421	1.50	631.50	1132.73	-501.23	3040	0
Dry maize – Low yield	Bag	22	70.00	1540	1328.86	211.14	5190	0.04
Green maize- Low yield	Cob	4333	1.00	4333	2432.71	1900.29	5190	0.37
Potatoes - Low yield	Bag	116	15.00	1740	1159.98	580.02	5670	0.10

Table B1. Traits and performance of farming systems in Thabina and Zanyokwe scheme (Source: authors work; Lavigne and Stirer, 2003; Ntsonto, 2003; Perret et al., 2003)

Schemes	Farmers types	Farm area / ha	No. of farmers	Area covered /ha	GM per ha	GM (farm)	Water cons. (m^3 / farm)	GM per m^3
Thabina SIS	Non-farming plot occupiers	1.5	65*	96.5*	-	-	-	-
	Subsistence oriented farmers	1.0	12	12.0	56	37	6884	0.01
	Specialized farmers	1.4	12	16.8	-443	-239	5904	0
	Diversified farmers with non-farm income	1.7	15	25.5	1 594	1 594	10315	0.15
	Diversified full-time farmer	1.0	7	7.0	1 260	718	4965	0.14
	Full-time commercial farmers	1.2	14	16.8	2 379	1 189	3467	0.34
	Pensioners commercial farmers	1.8	9	16.2	3 092	1 391	2611	0.53
	Commercial farmers with income	1.6	12	19.2	215	248	10471	0.02
	Large commercial oriented farmers	8.0	3	24.0	903	5 240	45782	0.11
Zanyokwe ZIS	Non-farming plot users	3.55	18	360*	-	-	-	-
	Dry-land involved farmers	4.64	7	43.10	-368	0	0	0
	Specialized farmers	4.15	9	49.60	2932	4105	4235.86	0.69
	Commercial oriented farmers (full-time)	5.61	20	74.40	2146	19134	5556.83	0.44
	Transitions commercial oriented farmers	4.78	10	104.34	1772	11695	4917.17	0.32

All figures are in average. The water consumption used here has taken into account rainfall, conveyance loss; bulk irrigation loss, and on-farm irrigation loss.

References

BEMBRIDGE, T.J. (1996). Small-scale farmer irrigation schemes in South Africa. Appendix to Backeberg et al. 1996. Policy proposal for irrigated agriculture in South Africa, 1996. *Water Research Commission,* Pretoria.

LAVIGNE, M. AND STIRER, N. (2003). *Transfert de gestion et durabilité des périmétrès irrigués en agriculture familiale noire en Afrique du Sud.* Unpublished Masters thesis. 170p, ENSAIA-UP-CIRAD, Montpellier, France.

NSTONTO, N. (2003). Zanyokwe smallholder irrigation scheme: Raw Data, Pretoria.

PERRET, S., LAVIGNE, M., STIRER, N., YOKWE, S., AND DIKGALE S. (2003). *The Thabina irrigation scheme in a context of rehabilitation and management transfer: Prospective analysis and local empowerment.* Final report: DWAF, CIRAD-IWMI-UP, Pretoria.

Appendix C: Questionnaire

All information provided here will be treated as STRICTLY CONFIDENTIAL

INVESTIGATION ON ECONOMICS OF WATER USED BY SMALLHOLDER IRRIGATION FARMERS IN SOUTH AFRICA

Stanley C.B. Yokwe
University of Pretoria,
Department of Agricultural economics,
extensive and rural development.
0002 Pretoria, South Africa

Mailto : Stanley_yokwe@yahoo.com.au
Telephone : 27 12 344 5409
Cellphone : 27 83 665 1407
Fax : 27 12 420 4958

General information

		For office use only
Date	:	
Village	:	
Scheme	:	
Ward, dam or group	:	
Respondent's name	:	
Gender (male or female)	:	
Name of head of household	:	
Ref. number	:	
Ref. number during previous		
interview (2000)	:	
Type	:	

1. HOUSEHOLD COMPOSITION

	AGE	Gender	MAIN OCCUPATION
1. Head			
2. Spouse			
3. Children less than 16 yrs			
4. Children with moret than 16 yrs			
5. Children less than 5 yrs			
6. Others			

For office use only

1. Male
2. Female

1. Retired
2. Unemployed
3. Full time farmer
4. Regular/salaried employee
5. Self employed
6. School
7. Pre-school

2. LAND TENURE

Type of plot 1. Dry land 2. Irrigated land 3. Kitchen/backyard garden	Size	Unit 1. Ha 2. Morgen 3. Acres 4. Square meter	Tenure system 1. PTO 2. Sharedholding 3. Freeholding 4. Quitrent 5. Leasing agreement 6. Other (borrowing)	For office use only

Farm size (total area of your plots in the scheme) ____________________

Do you pay any fees for land? Yes [ ] No [ ]

If yes, how much per ha? ____________________

To whom? ____________________

Do you pay any fees for water? Yes [ ] No [ ]

If yes how much? ____________________

3. CROPPING SYSTEM

Crop name	Area planted 1. Ha 2. Morgen 3. Acres 4. Square meters	Quantity harvested	Quantity sold	Price/unit	Quantity Consumed (specified unit)	Market outlet 1. Local 2. Shop 3. Neighbours 4. Hawkers 5. Contractor 6. Others (specify)

For office use only

 # Market price per unit will be checked with an extension officer

What is your favorite or main market outlet? ______________________

Which crops are grown mainly for family consumption (thus hardly sold)? ______________________

What problems have you got with crop production in the scheme? ______________________

____

____

____

____

4. EXPENDITURES / PRODUCTION COSTS

Crop name	Inputs 1. Fertilisers 2. Seeds 3. Herbicides 4. Pesticides 5. Labour 6. Tillage 7. Other	Suppliers 1. Local shop 2. Store in town 3. Coop. 4. Individual, (friends, neighbours…)	Quantity purchased (and used)	Cost per unit	Input market (descripion: distance, organization)	Marketing cost Transport Packaging other

For office use only

 # Inputs price per unit will be checked with an extension officer

What problems have you got about input supply? ______________________________

Do you own any large equipment (e.g. tractor, bakkie, implements) Yes [ ] [ ]
If Yes, which one? ______________________________

Do you hire them out Yes [ ] No [ ]

At which price? ______________________________

How much do you earn from that hiring out (on average) ____________________

5. Crop Calendar

Crop name	January	February	March	April	May	June	July	August	Sept	Oct	Nov	Dec

When is food scarce in your household (month)?

Jaunary	February	March	April	May	June	July	August	Sept	October	Nov	Dec

6. Livestock Description

Livestock type	Number currently owned	Number sold from sales	Gross income
Cattle			
Goats			
Sheep			
Pigs			
Chichens			
Horses			
Donkeys			
Mule			

For office use onl

 # Animal price per unit will be checked with an extension officer (calculation of gross income)

Number and type of animal slaughtered form family purpose last year? ____________________

Where are they grazing? On scheme? Yes [ ] No [ ]

Any problem with livestock? ____________________

7. Finance

For office use only

Do you hire people for farming? Yes ( ) No ( )

If yes, how much did you pay per year per ha? ______________________________

Have you got other sources of income in the household? (e.g. pension, wages, salaries, grant)

If yes, from whom? ______________________________

How much per month? ______________________________

Are you using credit facility? Yes ( ) No ( )

If yes, what was the source of the loan?
( ) Supplier
( ) Relative or friend
( ) Money lender
( ) Stockvel
( ) Output buyer
( ) Financial institution: ____________________
( ) Other

What was it for?
( ) Farming
( ) General maintenance / household purchases
( ) For food

Have you got any debts outstanding? Yes ( ) No ( )

8. Scheme Management

For office use only

Do you experience problems or conflicts about water sharing?

Do you experience water shortage?

Never ( )
Sometimes ( )
Often ( )
Always ( )

In the frame of an improved water supply and water related services, how much would you be ready to pay / ha /yr for such supply and services?

( ) a given amount per year per ha (specify in Rand if possible) ____________________
( ) An amount depending on your farm income (specify in % for instance) ____________________

In your opinion, if farmers had to pay, who should pay for water services?

( ) everyone in the scheme should pay for water services, regardless of what he/she does
( ) the one that are making money
( ) the one who are irrigating
( ) ones who are irrigating a lot?
( ) none / only the government

9. Water User's Association and management committee:

Do you know about these structures ____________________
Do you know the chairmen? ____________________

Any opinion on that? ____________________
____

10. Concluding the interview

For office use only

What are your major problems, as a beneficiary of the scheme? ______________________

What are your major problems, as a member of the community? ______________________

What proportion of plot holders actually farm today:

Less than a half ( )
About half of them (5 over 10) ( )
More than two third of them (about 7 over 10) ( )
Almost everyone (9 over 10) ( )

How do you see the future and what are your prospects
As a beneficiary of the scheme?
as a member of the community? ______________________

As a farmer in the scheme, has your situation improved over the last 2 years? ______________________

Why? ______________________

Final general comments the farmer would like to make: ______________________

***********Thank you so much for giving me your cooperation************