EFFICIENCY IMPLICATIONS OF WATER MARKETS IN THE LOWER ORANGE AND CROCODILE RIVERS, SOUTH AFRICA

BY

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DECLARATION

I hereby certify, that unless specifically indicated to the contrary in the text, this dissertation is the result of my own original work and has not been submitted for a degree at any other university.

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ABSTRACT

Irrigation farmers in the Lower Orange (Kakamas and Boegoeberg) and Lower Crocodile rivers (between Nelspruit and Komatipoort) areas in South Africa were surveyed during October 2003 in order to study whether water marketing has promoted efficiency in water use. This study is a follow-up on research undertaken by Armitage (1999) in the Lower Orange River area and Bate et al. *(1999) in the Lower Crocodile River area. Factors associated with future investment in irrigation farming were also studied in the Lower Orange River Irrigation Scheme. Econometric procedures used included principal component analysis, and logit and ridge regression. Results from the two areas will be discussed separately.*

Econometric results for the Lower Orange River farmers indicate that purchasers of water rights produce lucrative export grapes and horticultural crops with relatively less raisin, wine or juice grapes and less field crops; are more specialised in production (table grapes); have more livestock (probably liquidity factor) and have a less negative view of the five-year water license review period. The water market has facilitated a transfer of water use from relatively lower value crops to relatively higher value crops, and also promoted the use of more advanced irrigation technology. An investment model using Ridge Regression indicates that the following variables are associated with increased future investment in irrigation *farming; higher expected profitability and lower levels of risk perception and risk aversion (Arrow/Pratt). Results confirm that farmers who are more risk averse are likely to invest less in the future as can be expected from theory. Policies that increase risk in* agriculture *will have a significant negative effect on future investment in irrigation.* ***What is***

significant from the results is that irrigation farmers in the Lower Orange River area are highly risk averse (down-side). *Results also show that farmers who feel that water licenses are not secure expect to invest less in the future. The latter effect is thus amplified, as farmers appear to be highly risk averse. This has important policy implications, and measures should be taken to improve the perceived security of water licenses. This could be achieved by keeping farmers more informed about the practical implications of the New Water Act (NWA) (Act 36 of 1998) and, specifically, water licenses.*

In the Lower Crocodile River area, almost all the water trades (permanent and rentals) observed in this study were from farmers above the gorge to farmers below the gorge. It is concluded that in the transfer of water some attributes in the purchasing area such as lower production risk (sugar cane) and lower financial risk and better cash flow (bananas and sugar cane) were more important than the expected income per cubic meter of water. Water supply in this area is highly irregular, while sampled farmers were again found to be extremely risk averse especially as far as down-side risk is concerned. The average water price in this area in recent years (2002 to 2003) was between R2000 and R3000 per ha (1ha = 8000 cubic meters). Buyers have large farms and are progressive farmers that purchase (and rent) from many sellers (or lessors). It is concluded that information on water transfers (sale prices and rents) is asymmetrical. Few permanent transfers have taken place in the Crocodile River in recent years. It is concluded that there are reasons why transfers at present are not processed, such as excess demand for water (due to the irregular flow of the Crocodile River), and role players should discuss these reasons and possible solutions before further action is taken.

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INTRODUCTION

The worldwide demand for water is increasing, due to, amongst other reasons, population and economic growth, increasing industrialisation and urbanisation, and evolving environmental demands. Increasing water demand in most areas of South Africa is compounded by the factors of climatic variability, skewed regional distribution of water resources with respect to areas experiencing economic growth, and deteriorating water quality (Armitage, 1999). In many areas, in South Africa and in the rest of the world, it is becoming difficult to meet those demands due to the high construction costs of water storage and conveyance infrastructure, and the full appropriation of many water resources. Supply side responses have become more expensive, and relief from the demand pressures will require more effective water allocations and use of existing water resources.

This stage of the water economy's development is often referred to as its 'mature phase'. A water economy develops from an expansionary phase towards its mature phase. An expansionary water economy is characterised by relatively low social cost of expanded water use, in total and at the margin. As demand for water increases, new projects can be developed on favourable sites. This gives the false impression that water is relatively cheap (Randall, 1981). During this phase, analysis is mainly focused on cost benefit analysis and project evaluation. The mature phase of a water economy is characterised by a price inelastic long-run supply of impounded water, exacerbated by a high and growing demand for water; a need for repair and renovation of aging projects; intense competition for water among different sectors; major externality problems; and a high social cost of subsidising water (for a comparison of these phases, see Appendix 1 on page 119) (Randall, 1981).

Backeberg *et al.* (1996) maintain that South Africa has reached this phase in the sense that water available for impoundment has become increasingly scarce, and that water storage projects have become increasingly expensive to construct and maintain. The attention of participants in the policy process in future will be focussed on the role of price in generating revenues in order to finance new developments and maintain aging projects; dampening the growth in the quantity of water demanded; and in promoting and directing the reallocation of water in response to changing patterns of scarcity, externalities, equity, and conflicts among water users (Randall, 1981).

The agricultural sector in South Africa consumes 54 percent of water and is regarded as the primary source of water savings (Nieuwoudt *et al.*, 2003). It is also estimated that irrigation produces 30 percent of the value of commodities in South African Agriculture. As well as save water, irrigated agriculture will have to maintain and improve productivity in order to meet growing food demand. This will require a policy environment that will facilitate an optimal allocation of irrigation water. One such strategy is water marketing, as well-functioning water markets increase the likelihood that water will be transferred to its highest valued use, while the market attaches an opportunity cost to water, which in turn provides incentives for conservation. Several recent studies recommended the strengthening and support for water markets in South Africa (Conradie, 2002; Louw, 2001; Bate *et al.*, 1999; Armitage, 1999; Mirrilees *et al.*, 1994).

A new National Water Act (Act 36 of 1998) (the Act, or the NWA) has been gazetted in South Africa. This Act only guarantees rights to water for basic human needs and water to maintain environmental sustainability. The Act requires that farmers obtain water use licences in order to use water for purposes beyond basic human needs and other general authorisations (Government Gazette, 1998). In the interim, farmers must register their historical water use as an Existing Lawful Water Use (ELWU) in order to continue *abstraction* of water. The legislation makes provision for water trading as an option for water allocation (Section 25 of the Act). Although the main approach to water management is to a large extent centrally orientated, there is scope for the continued operation and development of water markets.

In this study, the Lower Orange River is studied as the area has an active water market. This study complements a study on water marketing in the Lower Orange River catchment undertaken by Armitage (1999) during 1997 as efficiency in allocation of water rights in the market situation was studied and the current study builds on the previous study. The dynamics of the water market can be studied by comparing water trades in the current study (2004) to those in the previous study. The current study has the following objectives:

(a) To assess whether or not the efficiency objectives of moving water from a lower value use to a higher value use envisaged in 1999 have been realised. The purpose would be to assess whether water marketing has promoted efficiency in the allocation of water entitlements and whether farmers' expectations are realised. This will be studied by comparing which farmers are buying, and which farmers are selling water.

(b) To study price trends in the water market.

(c) To study factors that affect future investment in irrigation farming. Efficiency in water use and future investment are closely linked. Increased investment in new irrigation technology promotes irrigation water use efficiency. Objective 'a' focuses on efficiency from a water allocation perspective, while objective 'c' focuses on factors that affect future investment, which has an impact on efficiency of irrigation water use. The focus is also on the farmers' perceptions of the security of the water license, and the risk aversion of the farmers.

For the purpose of this study, farmers along the Lower Orange River near Kakamas and Boegoeberg who purchased or sold water rights were interviewed during October 2003. The questionnaire used for the survey is presented in Appendix 6 on page 124. Data were analysed using Logit Regression to reveal the effect that trading has on allocative efficiency; Ridge Regression to investigate the factors which affect investment, in order to remedy multicollinearity; and Principal Component Analysis to combat multicollinearity and maintain degrees of freedom.

The performance of water markets in the Crocodile River Government Water Control Area is also studied as this river has also had an active water market. The flow of the Crocodile River is highly irregular and the major dam in this river (Kwena) is presently (March 2004) only 30 percent full (Holtzhauzen, 2004). Risk management in water use must therefore be an important strategy. Also while an active water sales market has developed, water renting is common. The markets will be studied not only as they function today but dynamic features will also be researched by comparing the present situation with a past study by Bate *et al.* (1999) in the same river. Farmers at the time when the studies by Bate *et al.* (1999) in the Crocodile River and by Armitage (1999) in the Lower Orange River were undertaken were concerned about the application of the NWA. When Armitage undertook this research, water marketing in the Lower Orange River had ceased. This was probably due to uncertainty regarding how the Act would be implemented and how the farmers would be affected. It is likely that farmers adopted a 'wait and see' attitude towards trading of water.

The proposed study also links with the current Water Research Commission (WRC) study on the "Supportive role of the market mechanism in implementing the provisions of the new Water Act." The research objectives in the Crocodile River and in the Orange River are the same but conditions differ. The flow of the Orange River is more stable than the Crocodile River, no renting occurs in the Orange River while it is common in the Crocodile River. Water sales in the Orange River take a short period (2 months), while no transfers are currently being approved in the Crocodile River although many irrigators have applied for transfers. Similar to the Orange River study, the research objectives are:

(a) To study whether water marketing in the Crocodile River has promoted efficiency and whether efficiency objectives envisaged in the Bate *et al.* 1999 study have been realised.

(b) To study price trends in the water market.

(c) To investigate farmers' risk behaviour and risk strategies in water use.

The dissertation begins by reviewing the South African water laws, since it is important to be aware of the institutional context within which the water market must operate. A literature review is then presented to identify criteria and methods used for allocating water resources and to discuss various features of water markets. The next chapter deals with the study methodology used, and is followed by the survey results for each of the study areas. The results from an econometric analysis are presented, and this is then followed by a discussion and conclusion, which serves to summarise the important findings and recommendations.

CHAPTER ONE

A REVIEW OF SOUTH AFRICAN WATER LAW: 1956 - PRESENT

It is important to understand the legal framework within which water allocation in South Africa must operate. The next sections discuss firstly, some points about the old Water Act of 1956, and continue with a detailed discussion of the new Water Act of 1998.

1.1 The National Water Act of 1956

The previous Water Act (Act 54 of 1956) was based on the riparian right doctrine. This Act regulated the control, conversion, and use of water. The power to exercise authority was vested in the Minister of Water Affairs and Forestry. The previous Act did not directly specify water rights, as it only specified the mechanisms for determining and obtaining water rights (Louw, 2001: 15). Water rights were defined in other documents, such as notices in the *Government Gazette*, and in schedules for Government water schemes and irrigation boards, amongst others (Backeberg *et al*., 1996). Owners who possessed land next to a flowing river or stream could make reasonable use of the resource as long as enough was left for downstream users.

1.2 The New National Water Act of 1998

The 1956 Act has been replaced by the new National Water Act (NWA) (Act 36 of 1998). The NWA specifies that the government, as the public trustee of the nation's water resources must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner, for the benefit of all persons and in accordance with its constitutional mandate (Government Gazette, 1998).

According to the Act, the following factors must be taken into account amongst others (Government Gazette, 1998):

(a) meeting the basic human needs of present and future generations;

(b) promoting equitable access to water;

(c) redressing the results of past racial and gender discrimination;

(d) promoting the efficient, sustainable and beneficial use of water in the public interest;

(e) facilitating social and economic development;

(f) providing for growing demand for water use;

(g) protecting aquatic and associated ecosystems and their biological diversity;

(h) reducing and preventing pollution and degradation of water resources;

(i) meeting international obligations;

(j) promoting dam safety;

(k) managing floods and droughts.

Also, the Act specifies the following entitlements to water use:

- A person may use water in or from a water resource for purposes such as reasonable domestic use, domestic gardening, animal watering, fire fighting and recreational use, as set out in Schedule 1 (see Appendix 2 on page 120).
- A person may continue with an existing lawful water use in accordance with section 34 (see Appendix 3 on page 121).
- A person may use water in terms of a general authorisation or licence under this Act.
- Any entitlement granted to a person by or under this Act replaces any right to use

water which that person might otherwise have been able to enjoy or enforce under any other law

(a) to take or use water;

(b) to obstruct or divert a flow of water;

(c) to affect the quality of any water;

(d) to receive any particular flow of water;

(e) to receive a flow of water of any particular quality; or

(f) to construct, operate or maintain any waterwork.

In terms of implementation of the new law, the Act requires that the Department of Water Affairs and Forestry (DWAF) as the custodian of South Africa's water resources, should provide a National Water Resource Strategy (NWRS) as a framework for the management of water resources in South Africa (Government Gazette, 1998).

The foundations of the NWRS are the National Water Policy (1997) and the NWA (1998). The NWRS has four main objectives:

1. To establish the national framework for managing water resources;
2. To establish the framework for the preparation of catchment management strategies;
3. To provide information; and
4. To identify development opportunities and constraints (Republic of South Africa (RSA), 2002).

In terms of the Act, The NWRS lays down three types of water use authorisations. These are

(RSA, 2002):

- Schedule 1 uses - which permit the use of relatively small quantities of water mainly for domestic purposes (including non-commercial gardening and stock-watering), but also allows use in emergency situations and certain recreational purposes. Users must have lawful access to the resource or permission to use the resource in order to exercise this type of use authorization (RSA, 2002).

- General authorisations - which allow limited use, conditionally, without a licence. Limits are placed on water use under general authorisations depending on the nature of the use, and the capacity of the resource to accommodate the use without significant degradation. Current general authorisations are described in Government Notice No. 1191, 8 October 1999. These authorisations are mainly for areas that are not priority areas and licences are not required for certain cases. According to the aforementioned Government Notice, an eligible person may (RSA, 2002):

  (a) abstract surface water at a rate of up to 25 litres per second:

    (i) for the irrigation of up to 25 hectares of land, at 6 000 cubic metres per hectare per annum; or

    (ii) for purposes other than irrigation, up to 100 cubic metres on any given day; and

  (b) store up to 50 000 cubic metres of water.

- Water use licences - which are used to control water use that exceeds a Schedule 1 use, or which exceeds the limits imposed under general authorisations. As a transitional measure, the Act allows water use that was previously lawfully exercised under any law to continue under the same conditions until it is formally licenced. A licence to use water replaces all previous entitlements to use water for the purpose specified in the licence, and is specific to the user to whom it was issued, to a particular area or property and for a specific use for which it was issued. A licence is valid for a maximum of 40 years and must be reviewed by the responsible authority at least every five years (RSA, 2002).

The conditions attached to licences may change during the life of the licence. Any condition, except the licence period, may be amended on review (RSA, 2002). The details of renewal and amendments to licences are outlined in section 49 of the Act (see Appendix 4 on page 122). The allocation of water use licences with insufficient duration could stifle farmers' incentives to invest in new irrigation technology and in new irrigated agricultural development. It is the opinion of the author that the duration of the licences should be sufficiently long and be inherently secure in order to allow farmers to recover the expected net income stream generated by any investments that they make.

1.2.1 Transfers of water use authorisations

Section 25 of the Act provides for the transfer of water use authorisations. However in the preamble to the Act it is clear that the approach to water management is to a large extent still centrally orientated:

"Recognizing that while water is a natural resource that belongs to all people, the discriminatory laws and practices of the past have prevented equal access to water, and use

of water resources. Acknowledging the National Government's overall responsibility for and authority over the nation's water resources and their use, including the equitable allocation of water for beneficial use, the redistribution of water, and international water matters; Recognizing that the ultimate aim of water resource management is to achieve the sustainable use of water for the benefit of all users." (Government Gazette, 1998)

However, the Act also contains many important aspects which will make is possible to introduce a water market:

- There is a clear division between land rights and water rights.
- The power and duty of managing of water catchments will eventually be assigned to Catchment Management Agencies (CMA) with representation of water user associations.
- A responsibility of the CMA's will be to prepare water allocation strategies for each catchment. It will, therefore, with the approval of the minister, be possible to include water markets as a water allocation strategy in catchments (Louw, 2001: 262-263).

Section 25 of the NWA states (Government Gazette, 1998):

1. A water management institution may, at the request of a person authorised to use water for irrigation under this Act, allow that person on a temporary basis and on such conditions as the water management institution may determine, to use some or all of that water for a different purpose, or to allow the use of some or all of that water on another property in the same vicinity for the same or a similar purpose (Government Gazette, 1998).

2. A person holding an entitlement to use water from a water resource in respect of any land may surrender that entitlement or part of that entitlement -

   (a) in order to facilitate a particular licence application under section 41 for the use of water from the same resource in respect of other land; and

   (b) on condition that the surrender only becomes effective if and when such application is granted (Government Gazette, 1998).

3. The annual report of a water management institution or a responsible authority, as the case may be, must, in addition to any other information required under this Act, contain details in respect of every permission granted under subsection (1) or every application granted under subsection (2) (Government Gazette, 1998).

Section 25 of the Act thus provides for two distinct circumstances in which water use authorisation may be transferred - temporary and permanent transfers.

A *temporary* transfer of water may be authorised for irrigation either on the same property for a different use, or to another property for the same or a similar use. The two properties, for the latter case, may be or may not be owned by the same person. In general, temporary transfers will be for one year only, with the option of applying for an extension of a further year. Users must apply to the water management institution that has jurisdiction in the area for permission to effect the transfer (RSA, 2002; Government Gazette, 1998).

A *permanent* transfer of water may be effected by one user offering to surrender all or part of an allocation to facilitate a licence application by another user. Transfers of this nature constitute trade in water use authorisations, which may be used to increase the efficiency of water use by moving water from lower to higher value uses, or may increase equity of access to water. In the case of permanent transfers, the new licence application will be subject to all the relevant requirements of the Act regarding applications for licences. Permanent transfers become effective only when the new licence is granted. They may only be authorised by a responsible authority, which may change the conditions of the new licence. One of the conditions of the new licence may be that the new user must pay compensation to the original licence holder. Both types of transfers (temporary or permanent) will only be permitted where both the original and transferred water use are from the same water resource (RSA, 2002).

1.2.2 Water User Associations

There has been some realisation that government agencies do not have to manage all parts of the system and many governments rely heavily on Water User Associations (WUAs). South Africa has been divided into 19 water management areas, established in 1999 by Government Notice No. 1160 (see Appendix 5 on page 123). These management areas will be governed by CMAs, which are statutory bodies with jurisdiction over a defined management area. Functions of CMAs are to develop a catchment management strategy in line with the NWRS. They will also coordinate the water-related activities of water users and other water management institutions within water management areas. WUA's are co-operative associations of individual users who wish to undertake water-related activities at a local level for their mutual benefit. A WUA falls under the authority of the CMA in whose area of jurisdiction it operates (RSA, 2002). From this it is clear that South Africa is moving towards a more decentralised system of water allocation. Although there is scope for market transfers, the condition that the licence must be reviewed at least every five years reduces the incentive to invest in irrigation farming and causes some uncertainty around the security of water licences. The next chapter describes criteria for the allocation of water resources and discusses past research in the selected survey areas.

CHAPTER TWO

CRITERIA AND METHODS FOR ALLOCATING WATER RESOURCES

Appropriate means of resource allocation are necessary to promote and achieve optimal allocation of water resources. There are many alternatives for water resource allocation, and it is necessary to have some criteria that can be used to compare different methods of water resource allocation.

2.1 Criteria for comparison of water allocation methods

Howe *et al.* (1986), list several criteria used to compare methods of water allocation:

- *Flexibility* in the allocation of existing water supplies which implies that the resource can be shifted from use to use and from place to place as demand and other conditions change, making it possible to equate marginal values over many uses with least cost. It is not necessary that all water be subject to reallocation, only that there exist a tradable margin within each major water-using area that is subject to relatively low-cost reallocation.
- Only if the water user has *security of tenure* will he/she invest in and maintain water-using systems. Security and flexibility need not be conflicting, as long as users can voluntarily respond to incentives for reallocating water.
- The user must be confronted with the *real opportunity cost* of the resources available for use. The opportunity cost is the stream of net benefits that are forgone when one resource use alternative is chosen over other alternatives. The user must be confronted with the opportunity costs associated with water use and transfer so that their decisions are based on a complete assessment of costs and benefits (Saliba and

Bush, 1987: 239). A competitive market that sets a market-clearing price directly confronts the user with the real opportunity cost.

- A fourth criterion is *predictability* of the outcome and implementation of the process. This is important so that uncertainty can be minimised. A major concern about a change in an allocation system is the extent of the eventual reallocation and the impacts of this. A predictable system would lessen these concerns.
- The prospective users should perceive the allocation process as *equitable*. Users should be compensated for giving up water, and other users should not impose uncompensated costs on other parties - an example of this would be the 'no injury rule' in the western USA - which includes injury from changes in points of diversion or return flows.
- The allocation system should be politically and publicly acceptable, so that it serves public values and objectives, and is accepted by various segments in society.

Winpenny (1994) identifies additional criteria of efficacy, administrative feasibility, and sustainability. Efficacy refers to the ability of water allocation to change existing situations and to strive towards policy goals. Administrative feasibility and sustainability refer to the ability to implement and administer allocations and to institute necessary changes.

These criteria are closely related to economic efficiency. Flexibility allows equating marginal values in the resource's various uses. Security of tenure and predictability encourage investment in long-term production systems that will generate positive net benefits. When opportunity costs are taken into account, and assuming a well-functioning water market, water will more likely be put to its most valuable use. If the allocation system includes public good values in evaluating alternative allocations, then water will be allocated towards uses that achieve the highest aggregate net benefit level (Howe *et al.*, 1986).

In practice, there is a continuum between government control and a free market system in allocating water (Walmsley, 1995). On the one extreme is centralised water management, and on the other is decentralised water management. Dinar *et al.*, (1997) describe four different water allocation mechanisms: marginal cost pricing, public allocation, water markets, and user-based allocation. Rosegrant and Binswanger (1994) identify three processes of reallocation, namely, administrative control, opportunity cost pricing and tradable water markets. However, due to the large body of literature already available on the variety of resource allocation methods, and the South African context, this dissertation will only discuss public allocation and water markets.

2.2 Public allocation of water

Under public allocation, a public or quasi-public water authority identifies water demands or alternative uses and simply reallocates existing water allocations or rights to higher valued users. The state decides which resources can be used by the system as a whole, and allocates and distributes water within different parts of the system. Under this allocation method there will undoubtedly be losers who will protest to reallocation of water away from them, so the authority will have to negotiate with them, and devise a method of compensation (Rosegrant and Binswanger, 1994).

Water has several distinguishing features that can define a role for public action. Large, lumpy capital requirements and economies of scale in water infrastructure tend to create natural monopolies, which warrant government intervention in order to prevent overpricing. The large size and long time horizons reduce incentives for private investment in the sector. The uses of water within a river basin are interdependent, withdrawals in one part of the basin reduce the availability of water for other users; and pollution by one user affects other downstream users (Rosegrant and Binswanger, 1994). Some aspects of water activities are public goods (e.g. flood control), which cannot accrue charges to an individual user. Water resources are often developed because of their strategic importance for regional development and for national security (Dinar *et al.*, 1997). Public allocation promotes equity objectives and intends to ensure water supply to areas of insufficient quantity. It can protect the poor and sustain environmental needs.

Public water allocation mechanisms are likely to be preoccupied with equity and concerns with satisfying the perceived greater public good. Supplying water to water-deficient areas leads to expensive publicly financed projects. The overall effect is that subsidised water supply development replaces market mechanisms of water supply via transfers of water titles. Prices, as a result, do not represent either the cost of water supply or its value to the user (Dinar *et al.*, 1997).

Public allocation mechanisms do not create incentives for water users to conserve water and improve water use efficiency. The dominant incentive is to comply with regulations or face sanctions. In many cases, the state lacks the local information and ability to penalise. It is relatively more efficient where there are fewer points to monitor. Implementing agencies dealing with water resources have only sectoral responsibility and respond only to single constituencies. This provides very little flexibility to respond to changing patterns of water demand (Dinar *et al.*, 1997).

Public allocation does not meet many of the criteria listed in section 2.1. As mentioned, there is little flexibility in allocation. The outcome of a public allocation process may not be predictable due to hidden agendas of bureaucrats. Security of tenure is not guaranteed in the long term since policies can be changed. A centralised authority does not have the necessary information to determine the real opportunity cost of providing the resource. A public allocation does however strive for equity in the allocation process, and it will by definition be politically acceptable and, in some respects, be publicly acceptable. Administrative allocations are more conductive to efficacy than water markets. The other water allocation mechanism dealt with in this paper is water marketing. Water markets are the primary focus of this dissertation and will be discussed in Chapter Three.

2.3 Past research on water marketing in South Africa

Water markets in the western USA have a long history and date back to 1882 (Howe, 1997). Water marketing in South Africa is relatively more recent. Several local researchers have strongly recommended the strengthening and support for these markets in South Africa (Backeberg, 1995; Conradie, 2002; Louw, 2001; Bate *et al.*, 1999; Armitage, 1999, Mirrilees *et al.*, 1994; Nieuwoudt, 2000). As the present research is a follow-up on research by Armitage (1999), and Bate *et al.* (1999), these studies will be discussed in detail.

2.3.1 Past research on water marketing in the Lower Orange River

Armitage (1999) used discriminant analysis to distinguish between farmers who had bought water rights (Buyers) and farmers who had either sold water rights or had not participated in any market transactions (Non-Buyers). The results showed that the most important variable discriminating between the two groups was that Buyers were table grape farmers (F statistic = 18.3) and had a higher estimated return per unit of water (F statistic = 14.9). This shows that the water market in the Lower Orange River in 1997 was promoting the efficiency of water use, as water tended to move to users with a higher estimated return per unit of water.

Armitage (1999) reported an average price (weighted asset value) for water trades in the Lower River Orange of R3378 per hectare (for 1997) or 22.5 c/m^3, with the water price varying from as little as R800/hectare to as high as R5000/hectare. Closer examination of the data shows that there were fewer Buyers (9) and more Sellers (21), while the number of contracts per Buyer varied from one to 14, and contracts per Seller varied from one to two. Purchase prices vary significantly, indicating that there may be asymmetric information (Buyers are better informed about prices than Sellers). Comparisons with the current study and the Armitage (1999) study are made in Chapter Eight where the survey data are discussed.

2.3.2 Past research on water marketing in the Crocodile River

Bate *et al.* (1999) studied water market trading in the Crocodile River Basin. They estimated the sale value of water between 18.75c/m^3 and 22.75c/m^3. A wide range of trade prices (rental value) for water was observed ranging from zero to six cents/m^3 with a modal of 2.5 cents/m^3. There were only a handful of buyers (four accounted for 90 percent of trade volume) but 45 sellers. Twenty-three permanent trades and 46 temporary trades occurred. Bate *et al.* (1999) concluded that the high variation in trade prices could be attributed to asymmetric information between large buyers and many small sellers, with a large buyer paying different small sellers different prices, including a zero price. Most of the trades (97 percent by volume) are from farmers in the upper/middle Crocodile selling to farmers in the lower Crocodile River. This is important, as trades from up- to down-river do not reduce stream flow between buyer and seller, which is desirable for the environment.

Bate *et al.* (1999) noted that sugar cane production increased in spite of relatively lower returns per hectare of land. This was attributed to the higher price stability in this industry with fixed domestic sugar cane prices. According to Bate *et al.* (1999), water traded on short-term leases is likely to be used on this crop as it is a shorter-term crop and production can be changed more quickly. A negative externality of trade is that river flow may be reduced causing increased concentration of industrial sewage and farming effluent. However, several farmers only sought extra water as assurance against drought, so not all supplies will have been used. Bate *et al.* (1999) estimated that out of 12 million m^3 of water traded, eight million m^3 are actually used. They concluded that the main reason for buying was to ensure a steady flow of water as insurance against drought, while expanding production was of lesser importance. Risk thus played an important role in decisions. An important reason for selling was that it was not practical to pump the water and topography appears important. Whereas almost no rentals take place in the Lower Orange River, they appear common in this area. The following chapter discusses various features of a water market and outlines benefits of well-functioning water markets and requirements for their efficient operation.

CHAPTER THREE

FEATURES OF WATER MARKETS

For most commodities and inputs, allocation by markets has been the favoured solution of economists (Rosegrant and Binswanger, 1994). However, the allocation of water resources through water markets is not without problems. This chapter discusses the benefits of, requirements for, and problems experienced in, water markets.

3.1 Benefits of well-functioning water markets

A well functioning water market meets the criteria for allocation, as stipulated by Howe *et al.* (1986), better than most other alternatives for allocation. Such markets guarantee flexibility in allocation while providing security of tenure (no one has to sell). The price established by the market and the ability to transact via the market, forces the decision maker to take the opportunity cost of water into account, and therefore provides the incentive to adopt water-saving technology. In addition, market transactions assure fairness between buyer and seller, since each party must be made better off otherwise no transaction would take place. Through the market, water users are empowered by requiring their consent to any reallocation of water and compensation of transferred water (Anderson and Leal, 1989).

Water markets are possible when individuals (and institutions) have a secure claim to water that is transferable and separate from land. A secure supply of water increases producer incentives to make long-term investments in water-saving production technology. Tradable water-use rights provide incentives for the transfer of water from low valued to high valued uses and for the improvement in water use efficiency through the introduction of an opportunity cost (Easter and Hearne, 1995). Water markets also allow decentralised information to be brought to bear on water management decisions. Within a water market, farmers can apply first hand knowledge of their land, hydrology, irrigation technology, and relative profitability of alternative crops to determine how much water to apply and which crops to produce (Anderson and Leal, 1989). Table 3.1 summarises the benefits of each type of allocation method.

Table 3.1: Relative benefits of administrative water allocations and water markets.

Criterion	Water Markets	Administrative allocations
Flexibility	•	
Security of tenure	•	
Real opportunity cost	•	
Predictability	•	
Efficiency	•	
Equity		•
Political and public acceptability		•
Efficacy		•
Administrative feasibility and sustainability	•	

Source: Backeberg *et al.* (1996).

3.2 Requirements for the efficient operation of a water market

The efficient operation of any market requires some necessary conditions to facilitate trading (Louw, 2001: 48). These are:

- well defined, broad, durable and assured property rights,
- the physical and legal possibility for trading to occur,
- public information on the supply and demand for water, and

- low transaction costs.

The way in which farmers use a resource such as water is dependent on the property rights governing the resource. A property right refers to a set of entitlements that define the owner's rights, privileges and limitations of the specific resource utilization. In order to understand and explain property rights to water, there is a need to understand how rights to water are defined and developed.

3.2.1 Water rights regimes

A water right is "a collectively recognised access to water resources under specific conditions defined in the right, such as point of diversion, season, location and purpose of use, and quantity of withdrawals" (Saliba & Bush, 1987: 1). According to Sampath (1992), water rights are generally based on a variant or combination of the following three systems: *riparian rights, prior (appropriative) rights,* and as was previously discussed, *public allocation.*

Under the *riparian rights* doctrine, water rights are linked to land ownership: anyone who possesses land next to a flowing river or stream may make reasonable use of the resource as long as enough is left for downstream users. The location to which the water is diverted must be adjacent to the water source otherwise the diversion is prohibited. Regions where water is relatively abundant tend to make use of the riparian rights doctrine (Holden and Thobani, 1996). The rights entitle the landowner to a percentage of the water available for irrigation. This structure of water rights spreads the risk of variability in water supply equally among the shareholders (Nieuwoudt, 2000).

Prior rights are based on the appropriation doctrine, under which the water right is acquired by actual use over time (Sampath, 1992). Quotas are allocated to users on a first-come first-served basis. Diversions of water under this regime are subject to the 'use it or lose it' rule. For this reason 'sleeper' rights do not exist. This system is used extensively in the western United States of America (USA) (Holden and Thobani, 1996; Nieuwoudt, 2000). Rights can also be classed as senior rights and junior rights. Those users who established a beneficial use of water earliest are given senior rights over users who established use later. This provides certainty in supply as senior rights are met before junior rights (Nieuwoudt, 2000).

According to Saliba and Bush (1987: 23), property rights for water resources must have the following characteristics: they must be well-defined and completely specified in the unit of measurement, reliability, priority, and enforced so that all individuals know the privileges and restrictions that a water right provides and requires, and also know the penalties for any violation. In addition. in large river valleys where downstream users are dependent on the return flows of upstream users, the right should account for these return flows. One way to account for return flows is to restrict water transfers from one water district or area to another to only the portion of the right that is actually consumed. However, this situation requires measuring of water, which can often be costly and difficult to implement. Further, rights can only be transferred from up-to down-stream in the western USA so that the users are ultimately unaffected. Rights need to be exclusive so that the benefits and costs associated with water use and transfer decisions accrue directly to the decision maker. They must also be comprehensive so that all value generating aspects of water can be represented by water rights, such as water quality and instream flows. Rights should be transferable, so that water right holders can respond to differing conditions and attractive offers by higher value users. This accommodates changes in water uses from low value to high value uses. The right can be actual ownership, a usufructuary right, or a contractual right of use. The right must be specified in perpetuity or be of sufficient length to be valuable to a user (Simpson, 1992). If rights and titles are secure, Government, or preferably courts, could have jurisdiction over transactions.

3.2.2 Administration, infrastructure, and information issues

A water market requires an efficient administrative system that will prevent abuses of the system and maintain the proper chain of title over the water rights. An authority is necessary to legally sanction water trading, ensure legal formalities are adhered to, register the right, enforce legislation and regulations, and resolve disputes among users (Armitage, 1999). Water markets need infrastructure, as they can only be instituted where water can be delivered. Infrastructure, such as dams and canals, needs to be established in areas where water does not naturally flow and where demand for water exists. Infrastructure, however, can only be established where the users of water can bear the cost of creation of new infrastructure. Any improvements needed for the physical transfer of water from the place of use of the seller to the place of use of the buyer should be part of the transaction cost borne by the parties involved in the transfer. Information regarding water prices, trades, and availability should be readily available to potential buyers and sellers. Hydrological information is also required to permit the right to be defined. Different types of information are necessary for rational decision-making by water rights holders, such as information on legal and hydrological characteristics of water rights, and the cost of alternate means of obtaining water. This requires the existence of good data and monitoring systems (Louw, 2001: 52).

3.3 Sources of market failure

Water markets seem to be a practical solution to many water allocation problems, but some countries have not established them. The economic argument against trading water rests on the perception of market failure, which arises because of varying factors. One such factor is high transaction costs which are attributable to the setting up of a new legal, regulatory and institutional framework; defining, measuring and enforcing water rights; the identifying of potential beneficial and profitable opportunities for trades (information costs); the costs of negotiating the transfer and administrative costs surrounding the transfer (contracting costs); the cost of monitoring possible third-party effects and other externalities resulting from a transfer; the infrastructure costs of monitoring, mitigating and eliminating third-party effects; and making necessary changes in water intakes and conveyance infrastructure to effect the transfers (Holden and Thobani, 1996; Rosegrant and Binswanger, 1994; Young, 1986). Table 3.2 overleaf summarises who bears these costs.

Under administrative allocation, all costs are borne by the authority or governing body within the jurisdiction of the authority. In a market system, the water rights users bear the costs of identifying opportunities and negotiating the transfers. The costs of conveyance and mitigating third party effects fall on the buyers, and they would attempt to find those trades which minimise the total of purchase price, conveyance and mitigation costs.

Table 3.2: Transaction costs under alternative water allocation systems.

Costs of	Allocation Process Administrative	Tradable Rights
Identifying opportunities	Authority	Users
Negotiating transfers	Authority, Users	Users
Monitoring third-party effects	Authority	Authority
Conveyance	Authority	Buyer
Mitigation of third party effects	Authority	Buyer
Resolving conflicts	Authority, Courts, Users	Authority, Courts, Users

Source: Adapted from Rosegrant and Binswanger, (1994).

On the other hand, administrative allocation may be subject to political pressures and authorities may not have the same incentive to minimise the total cost of the transaction as the buyer would (Rosegrant and Binswanger, 1994). In addition, a central authority may not have access to the same information available to the individual users of water and cannot make a decision based on as much information as a market would facilitate.

The institutional arrangements around which a market is designed and the regulations that it is governed by, have a major impact on transaction costs (Armitage *et al.*, 1999). Excessive regulation can create high transaction costs, which greatly reduce the benefit of water trading (Rosegrant and Schleyer, 1994). Conversely, if there is very little regulation, then unacceptable costs could be placed on the environment and third parties (Saliba & Bush, 1987: 236). In addition, with little regulation, transacting may become too risky.

Externalities or "third-party" effects are identified by Howe *et al.* (1986) as the main administrative problem in water markets. These externalities take the forms of altered return flows, changed groundwater levels, and water quality changes. A water market transaction will guarantee that both buyer and seller are made better off, but some third parties will gain and others will lose. Gains can be from increased instream flows between the seller and the buyer in the case of an up- to down-stream transaction and from a change in irrigation activities which increase return flows or maintain water quality. Losses can occur when reduced instream flows are experienced by users downstream from the buyer in the case of a down- to up-stream transaction and also from changes in irrigation activities which decrease return flow or reduces water quality. These third party effects need to be accounted for in the decision making process of the transacting parties and the losers should be compensated so that no one is worse off as a result of the transfer (Howe *et al.*, 1986). These effects need to be identified and quantified as accurately and quickly as possible so that adjustments can be made and/or compensation be paid and the transfer can be completed without excessive transaction costs. This can be partially overcome by trading only the consumptive use by water users. Consumptive use of different irrigation methods and different crops in various regions could be estimated by hydrologists and some standards could be prescribed by a public or private water authority, where necessary, to facilitate transactions.

There are also issues of return flows, public goods aspects, and equity considerations, which oppose markets. Other arguments have been identified by Rosegrant and Binswanger (1994). These authors add that the high costs of investment needed to develop markets are exacerbated by the relatively low value of water in developing countries. They also identify externalities as a major problem in the establishment of water markets.

Since these problems exist and are not easily overcome, public institutions are required in some aspects of a water market. Some of their roles are protection against third party impairment from trades and to resolve conflicts among water users (Rosegrant and Binswanger, 1994). These institutions need to be decentralised so that they can make use of local information, which is unique to certain areas, in order to make informed decisions. Despite the many obstacles to water markets, many countries have successfully introduced them, such as the western USA, Australia, Pakistan, Chile and Mexico (Holden and Thobani, (1996); Nieuwoudt, (2000); Bjornlund and McKay, (1996)).

The following chapter discusses the survey methodology. It outlines the hypothesised model and describes the statistical techniques that are used in the estimation of the models. The survey areas are also introduced and described at the end of the chapter.

CHAPTER FOUR

STUDY METHODOLOGY

This chapter is arranged in three sections. The first section outlines the hypothesised economic model of water transfers. The second section describes the statistical techniques that are used to estimate the models. The third section introduces and discusses the study areas of the Lower Orange and Crocodile Rivers.

4.1 The economic model of water transfers

The theoretical economic model was based on the hypothesis that water is likely to be transferred from farmers who have a low return per unit of water because of climatic or soil conditions to farmers who are able to achieve a higher return (Thobani, 1997). In a well-functioning water market, water will have an opportunity cost so both buyers and sellers are expected to adopt water conservation technologies although buyers may be more frugal as the opportunity cost they face may be slightly higher due to transaction cost. No international study of factors associated with buyers or sellers of water could be found, probably because water markets need no justification in a country such as the USA where they have been operating for more than a century.

4.1.1 Economic efficiency hypothesis

The economic efficiency hypothesis for a well-functioning water market is tested in the first model that attempts to identify the characteristics that distinguish between buyers and sellers of water use rights to determine the types of users and uses that water is transferring between. This will indicate the types of users from which and to which water is transferring. From this, conclusions can be drawn as to whether water is moving from relatively less efficient users to relatively more efficient users and hence whether the market promotes efficiency. In addition, if water is transferring from small to large farms, this may indicate that the market does not promote equity in allocation, or, conversely, may show a lack of evidence supporting the notion that a market does little to promote efficiency. The economic efficiency hypothesis is that the buyer of water has a high expected return per unit of water (grows lucrative export crops), is more liquid (cash-flow), has a less negative view of the five-year license review period and uses more advanced irrigation technology. Where irregular river flow is a problem, then other considerations such as lower production risk, lower financial risk and better cash flow may be more important.

4.1.2 Factors affecting future investment in irrigation farming

A second objective of the study was to measure the impact of certain economic variables on future investment in irrigation farming. It was hypothesised that future investment will depend on expected income, risk, risk aversion and liquidity. For more on factors that may be considered in an investment model the reader is referred to Landsburg (1992). This objective was achieved in the second economic model, which identified important factors affecting farmers' investment decisions. Included in these factors is the relatively short license review period. The model will estimate if this is a concern among the farmers and whether it will affect their future investment. The model will highlight factors that stifle investment and allow policy makers to identify what conditions to improve for increased investment in irrigation. Increased investment in irrigation may not necessarily increase the demand for water but may increase the efficiency with which it is used, and more efficient users are able to access more water by purchasing it from less efficient users through the market.

4.1.3 Other research objectives

In addition to the empirical models estimated, additional information will be gathered from the farmers regarding other important issues such as inter-basin water transfers, return flows and transaction costs. Problems experienced in practice may be different to expectations. Also, solutions to some of these problems may become apparent in practice because farmers are forced to deal with them. For these reasons, it is expected that information collected from farmers may be useful to further studies in this field.

This study is intended to add to the current literature on water markets. It builds on a previous study by Armitage (1999), and uses additional techniques such as logit and probit analysis, and also attempts to include the effects of farmers' risk preferences on water trading decisions. In addition, the study will investigate farmers' perceptions on certain aspects of the NWA. The models estimated by the dissertation will provide insightful information regarding the efficiency of local water markets, the effects of risk preferences on market behaviour, and uncertainty towards the security of water rights within the framework of the NWA.

It is clear from the literature that water resources need to be used more efficiently. In addition there are other necessary objectives that must be met. These include equity in water allocation, and sustainable use. A well-functioning market requires a number of necessary conditions to facilitate trading. Firstly, a market requires well-defined property rights. This reduces uncertainty in the market and participants can trade with clear knowledge of what the right to the water prohibits them from doing or allows them to do with the water. The physical and legal framework within which the market operates is also important for a successful water market. It must be physically possible for participants to transfer water corresponding to the traded rights, and also the law must support trades and enable enforcement of the legislation surrounding the trading process. In addition, the law is important in defining the property rights to water.

4.2 Statistical procedures

Special attention is given in this section to the theoretical measurement of risk as it affects the decision-making of water traders. Econometric procedures used in the study are also discussed in this chapter.

4.2.1 Risk and risk aversion

It is hypothesised that investment decisions are influenced by the risk behaviour of the individual. This is especially true in a situation of high risk as is experienced in the SA study areas arising from marketing risk, irrigation water availability, production risk, and policy changes amongst others. The risk aversion of farmers included in the survey was measured using the Arrow/Pratt absolute risk aversion coefficient. The Arrow/Pratt absolute risk aversion is defined as $-U''(x)/U'(x)$ where $U''(x)$ and $U'(x)$ are the second and first derivative of a von Neumann-Morgenstern utility function, $U(x)$. In the study the negative exponential utility function, $U(x)=-\exp\{-\lambda x\}$ is assumed for simplicity as it has a constant Arrow/Pratt coefficient (λ). This utility function is estimated by asking farmers two questions relating to a hypothetical situation where they were faced with two options in each question. In both questions, the farmer had to choose between an amount dependent on the results of a coin toss, and another amount with certainty. The certain amount was then adjusted until a level was reached where the farmer was indifferent between the two choices. A farmer is risk neutral if the certain amount selected equalled the expected income of the coin toss gamble. For the first question, the gamble was an equal probability of earning R1 000 000 (x_{max}) and zero (x_{min}) ($p=0.5$), with an expected income of R500 000. The second question gamble was an equal probability of earning R800 000 and losing R200 000 ($p=0.5$), with an expected income of R300 000. These amounts were chosen to resemble turnover amounts that may occur in the local farming operations managed by the study farmers.

Although the Arrow/Pratt absolute risk aversion coefficient has been extensively quoted in literature, it has a major weakness in that it cannot be compared between different studies as the coefficient depends on the scale and range of the data. Nieuwoudt and Hoag (1993) suggested that the coefficient be standardised, a procedure followed by Ferrer (1999) and also adopted in this dissertation. Standardisation was undertaken by converting the distribution ($x_{min} \leq x \leq x_{max}$) into a distribution ($0 \leq x^* \leq 1$) where x_{min} and x_{max} are the minimum and maximum values on the x-scale. This provides a unit-less expression of the absolute risk aversion function. The algebraic derivation below shows the sensitivity of λ to changes in the scale (whether data are expressed in Rands or Dollars) or range of data.

Let $x^* = (x-x_{min})/(x_{max}-x_{min})$ (1)

$\therefore\ x = x_{min} + x^*(x_{max} - x_{min})$

where $U(x) = -e^{-\lambda x}$ and $U(x^*) = -e^{-\lambda^* x^*}$

$\therefore\ \lambda^* = \lambda(x_{max} - x_{min})$ since λx_{min} = constant.

In this study λ^* is estimated, which is not affected by the range and scale ($x_{max} - x_{min}$) of the data.

4.2.2 Ridge regression

Ridge Regression (RR) allows biased estimation of the regression coefficients by modifying the method of least squares to remedy a multicollinearity problem. If an estimator has only a small bias and is more precise than an unbiased estimator, it may well be the preferred estimator, since it will have a larger probability of being close to the true parameter (Neter *et al.*, 1996:411; Maddala, 1992). The ridge standardised regression estimators are obtained by introducing into the least squares normal equations a biasing constant $K \geq 0$ where K usually varies between 0 and 1. Following Neter *et al.* (1996:412), the *ridge trace* and the V*ariance Inflation Factors (VIFs)* were used to determine the optimum value of K. This is done by choosing the smallest value of K where the regression coefficients first become stable in the ridge trace.

4.2.3 Principal component analysis

Principal Component Analysis (PCA) is a multivariate transformation technique with which a set of complex relations can be reduced to a simple canonical form. The purpose of PCA can also be described as an effort to economize on the number of variables (Jolliffe, 1986). Principal components are obtained by linear transformations of the observed variables as follows:

$$PC_i = a_{i1} X_1 + a_{i2} X_2 + \ldots + a_{ip} X_p \qquad (2)$$

where $X_1, X_2 \ldots X_p$ are the *original variables*; the a_{ip} are the *component loadings* such that $a_{i1}^2 + a_{i2}^2 + \ldots + a_{ip}^2$ = unity or the eigenvalue for PC_i (i.e., normalization). In doing so, PC_1, the first principal component, makes the greatest contribution to the variance as contained in the *p* original variables; the second, PC_2 is chosen to be uncorrelated with the first, and to have as large a variance as possible, etc. The X variates are thus transformed using the correlation matrix (where variables are measured in widely differing units) to new uncorrelated variates, which account for as much variation as possible in descending order (Nieuwoudt, 1977:78). The number of PCs retained also depends upon whether or not the estimated PCs can be meaningfully interpreted.

4.2.4 Logistic regression

This model uses logit analysis to assess factors that influence a farmer's decision to be a buyer or a seller in the water market. If Buyers are coded 1 and Sellers are coded 0, then the probability that a participant is a buyer (P_i) can be represented by:

$$P_i = E(Y = 1 \mid X_i) = \frac{1}{1 + e^{-Z_i}} \qquad (3)$$

where $Z_i = \beta_0 + \beta_n X_{ni}$ and the X_n are n variables hypothesised to explain why water is bought or sold.

This equation (3) represents the (cumulative) logistic distribution function. As Z_i ranges from $-\infty$ to $+\infty$, P_i ranges from 0 to 1. In addition, P_i is nonlinearly related to X_i. However P_i is also nonlinearly related to the β's, and the Ordinary Least Squares (OLS) procedure cannot be used to estimate the parameters (Gujarati, 1995:554). The probability of the i^{th} participant being a seller is $(1-P_i)$, while $P_i/(1-P_i)$ is known as the odds ratio in favour of the participant being a buyer in the market. The natural log of $P_i/(1-P_i)$ is:

$$L_i = \ln\left[\frac{P_i}{1 - P_i}\right] = Z_i = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_n X_{ni} \qquad (4)$$

Now L, the log of the odds ratio, or logit, is linear in X and, more importantly, in the parameters. However to estimate this model, the values of the logit (L_i) must be known. For estimation purposes, (4) is written as:

$$L_i = \ln\left[\frac{P_i}{1-P_i}\right] = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_n X_{ni} + \mu_i \qquad (5)$$

For data on individual participants, the logits are meaningless, as:

$L_i = \ln[1/0]$ if the i[th] participant is a buyer, and

$L_i = \ln[0/1]$ if the i[th] participant is a seller.

In this case, the maximum likelihood method is used to estimate the parameters (Gujarati, 1995: 556). A key advantage of the maximum likelihood method is that it does not require the restrictive normality assumption about the distribution of the independent variables in order to make inferences about the estimated model parameters.

The model analyses permanent trades of water entitlements in the water market, since no temporary trades occurred amongst the survey farmers. The main aim of the model is to identify the important factors that contributed to the farmers' decision to either buy or sell water in the market. The farmer type – Buyer or Seller – is hypothesised to be determined by the *n* attributes (*X*s) of the farm business and the farmer. The dependent variable in the analysis (TYPE) was coded using one (1) for farmers who had purchased water entitlements, and zero (0) for farmers who had sold water entitlements within the past five years.

4.3 The study areas

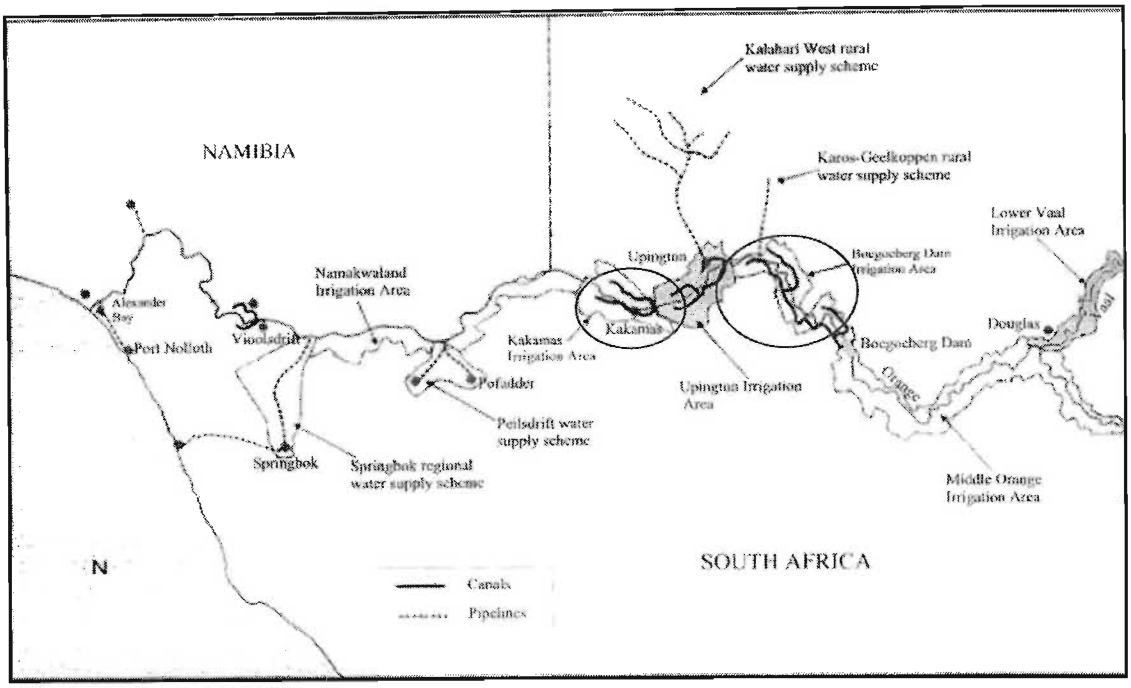
The first section of this chapter discusses the areas studied, which describes the geographic location of the area, brief climatological information, and information regarding the water resources of the area. The second section specifies and discusses hypothetical economic models that will be tested with data collected from the study areas.

4.3.1 The Lower Orange River

The Orange River, South Africa's major river, rises in the Drakensberg in Lesotho, where it is known as the Senqu. The river flows westward for some 2200km ending up in the Atlantic Ocean at Alexander Bay. At the source of the Orange River the rainfall is approximately 2000mm per annum and the rainfall levels decrease as the river flows westward. At its mouth the rainfall is less than 50mm per annum. Evaporation, on the other hand, increases in a westerly direction. The study was conducted among irrigation farmers in the Boegoeberg and Kakamas Irrigation Schemes along the Orange River in the Northern Cape Province during October 2003. These areas are roughly 120km Southeast and 95km Southwest of Upington respectively. Figure 4.1 overleaf shows the location of Boegoeberg and Kakamas along the Lower Orange River, where the study was undertaken (Water Management Area 14). The climate over the Lower Orange region is harsh and semi-desert, with minimum rainfall ranging from 400mm to 50mm per year. This area is totally dependent on the flow of water in the Orange River (RSA, 2002). The largest primary contributors to the economy are made by mining and irrigated agriculture. With over 90 percent of water use in the Water Management Area (WMA) being for irrigation, most attention is given to the continuous improvement of irrigation practices and maximisation of the benefits derived. The tendency for irrigation agriculture has been towards the growing of high value orchard crops and export grapes.

The target population of water buyers and sellers was identified using records obtained from the Department of Water Affairs and Forestry (DWAF) head office in Pretoria and consisted of farmers who had transferred water entitlements between January 1998 and August 2003.

A census survey was attempted, although not all farmers were available to be interviewed and not all the farmers' phone numbers were available. An effort was made to personally interview all farmers who bought or sold water during this time.



Source: www.dwaf.gov.za

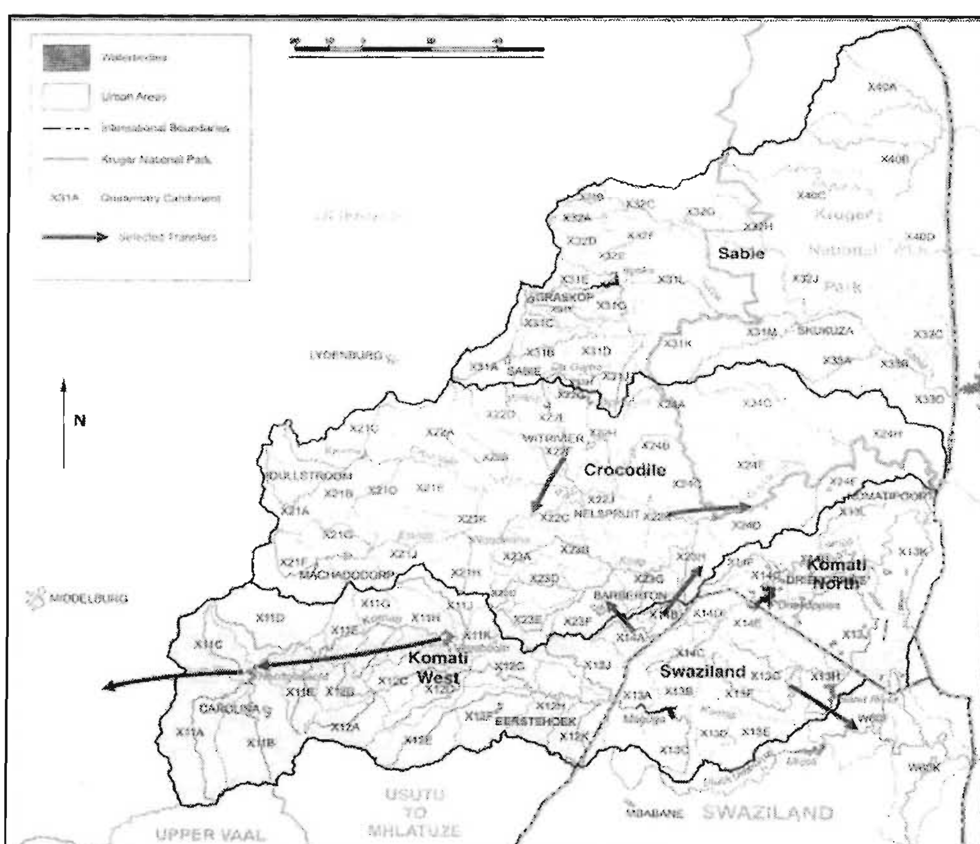
Figure 4.1: Map of the Lower Orange River.

An extensive canal irrigation system exists along the Lower Orange River. Farms usually stretch from the riverbanks to land beyond the canal, which divides them into "inner land" and "outer land". "Inner land" is arable land situated between the river and the canal and is coupled to a canal water right. The lowest cost method (but not necessarily most efficient method) of irrigation for this land is usually flood irrigation, unless the land is unusually steep. "Outer land" is land situated on the inland side of the canal and requires an alternative form of irrigation if the land is to be developed. Originally, water rights stemmed from the riparian rights doctrine, where riparian land which must be situated within a distance of 2000 metres from the banks of the river, and within a height if 60 metres vertically above the river bank. The maximum area allocated to each property was 30 hectares of canal water rights, which could be used to irrigate "inner land". If a property had an irrigable "inner land" area smaller than 30 hectares, then the difference between the 30 hectares and the "inner land" size was allocated to the "outer land" as a river water right. The maximum quantity of water that a right provided annually was determined to be 15 000m^3 of water per hectare. After the completion of the Verwoerd dam in 1997, now known as the Gariep dam, farmers were given the opportunity to buy additional rights over and above their initial allocation. The completion of this dam also allowed regulation of the flow of water below the dam, which provided water users with more consistent access to water. The canals have historically been operated and maintained by the DWAF, but these activities have recently been handed over to the newly formed Water User Association (WUA). The WUA allows farmers to participate in the maintenance duties in order to reduce their levies.

4.3.2 The Crocodile River Catchment

The Inkomati Water Management Area is situated in the north-eastern part of South Africa in the Mpumalanga Province and borders on Mozambique and Swaziland. Topographically, the Great Escarpment (referred to as the gorge section of the river) divides this area into a western plateau and sub-tropical Lowveld in the east. Rainfall varies from 400mm to over 1200mm per year in the mountains (RSA, 2002). The study was undertaken amongst irrigation farmers along the Crocodile River above the gorge, and below the gorge towards Komatipoort during November 2003 with additional interviews conducted in March 2004. The climate in the study area varies from warm subtropical at Nelspruit, above the gorge, to hot subtropical downstream from the gorge. The area below the gorge falls within the

Nkomazi/Onderberg region of Mpumalanga an area that has been thoroughly researched in recent times (NOWAC, 1999). The NOWAC (1999) study reports the following hectares planted under irrigation: bananas (4400), citrus (6000), litchis (330), mangoes (1150), papaya (700), sugar cane (34 000), and vegetables (200). This area produces more than 50 percent of South Africa's banana crop. Figure 4.2 shows the location of irrigation farmers surveyed along the Crocodile River from Schagen (west of Nelspruit) through to Komatipoort (near the border with Mozambique). For an additional map that also shows the major roads, please see Appendix 8 on page 150.



Source: RSA (2002)

Figure 4.2: Map of the Inkomati Water Management Area.

The target population was identified using documents supplied by the Department of Water

Affairs and Forestry (DWAF), which record the names of buyers and sellers of water entitlements from 1998 to 2003. Phone numbers were then obtained from the Malelane Irrigation Board and from Transvaal Suiker Beperk. Very few water market transactions had occurred, with many records indicating land transfers (with the coinciding water entitlement), and internal transfers of water[1]. Many sellers were unavailable, as they had retired and/or moved away. An effort was made to interview as many farmers appearing on the list as possible, and some respondents were neither buyer nor seller – contrary to the list. These cases are possibly internal transfers between different organisational structures with the same owner – such as a company or trust.

The study was undertaken in the same area and possibly on the same farms visited by Bate *et al.* (1999) in order to study dynamic features of the market. A list of farm names visited in the earlier study was available that aided selection. This information was, however, vague and it was often not possible to locate the same farmer as interviewed before. Bate *et al.* (1999) reported few buyers, with four of them accounting for 90 percent of the trade volume. In the present study, six buyers were visited that collectively farm on 85 percent of the irrigated area under the gorge, so the author is confident that the buyers in the earlier study were included. Putter (2004) estimates that about 16000 hectares are under irrigation below the gorge along the Crocodile River.

Sellers in the earlier study were from the Schagen, Cairn, and Alkmaar areas. These areas were revisited and similar, and possibly the same, farmers were interviewed (the location of these areas is above Nelspruit). Holtzhauzen (2004), a former professor in horticultural

1 Transfers between different portions of land owned by the same farmer

science who farms above the gorge, is of the opinion that water from tributaries that flow into the Crocodile River will enter the market in future. He is at present facilitating such a case. It is puzzling that while there is concern about low dam levels and shortages of water that new still unused water may enter the market, which will further aggravate water shortages during dry periods. An opinion is that the Kwena dam has a limited catchment and that it is too high up the river. Holzthauzen (2004) further suggested that another dam at a more appropriate location is the only solution. The issue is then whether farmers will be prepared to pay the full recovery cost of such a dam.

The following chapter discusses the survey results for the Lower Orange River region. The characteristics of the surveyed farmers (Buyers and Sellers) are described. Price trends for water market transactions are also presented. This is followed by a discussion of the farmers' collective opinions regarding certain aspects of the NWA.

CHAPTER FIVE

THE LOWER ORANGE RIVER SURVEY

This chapter analyses and discusses various characteristics of farmers in the Lower Orange River area. Farmers are grouped as either buyers or sellers depending on whether they bought or sold water entitlements in the market.

5.1 Characteristics of water Buyers and Sellers

Thirty-seven farmers were interviewed, of which four questionnaires were unusable as the transfer of water was linked to the transfer of land and therefore was not a water market transaction. Of the 33 remaining farmers, 13 were solely Buyers and 18 were solely Sellers in the water market. Two farmers could not be classified as Buyer or Seller, since they had both purchased and sold water. These farmers were included in the analysis as both Buyer and Seller bringing the total for Buyers to 15 and Sellers to 20. Table 5.1 summarises the average available irrigation land and average water entitlements held by surveyed farmers, and shows that most of these farmers – whether buyers or sellers - held more water entitlements than their actual irrigated area. The typical motive was that additional water was held for future expansion of enterprises.

Table 5.1: Average irrigation land area and water entitlements of survey farmers in the Lower Orange River Region, October 2003.

	Average available irrigation land	**Average actual irrigated area**	**Average water entitlements held**
Buyers (n=15)	221.8 ha	97.2 ha	137.7 ha
Sellers (n=20)	84.8 ha	59.8 ha	73.0 ha

Sellers had, on average, about 22 percent more hectares of water entitlements than actual area planted, whereas Buyers had 41 percent more hectares of water entitlements. This is probably because Buyers purchase water entitlements from Sellers and are in the process of developing new land. Buyers have used, on average, only 43 percent of their available irrigation land, compared with Sellers who have used 70 percent. This means that Buyers on average have more additional irrigation land available than Sellers and this could be a reason for purchasing additional entitlements. This is consistent with Armitage's (1999) findings.

A summary of the cropping enterprises operated by survey farmers is presented in Table 5.2. None of the survey farmers produced dryland crops. The table shows the total land use of all surveyed farmers.

Table 5.2: Irrigated land use by survey farmers in the Lower Orange River Region, October 2003.

	Export (Table) Grapes	**Other Grapes[1]**	**Horticultural Crops[2]**	**Field Crops[3]**	**Total**
Buyers (n=15)	930.8 ha (64.0 %)	404.6 ha (27.8 %)	106.3 ha (7.3 %)	12.8 ha (0.9 %)	1454.5 ha (100 %)
Sellers (n=20)	167.4 ha (14.0 %)	633.6 ha (53 %)	22 ha (1.8 %)	373.4 ha (31.2 %)	1196.4 ha (100 %)
Total (n=35)	1098.2 ha (41.4 %)	1038.2 ha (39.2 %)	128.3 ha (4.8 %)	386.2 ha (14.6 %)	2650.9 ha (100 %)

1 - Wine, juice and/or raisin grapes
2 - Citrus, pecan nuts, mangoes, and melons
3 - Lucerne, cotton, maize, and wheat
Note: Figures in parentheses indicate percentage land use.

About 64 percent of Buyers' land is used for export (table) grape production while only 14 percent of Sellers' land is used for this enterprise. The Sellers have a larger area (53 percent) under wine, juice, and raisin grapes than Buyers (28 percent). This feature was also observed in the earlier study by Armitage (1999). In total, 80 percent of the respondents' land is used for grape production. A much higher percentage of Sellers' land is devoted to field crops (31 percent) compared with Buyers' land under field crops (1 percent). There is a small difference in the area of horticultural crops between Buyers and Sellers. Four Buyers grew citrus and melons whilst one Seller grew pecan nuts.

Scores, indicating the degree of crop diversification by survey farmers were estimated for Buyers and Sellers using the Herfindahl index, which is calculated as follows (Pope and Prescott, 1980):

$$\text{Herfindahl index} = \sum p_i^2 \qquad (6)$$

where $$p_i = \frac{A_i}{\sum_{i=1}^{N} A_i} \qquad (7)$$

A_i = crop acreage of activity i

$\sum_{i=1}^{N} A_i$ = total farm acreage cropped.

The scores are obtained by summing the square of the proportion of each crop grown. A score of 1 means complete specialization, while a score closer to zero shows high crop diversification. Buyers had slightly less crop diversification (0.5119) than Sellers (0.4232), which implies that Buyers are more exposed to market sources of risk than Sellers.

The types of irrigation systems used by survey farmers shown in Table 5.3 consist of drip, micro and flood irrigation systems, while two farmers utilise macro systems. Buyers make more use of advanced irrigation systems (drip and micro), with almost 70 percent of their crops irrigated by either of these systems. A reason for this is that Buyers often develop additional 'outer' land, which cannot be irrigated using flood irrigation.

Table 5.3: Irrigation systems used by survey farmers in the Lower Orange River Region, October 2003.

	Drip	**Micro**	**Flood**	**Macro**[1]	**Total**
Buyers (n=15)	607.9 ha (41.8 %)	390.1 ha (26.8 %)	456.7 ha (31.4 %)	0 ha (0 %)	1209.7 ha (100 %)
Sellers (n=20)	60.4 ha (4.6 %)	128.5 ha (9.7 %)	1123.2 ha (85.2 %)	6 ha (0.6 %)	1073.1 ha (100 %)
Total (n=35)	668.3 ha (24.1 %)	518.6 ha (18.7 %)	1579.9 ha (57.0 %)	6 ha (0.2 %)	2772.8 ha (100 %)

1) Overhead sprinklers
Note: Figures in parentheses represent irrigation use percentages.

Few Sellers use advanced irrigation, and seem to use mostly flood irrigation (85 percent) (some laser levelled flood lands). Sellers usually have less land available for further development, or find it infeasible to develop their 'outer' land, which are often reasons for selling their additional water use entitlements.

5.2 Trends in water prices in the Lower Orange River Region (1998 – 2003)

A total of 49 water-trading transactions occurred for the period 1998 to 2003 amongst farmers surveyed[2]. Although the study was undertaken in 2003, the farmers were asked for details of transactions that occurred within this five-year period. All transactions were permanent, and no temporary trades had taken place amongst surveyed farmers. Farmers were of the opinion that no temporary trades had taken place due to the relatively stable river level – continually high degree of assurance of supply – and the need for long-term rights to water. Two transactions were excluded from the price analysis, as one was water traded for land, and in the other transaction, the farmer could not remember the price of the transaction.

Table 5.4 overleaf summarises the transactions that took place, while the trend in real water prices is shown in Figure 5.1 overleaf. The amount of purchases and sales are not equal because water was traded with farmers who were not in the surveyed areas. Water prices in real terms fluctuated from year to year, presumably in accordance with market conditions of demand and supply of water. There are two measures of price; one is a simple average of the transaction price, and the other is a weighted average of prices. The weighted average is measured by calculating the sum of the total price paid for each transaction and weighted by the total area transacted.

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2 One farmer stated that the trade referred to in the DWAF records for 1998 actually occurred in 1997. The approval date of the transaction was in 1998. This was consequently used as a 1998 transaction.

Table 5.4: Real trading prices of water in the Lower Orange River, 1997 to October 2003.

Year	Purch-ases[1]	Sales[1]	Avg size (ha)	Average Transaction Price/ha (R)	Std Dev[2]	Minimum Transaction Price/ha (R)	Maximum Transaction Price/ha (R)	Average Price/ha[3] (R)	CV (%)[4]
1997[5]	9	21	55.5	R4929	-	R1157	R7233	R4888	-
1998	4	6	45.1	R6327	R3222	R4064	R13548	R5839	50.9
1999	5	1	8.6	R9801	R2106	R7726	R12877	R10404	21.5
2000	7	8	12.5	R11552	R2131	R5499	R14053	R10425	18.4
2001	5	3	15.6	R10333	R1397	R9249	R12717	R10101	13.5
2002	4	1	11	R9276	R1455	R7201	R10589	R9424	15.7
2003	0	2	16.8	R14000	R5657	R10000	R18000	R16328	40.4

1 – These columns represent number of purchases and sales recorded
2 – Standard deviation
3 – Weighted Average – weighted by area transferred
4 – Coefficient of Variation (CV) = standard deviation divided by mean (Spiegel, 1961:73)
5 – Data from Armitage (1999) for years 1994 to 1997
Note: All prices are in real (2003 rand) terms (using the Consumer Price Index (CPI) 2003=100, source: StatsSA).

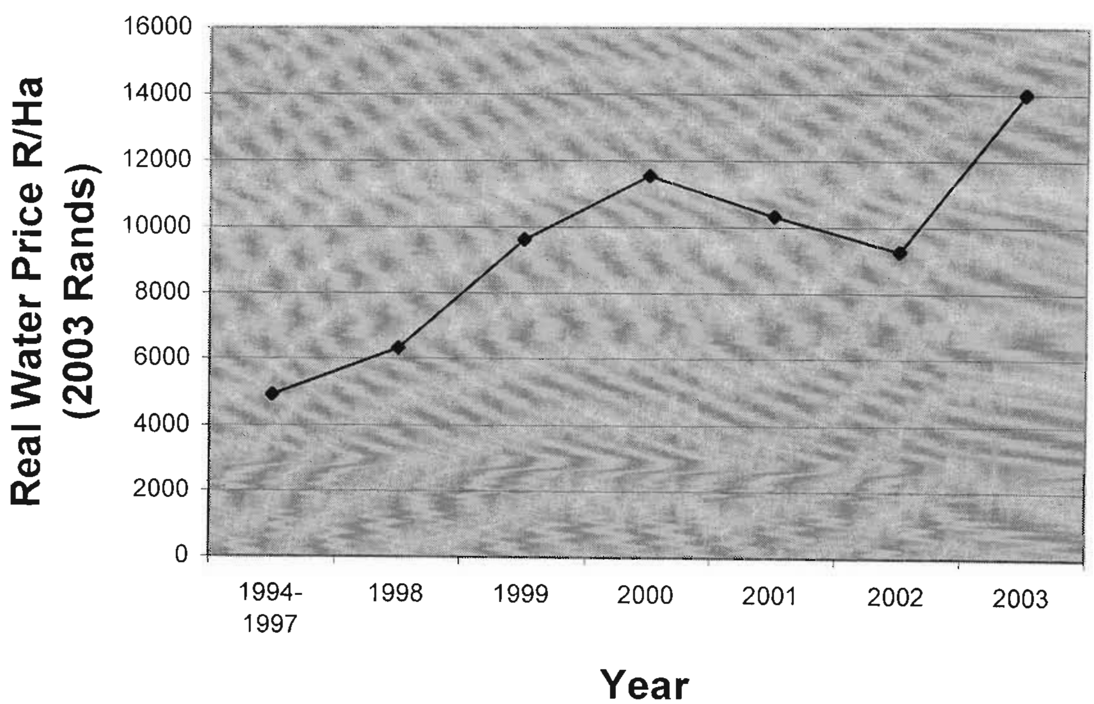


Figure 5.1: Trends in real water prices (2003 Rands) in the Lower Orange River Area, 1997 to 2003 (Average transaction price (R/ha)).

The average size of transactions was 21.19 hectares of water entitlements (or 328500m^3). The average transaction price per hectare of water (15000m^3) for the period was R9882 in 2003 rands, which is R0.66 per cubic meter. This is the sum of the per hectare price for each transaction divided by the number of transactions, and not a weighted average. The total value for all water transacted was R8 906 020 for 1038.1 hectares of water entitlements, which is a weighted average price of R8579 per hectare or R0.57 per cubic meter. The average transaction price per hectare recorded by Armitage (1999) for the period 1994 to 1997 was R4929 per hectare, and the weighted average was R4888 per hectare (or R0.33 per cubic meter) in terms of 2003 rands. This is substantially lower than prices indicated in Table 5.4 (columns 5 and 9) for the subsequent period. The average price of water per hectare for 1998 was relatively low compared with the years from 1999 through to 2003. The price was fairly stable during 1999 to 2002 with a large increase in 2003. The 2003 figure is likely to be an inaccurate representation of the true market price since only two transactions were recorded.

One possible reason for the increased price per transaction from 1997 to 2000 is that supply has become more inelastic due to a reduced supply of unused water entitlements as many unused entitlements have been sold. Most farmers who sold water use entitlements were not using the water and would not have been using it in future due to perceived, relatively high costs of developing 'outer' land. Many farmers considering trading water consulted the DWAF offices in Upington for information regarding available water entitlements. Potential Buyers occasionally use DWAF records to identify farmers with excess unused water entitlements. In addition, farmers intending to sell water inform the DWAF office of their intention (Steenkamp, 2003). In this way, much of the unused allocations have been reallocated, and it is becoming increasingly difficult to find available unused water use entitlements for sale, which has affected the price as competing Buyers vie for fewer available entitlements (more inelastic supply).

The demand for water is a derived demand, derived from the demand for the product, the production function and supply conditions of other factors. The implication is that water prices will increase if expected product prices, and hence profits, increase, especially if supply is relatively inelastic. Table grape export prices are sensitive to the rand exchange rate. The Rand weakened against major currencies during the period studied, which most likely caused an increase in the price of exported grapes. The strengthening of the Rand exchange rate during 2003 to 2004 has, according to several farmers in the region, severely affected profits from export table grapes and it is expected that real water prices will fall again.

Information about the prices of water use entitlements is not freely available, as DWAF offices do not keep records of prices of previous transactions since the agreement for compensation is between farmers. There is also no central notice board that farmers can consult in this regard. Farmers ascertain prices for water use entitlements by 'word of mouth'. This could partly explain why there is such a large range in the price per hectare for transactions. The coefficient of variation (standard deviation/mean) in water prices appears to have declined from 1998 to 2003 (Table 5.4 last column), which would be expected if more information becomes available. The source of additional information in this case could be from the DWAF regional office.

It is difficult to identify temporary transactions in the Lower Orange River water market since most are informal arrangements between farmers along a single section of a canal, and no records are kept of these trades. According to some farmers, few temporary transactions take place because farmers need the long-term security of having water available for perennial crops and prefer covering this need with permanent rights. Many farmers also have more permanent entitlements than water used at present. These excess water entitlements are usually for future enterprise development, and not necessarily for insurance against a lack of water. Water has been readily available over the last ten years, which respondents attribute to the Vanderkloof dam, which has stabilised the flow of water in the river.

5.3 Arrow/Pratt Absolute Risk Aversion Coefficient

The risk profile of the respondents was estimated using the Arrow/Pratt Absolute Risk Aversion (APARA) Coefficient, which is estimated by asking the farmer specifically formulated questions. The first risk question estimates the risk aversion of the farmer where no unfavourable outcome (loss) is allowed (excludes downside risk). The median APARA coefficient for Buyers was 2.44 (n=14) and for Sellers 2.12 (n=20). A positive coefficient implies that farmers are risk averse. The minimum and maximum values for both Buyers and Sellers were -1.18 and 69.28 (n=14). The minimum value was for the farmer who bought and sold water and was classified as both Buyer and Seller. The maximum values for each category were from two different farmers. Three Buyers were risk neutral, and two were risk preferring. One Seller was risk neutral and one was risk preferring. This indicates that the farmers were, on average, risk averse, with Buyers being slightly more risk averse than Sellers. In the second scenario, farmers are faced with downside risk where there is a chance that they can lose money if they select the uncertain alternative. Farmers are more risk averse (downside risk) than anticipated in the questionnaire as almost all of the farmers picked the most risk averse category. That is, they did not pick a choice where money could be lost.

The median APARA coefficient for both Buyers (n=14) and Sellers (n=20) calculated as 3.28 is thus an underestimate. In a choice situation an estimate of 3.28 implies indifference between a certain income of R0 and being given a 50% chance on winning R800 000 and losing R200 000. The mean of this gamble is R300 000 which is a significant reward for taking a risk. All but one of the Sellers and 57 percent of the Buyers would rather not receive any amount in order to avoid the possibility of a loss. Faced with downside risk, farmers are more risk averse than when downside risk is excluded (3.28 exceeds 2.44 and 2.12). The effects of risk on investment in irrigation will be analysed in an investment model. The downside APARA coefficient was not used in the regression models due to lack of variability in the APARA coefficient scores.

5.4 Further analysis of farmer responses

The responses of farmers regarding questions on their opinions about the NWA, and their perceptions regarding the five-year license review period are discussed in this section. Other responses gathered from the questionnaires are also analysed.

5.4.1 Farmers' perceptions of the NWA

Respondents were asked to rank specific questions pertaining to the NWA on a five-category scale ranging from 'strongly agree' to 'strongly disagree'. The statements and the farmers' responses are presented in Table 5.5 overleaf. The responses are categorised as: SA – 'Strongly Agee'; A – 'Agree'; U – 'Uncertain'; D – 'Disagree'; and SD – 'Strongly Disagree'. The responses were also classified according to Buyers and Sellers to identify any anomalies. The total (33) reflects two fewer observations than the total of Buyers and Sellers (35) since two farmers were classified as both Buyer and Seller, but were included only once for the total.

Table 5.5: Summary of farmers' responses to statements made regarding the NWA, Lower Orange River Area, 2003.

Statement	Trade Type	Category					Total = n
		SA	A	U	D	SD	
1	**Buyer**	2	6	4	2	1	15
	Seller	1	5	7	5	2	20
	Total	2	**11**	11	6	3	33
2	**Buyer**	2	9	2	2	0	15
	Seller	2	6	6	4	2	20
	Total	3	**14**	8	6	2	33
3	**Buyer**	1	1	9	4	0	15
	Seller	0	5	10	4	1	20
	Total	1	6	**17**	8	1	33

1 'My opinion of the New Water Act has become more positive since the Act was first published'.
2 'The New Water Act provides increased protection for the environment, which sets it apart from the old Act'.
3 'The New Water Act has made the trading of water use rights (licenses) a simpler process'.

Results show that there is a lot of uncertainty amongst the sample farmers regarding the NWA. Farmers interviewed admitted that they had little knowledge of specific details of the Act, which is reflected by Table 5.5. Responses are evenly distributed around the 'Uncertain' option, while Buyers and Sellers differ regarding the first two statements. Buyers have become more positive about the NWA since it was first published, with 53 percent of responses in agreement with the statement, compared with only 30 percent of Sellers in agreement. Similarly, Buyers feel the Act provides increased protection for the environment (73 percent in agreement) compared with Sellers (40 percent in agreement). The totals for each of the first two statements also reflect more responses in agreement with the statements than in disagreement. However, there is much uncertainty surrounding the respondents' opinions of the Act, suggesting that more needs to be done to supply relevant information to the farmers, especially about the practical implications of the Act, and necessarily at a level of detail that can easily be understood by the non-technical reader.

Responses to the third statement about transfers of water reveal that farmers have experienced no increased administrative burden in the trading process. All traded water must result in a conversion to a water licence (Steenkamp, 2003). The Buyer must apply for a licence for the trade to occur. Farmers stated that although the administrative burden of trading of water is fairly substantial, they had much assistance from the relevant personnel at the DWAF offices in Upington. This support function provided by the regional DWAF office is vital to reducing the transaction costs (including risk), but approval from the Head Office is required and increases the time span of the transaction (Steenkamp, 2003).

5.4.2 Farmers' perception of the five-year review period

Farmers were also asked to rate (on a scale from 0 to 100) the importance of the five-year review of licenses as a factor affecting their investment decisions (REVIEW in Table 5.6 overleaf). Ratings close to 100 indicated that the review period would be a major factor, and zero indicated no effect. Similarly, farmers were asked to rate (on a scale from 0 to 100) what effect the five-year review period would have on the security of water licenses (INSECURE in Table 5.6). Ratings of 100 indicate a high degree of uncertainty surrounding water licenses, and zero indicates that licences are secure. Table 5.6 shows, as was the case in Table 5.5, that the total reflects two less observations than the total of Buyers and Sellers as two farmers were classified as both Buyer and Seller.

Table 5.6: Farmers' ratings of water licence review and security, Lower Orange River Area, 2003.

Aspect	Trade Type	Category					Total
		0-20	21-40	41-60	61-80	81-100	
Review	Buyer	3	0	2	2	8	15
	Seller	6	0	5	3	5	19
	TOTAL	8	0	6	5	**13**	32
Insecure	Buyer	2	0	3	2	7	14
	Seller	4	1	5	3	6	19
	TOTAL	5	1	7	5	**13**	31

Both Buyers and Sellers tend to rank REVIEW and INSECURE on the higher end of the scale. This implies that many farmers feel that the five-year review period will affect their investment decisions, and that the review period affects the perceived security of licenses. This is likely explained by the planning horizon for many of the crops grown in the area, such as vineyard and orchards crops, exceeding five years and farmers' need for assurance of water supply for the lifespan of the crop. In fact, farmers' require security of water entitlements for as long as they run the farming business. The respondents were also unsure as to what would be subject to review, and whether or not any water entitlements held in excess of planted area would be lost due to non-use at review, which could be an additional reason for the absence of a formal temporary entitlement market. The lack of clear information about the review process affects farmers' irrigation investment decisions and the security of the water licenses. The practical implications of the review period should be made clear to farmers as it may be hampering plans to further invest in and develop in the area.

5.4.3 Farmers' reasons for sale/purchase of water

The main motivation for selling water was the large distances that water needed to be pumped to reach their land, the cost of developing 'virgin' land, and the rugged terrain that some farmers are faced with. It was not economically feasible for sellers to develop 'outer' land, while some stated that the land is not suitable for irrigation. Even if such land was suitable for irrigation then export crops such as table grapes cannot be grown. Some Sellers stated that they have more water entitlements than land, while others identified financial constraints. Financial constraints are not expected to be a factor in the long run since in this case farmers with more capital will likely move into the area. Most sellers stated that they were not using the water, and feared losing the water entitlement if they continued their non-use. Buyers tended to use the water to expand development on their farms, with the primary expansion focus in table grape production for export while some mentioned citrus. Some buyers stated that they were in the process of expanding development and had water entitlements exceeding their current water use.

5.4.4 Transaction costs of water sales

Transaction costs can be divided into fixed cost (search cost) and variable cost components, while a distinction could be made between actual and subjective costs (opportunity cost of time). The opportunity cost of time, for trading in water entitlements, appears to be small. The time span of most sales is from one week to three months, which is very short for a sale. This period is short as consent is required only from DWAF. The potential transaction costs arising from disputes and litigation due to negative externalities are usually very low amongst the respondents. The above period can be compared to the transfer time of water sales in the Northern Colorado Water Conservancy District of two to three months which is considered a very short period (Nieuwoudt, 2000).

Actual transaction costs reported by farmers vary markedly from farm to farm. Sellers indicate that buyers are responsible for the cost of the transfer, while most buyers either indicate no cost or they could not remember any cost. Costs depend on whether an agent is used to assist in the transaction or whether a legal person is involved. The cost of an agent (or legal person) could be about 1.5% to 3% of the total sale price. Many mentioned that a plough certificate is required, while one farmer reported land survey costs and another environmental assessment costs.

In most cases DWAF was the main source of information for trading, so this was not an actual cost to the parties apart from the time spent at the DWAF offices and travelling costs. Other sources of information are by word of mouth, the DWAF website and local newspapers. However, there are great differences between minimum and maximum selling prices, which indicate a lack of information on trade prices. The impression is that farmers need simplified and practical information. The market also appears thin (few trades) which increases search cost. Fixed transaction costs (search cost) are reduced if a buyer (seller) trades with many other parties. One buyer had five transactions with two sellers, which must have reduced the cost of information between parties. Olmstead (1998) explained that repeated trading between the same parties in the Westlands Water District in California was due to the high fixed transaction cost. In the Lower Orange it was more common for a large buyer to contract with different sellers. For instance one buyer had seven transactions with six sellers. This could also lead to asymmetric information where buyers know more about water prices than sellers. In summary, transaction costs appear low in most cases, as approval is only needed from DWAF (no disputes and litigation), while transaction time is short (opportunity cost of time low). Although DWAF provides a clearinghouse for sales, the impression is that there is generally a lack of information about water trading opportunities (information is relatively costly).

5.4.5 Water conservation practices

Some buyers indicated that they have always used drip irrigation and conserved water this way. One buyer indicated that water entitlements he saved by using water conservation strategies, he uses to irrigate a larger area. He also uses conserved water entitlements for security purposes. For instance water allocation is 15000 cubic meters per ha but by using drip (arguably) only 7000 cubic meters per ha is used. According to another this practice is not allowed, so there is uncertainty regarding what is permitted. The former farmer also irrigates a small area under lucerne, which he uses as a water reserve for his table grapes. Most sellers indicated no change in water conservation methods although some mentioned levelling of flood lands. Some sellers indicated that water conserved in this way is used to irrigate a larger area while others keep it for security purposes.

5.4.6 Externalities associated with irrigation practices

The irrigation of outer land could lead to a salinity build-up on inner land, implying that externalities are not internalised if the owners of adjacent inner and outer land are not the same person. All transfers have been from non-users to users, which mean that transfers will reduce in-stream flow. Application of the NWA will prevent this if no surplus water is available. Further, all transfers are also from higher up the river to down stream users. This is the more desirable direction of transfer (in the Western USA, transfer from down to up-stream is not permitted) as in-stream flow is reduced below the point where water is withdrawn from the river. The transfer of unused water from Boegoeberg to Kakamas means that the transfer does not adversely affect employment and economic activity in the former area.

5.4.7 Total water market transactions in Boegoeberg and Kakamas

Table 5.7 shows the numbers of water trades that have been approved by DWAF in Boegoeberg and Kakamas from 1998 to June 2003. Some of the transactions consist of the sale of many small irrigation plots by the same farmer. Each plot is entered as an entry in the register, explaining the large number of entries compared to transactions, especially in Boegoeberg. The export of water from Boegoeberg was matched by imports from Kakamas. The number of transactions declined in Boegoeberg after 2001, while the area imported in Kakamas also declined in that year. In both areas few trades were approved since 2002. The large number of sales in 1998 and shortly afterwards gives the impression that sales were motivated by perceptions that unused entitlements would be lost.

Table 5.7: Water market transactions, Boegoeberg and Kakamas, 1998 to June 2003.

	Boegoeberg			Kakamas		
Year	**Transactions**	**Entries**	**Hectares**	**Transactions**	**Entries**	**Hectares**
1998	40	165	-282.1	17	26	+596.5
1999	15	82	-151.8	24	33	+132.9
2000	32	74	-237.6	26	29	+235.2
2001	11	30	-140.6	30	37	+4.6
2002	3	7	-56.8	6	8	+32.3
2003	5	9	+7.9	0	0	0
Total	106	367	-861.0	103	133	+1001.5

Source: Ceronio (2003).

During 1998 to June 2003, 861 ha of water entitlements were transferred out of Boegoeberg. The net sales of farmers in Boegoeberg included in the survey were 316.6 ha for the same period. According to Table 5.7, Kakamas imported 1001.5 ha. The corresponding net purchases by surveyed farmers were 480.3 ha. It appears as if farmers in the sample were responsible for a considerable proportion of water traded in these areas.

The following chapter discusses the survey results for the Crocodile River region. The bio-climatic conditions experienced in the areas within the catchment are discussed. Problems with water transfers are highlighted and discussed as this market operated differently to that in the Lower Orange River area. The characteristics of the surveyed farmers are described. Price trends for water market transactions are presented and discussed. This is followed by a discussion of the farmers' opinions regarding the same aspects of the NWA discussed in section 5.4 above.

CHAPTER SIX

THE CROCODILE RIVER SURVEY

This chapter discusses the growing conditions experienced in the Crocodile River Region and analyses and discusses various characteristics of farmers in the region. Farmers are grouped as either buyers or sellers depending on whether they bought or sold water entitlements in the market.

6.1 Nature of water transfers

All but one of the trades (permanent and rent) observed in the Lower Crocodile River occurred from farmers above the gorge to farmers below the gorge and all transfers were from up- to down-stream. Only water that was not used was sold or rented out.

6.1.1 Bio-climatic conditions in areas trading in water

In a well-functioning water market it is expected that water will move from less desirable land to land where the return per unit of water (allowing for risk) is higher. It is thus essential to understand the climatic conditions in this area in order to draw conclusions regarding the desirable outcomes of transfers of water. Holtzhauzen (2004) is of the opinion that the reason why water moves from above the gorge to below is because of constraints faced by farmers above the gorge such as financial and management. He believes that the soils above the gorge can be improved artificially. If these were the only constraints on horticultural production above the gorge then, from an economic point of view, one would expect that new farmers who are financially stronger and better managers would move into this area. This is not the case. Economic logic thus does not support the reasoning that the binding constraints above the gorge are financial and management, although these may play a role.

Wolstenholme (2004) attributes the movement of water from above to below the gorge to better growing conditions below. Wolstenholme (2004), a retired professor in horticultural science, often consults in this area while he also grew up nearby (White River). Wolstenholme's observations are strongly supported by Bower (2004), also a professor in horticultural science, who for many years worked in this area (Nelspruit) as a horticulturalist. All the information regarding growing conditions provided in this section is from Wolstenholme (2004) unless another resource is referenced.

More specifically, the reasons for the relatively unfavourable growing conditions above the gorge are the following. The soils above the gorge from Schagen down are sandy (low clay - below 10 percent - and low organic matter content) which means that water and minerals cannot be stored to any significant degree. Temperatures above the gorge are also not hot enough for the heat loving crops under irrigation (sugar cane, mangoes, grape fruit, Valencia's and bananas) while on the other hand it is not cool enough for temperate crops that require coolness (pecans). The heat loving crops achieve greater yields below the gorge. Under good husbandry (irrigation and fertilization), orcharding is possible above the gorge but conditions are not as favourable as below. Downstream from the gorge, different soil types occur but generally with a higher clay content. The best soils are the Basalt found near Komatipoort. These soils are rich in calcium, potassium and magnesium.

The suitability of the two areas to specific crops is instructive to an understanding why water entitlements are transferred from up- to down-stream.

Citrus. Hall and Sons, a well-known citrus grower above the gorge has now pulled out all their citrus trees. A reason is that the relatively cooler climate above the gorge coupled with moist conditions leads to relatively high humidity levels in which the bacteria *Citrus psylla* flourish. These bacteria cause greening in citrus. Fruit infected with this disease are small, have a bitter taste, and cannot be exported or even sold locally (Bower, 2004). This disease is also the reason why farmers in White River stopped producing citrus in the 1950's and 1960's. Downstream from the gorge, it is hotter and relative humidity is thus lower and *Citrus psylla* does not thrive. The heat experienced here inactivates the bacteria further. There are still large citrus growers near Nelspruit (above the gorge).

Macadamia. Macadamias grow well above the gorge (Holtzhauzen, 2004) and production is expanding (Malan, 2004), but growing conditions in other areas, such as in White River, are better (higher lying country, red soils which are more weathered with a higher clay content).

Tobacco. Tobacco yields are higher than average above the gorge and a relatively large area is under tobacco (Malan, 2004). Tobacco, however, requires high production costs and risk is consequently high. Malan (2004) is of the opinion that the high income variability limits the area under tobacco per farm.

Avocado. Avocados are more suited to a cooler climate with more clay than is the case above the gorge.

Vegetables. Holzthauzen (2004) considers vegetables a possible crop above the gorge but Malan (2004) contends that vegetables will be less productive in the sandy soils. Vegetables do not appear to be an attractive crop even below the gorge where soils are more suitable. Sugar cane has replaced vegetables downstream towards Komatipoort. This indicates that vegetables are not as attractive a crop as sugar cane. At one time the area towards Komatipoort was considered as South Africa's winter pantry for vegetables as it is frost free, but risk arising from pests and price uncertainty has lead to its replacement by sugar cane.

Maize. Maize can be grown above the gorge (Holtzhauzen, 2004) but profits from this crop cannot be compared to that of other horticultural crops and sugar cane grown downstream. It is highly unlikely that water will be used for maize if it can be used for horticultural crops or sugar cane.

Pecans. The area above the gorge is not hot enough in summer and not cold enough in winter. Pecan production has shifted from these areas toward the Middle Orange River in the North Western Cape.

Sugar Cane. As it is cooler above the gorge a longer growing cycle is required relative to below the gorge. Sugar cane requires heavy applications of fertilizer, which must be even higher on the sandy soils above the gorge. Some sugar cane is grown near Nelspruit but a further cost is that it is a bit far from the Sugar Mill.

Paw-Paw. Paw-paws production is possible in the hotter climate downstream from the gorge.

Mangos. Mangos are better suited to dry heat and do better downstream from the gorge.

Bananas. Frost is a problem near the river upstream. Yields downstream are higher.

The issue in a water market is not whether crops can be economically viable above the gorge but whether this area will provide the same return per unit of water (allowing for transaction cost and risk) as downstream. Bio-climatic conditions indicate that the area downstream is more conducive to horticultural production which supports the downstream movement in water entitlements. According to Holtzhauzen (2004) the area above the gorge can produce vegetables, tobacco, macadamias, citrus (naartjies), and litchi's, but because water rates are high, farmers sell their water. This statement implies that expected profits do not even cover water charges or that the farmer wants to keep water for possible future use or sale. This tends to be supported by the phenomenon that the lease price is sometimes zero. The real sale price, however, has varied from about R2000 to R12 000 (2003 Rands) per hectare since 2000 indicating a greater demand for more permanent rights. If the lease price is non-zero then it would be more correct to say that the high opportunity cost for water (water price and tariff) facilitates transfers. The seller of water is not only faced with the water tariff but the opportunity income of renting it out or selling it.

6.1.2 Importance of risk and cash flow in crop selection

It is of interest why the major area in this basin is under sugar cane as incomes from other crops are higher. Farmers see sugar cane as a lower risk crop than other crops, which partly explains the choice of the crop (NOWAC, 1999). Sugar cane has fewer pests, is reasonably drought resistant, has an established marketing and service structure that exists once a milling facility has been established, has more regular cash flows and smaller fluctuations in market prices, and requires less expertise and management inputs.

Some of these factors are further discussed:

(a) Uncertainty of supply of water.

The flow of the Crocodile River is highly irregular, which means that water management is crucial. Sugar cane can still survive without irrigation although yields will be considerably lower in the year of drought. The plant, however, will recover if conditions improve again. Bananas and citrus will suffer not only in the current year but the following year's production is also adversely affected (Bower, 2004). During relative water scarcity, farmers can switch their water from enterprises the least affected by reduced water application (sugar cane) to those the most affected. Vegetables are generally under drip irrigation, which helps water management, however without water no yield is possible. The uncertain water supply explains why a farmer who had a large area under bananas and no other crops was keeping almost double the volume of water entitlement than he actually applied. The retention of 'surplus' water entitlements as a risk management strategy is supported if this water is needed in dry periods. Due to the uncertainty in water supply the unused water may be seen as an existing lawful use of water and be given legitimacy.

(b) Positive cash flows at an early stage are desirable.

Income from sugar cane is earned during the second year depending on the harvest cycle, while with horticultural crops the farmer has a cash flow problem in early years. Holtzhauzen (2004) downplays this as he considers that newer varieties of macadamias and certain citrus cultivars could come into production sooner. (Wolstenholme, 2004) agrees with the introduction of early varieties but for many subtropical fruits the break-evens of incomes and costs are only reached after six or seven years. Cash flow data for this area indicate that the highest gross margin for sugar cane and bananas is reached in the second year, Valencias show negative gross margins for five years, while litchi's and mangoes show negative gross margins for three years after which it gradually increases (Conningarth Consultants, 1998). Macadamias have a negative cash flow for five years and break-even after seven years (Macadamia Growers' Association, 2004). This may further explain the relatively large areas under sugar cane and bananas. Conningarth Consultants (1998) conclude that the so-called high yielding horticultural crops only show a higher return than sugar cane from six years (grapefruit) to about 14 years (Valencias) at a four percent discount rate. At a higher discount rate sugar cane appears even more attractive.

(c) Marketing risk.

Sugar cane has an established marketing structure with product prices set by the local industry. Farmers interviewed in the area exhibited a high level of risk aversion (down-side risk), which further explains the attractiveness of sugar cane.

6.2 Characteristics of water buyers and sellers

A total of 18 farmers were interviewed, consisting of six buyers, nine sellers (six permanent and three temporary) and three that were neither buyers or sellers. Although the number of farmers is small, some of these farmers entered into several contracts, for instance, one farmer leased from 12 lessors. The respondents were classified as either buyer or non-buyer for the analysis. Due to the low number of permanent transfers encountered, short-term leases of water were included in the analysis. Participants who lease water inwards are regarded as buyers, and farmers leasing water outwards, or who did not participate in the market are regarded as non-buyers. Participants who had both purchased or sold, and leased water were only included once for the summary data. This classification resulted in six buyers and 12 non-buyers (6 permanent sales, 3 temporary leases, and 3 non-participants), which is a relatively small sample.

6.2.1 Water entitlements and land use

The total land areas farmed and summary of water entitlements owned by respondents are presented in Table 6.1 overleaf. Buyers farm a larger area than non-buyers, but do not have enough permanent water entitlements for the area planted, and have to lease or purchase a large amount of water to irrigate their crops. There is also a wide range of sizes of buyers indicated by the mean and the median. These measures indicate that there is a positively skew distribution of farmed area. This is caused by data collected from a company, that produces 8000 hectares of sugarcane in this region. There are also two other buyers who farm relatively large areas of about 1000 and 2000 hectares each. Non-buyers tend to own an excess of water entitlements, which they might hold for times of drought, lease to other farmers, or sell to other farmers.

Table 6.1: Area farmed and water entitlements before and after sampled transfers, Crocodile River, 2003.

		Farmed area (ha)	**Surplus (Deficit) entitlements – after transaction (ha)**	**Surplus (Deficit) entitlements – before transactions (ha)**
Buyers (n=6)	**Total**	12 156	(592)	(1584)
	Mean	2 026	(99)	(264)
	Median	809	(13)	(89)
Non-Buyers (n=12)	**Total**	458	136	301
	Mean	38	11	25
	Median	40	1	19

Source: van Aswegen (2004).

The data indicate that buyers who are situated below the gorge had significantly exceeded their water use entitlements. These data include permanent water entitlements only, and temporary arrangements could lessen the excess. Farmers downstream from the gorge have rented and purchased in recent years to make up some of their deficit. In addition, farmers using drip and other advanced irrigation systems indicate that their usage is below the prescribed allocation of 13 000 cubic meters per annum, which implies that they can irrigate a larger area. For example, a one-hectare entitlement (13 000m^3) could be used to irrigate 1.3 hectares if the irrigation method only uses 10 000 cubic meters per year.

Deacon (2004) contends that the excess use of water without enough water rights is particularly a problem below the gorge as in his view farmers simply expanded production even though they did not have entitlements to the water to support the expansion. He does not have a problem with farmers who irrigate a larger area than their allocation if they use drip irrigation as long as their volumetric entitlements are not exceeded. He contends that many farmers far exceed their volumetric entitlements and that this has put the system under stress. He, however, thinks that there is enough water in the system to justify current entitlements if every farmer only uses what he is entitled to. This view is somewhat different from that of Comrie (2004) who is of the opinion that demand exceeds supply in the system.

Table 6.2 overleaf summarises the land use of the respondents. The main crops produced by the buyers were sugar cane, bananas, and citrus while non-buyers produced more macadamia nuts, mangoes, and avocados. The table shows the area under production for each crop type produced by Buyers and Non-buyers. The number of respondents, the average area and standard deviation is also shown. The large size of buyers compared with non-buyers is evident in Table 6.2.

Table 6.2: Crop production of respondents in the Crocodile River Basin, November 2003 and March 2004.

	Sugar	Banana	Citrus	Nut Trees[1]	Other Trees[2]	Crop Rotation	Vegetable
Buyer Area (ha)	9900	1256	862	37.2	61	40	0
Number of Buyers	4	4	2	1	2	1	0
Average Buyer Area (ha)	2475	314	431	37.2	30.5	40	0
Std Dev (ha)	3715.7	134.22	295.57	NA	41.72	NA	NA
Non-Buyer Area (ha)	55	0	102	132	70.6	50	48
Number of Non-Buyers	2	0	4	6	4	1	2
Average Non-Buyer Area (ha)	27.5	0	25.5	22	17.65	50	24
Std Dev (ha)	10.61	NA	19.67	16.91	21.68	NA	8.49

1 – Macadamia and pecan nuts
2 – Litchi, mango and avocado trees

The median area under sugar cane is 907.5 hectares. The median is a better indication of the situation because of the large area (8000ha) of sugar cane operated by a company that was surveyed. Buyers grow relatively large areas of sugar cane, banana, and citrus, while non-buyers produce on relatively small parcels of land. This is probably due to the fact that most (5 of 6) buyers are located below the gorge. The buyer located above the gorge purchased more water entitlements so that he could sell a portion of his land. The buyers from below the gorge mostly used purchased water for crop production and one farmer used the purchased water for assurance of supply (security). The area below the gorge seems more suited to large scale farming enterprises, since there are more relatively flat areas, hotter climate, and better soils. The crop types grown by buyers and non-buyers are consistent with the earlier discussion of crops, given that most buyers were located below the gorge and most of the non-buyers were located above the gorge (11 of 12). Sellers of water did not cease production of crops in order to sell water but sold water that was not used for irrigation. The reason for having an unused water entitlement was that it was too costly to pump the water to the productive land.

6.2.2 Crop diversification

Crop diversification scores were calculated for buyers and non-buyers by using the Herfindahl index (Pope and Prescott, 1980). A score of 1 means complete specialization, while a score closer to zero shows high crop diversification. The average crop diversification score for buyers is 0.73, with one farmer specialising in macadamia production, and the average score for non-buyers is 0.70, with three farmers specialising in macadamia production and one farmer specialising in citrus.

6.3 Problems with water transfers in the Crocodile River

Table 6.3 overleaf shows the water market transactions that occurred in the Crocodile River from 1998 to 2003. The table was compiled from the records received from the DWAF, which records all transfers of water allocations. These include transfers of water between the same farmer to different portions of land, and also water transfers associated with transfers of land.

According to Table 6.3, the water market was active during the period 1998 to 2000, which was also the case during 1994 to 1995 when Bate *et al.* (1999) conducted their study. Few transactions have been approved from 2001 onwards. Some farms comprise of several irrigation plots explaining why the entries in Table 6.3 exceed the number of transfers.

Table 6.3: Water market transactions in the Crocodile River: 1998 – 2003.

	Entries (Plots)	**Transactions**
1998	11	8
1999	29	27
2000	57	41
2001	1	1
2002	4	2
2003	0	0

Source: C. Ceronio, (2003).

Transfers of permanent water rights in the Crocodile River area have ceased and some farmers say that the situation is chaotic as no applications are currently (2004) being processed. The only transfers that currently take place in the Crocodile River are rental agreements. This is in direct contrast to the situation in the Lower Orange River where permanent transfers take a short period. According to Joubert (2004) the problem is that in many cases there is no existing use and the seller must first apply in terms of article 33 of the NWA for the use to be an existing lawful use. Alternatively, the seller can apply for a license. The seller must have been an existing lawful user for at least two years before October 2002 (the legal application of the Act).

Joubert (2004) considers that the following two reasons may explain the lack of approval of permanent transfers in the Lower Crocodile River compared to the Lower Orange River. (1) Availability of water in the Crocodile River is a problem while the flow in the Orange River has been more reliable. This appears to be a major problem as the Crocodile River flow is irregular. The normal flow of the river must be considered while other commitments such as international obligations must be honoured. One can only think that transfers at present complicate the water scarcity problem as all sales have been from farmers who did not use the water for irrigation. (2) The Orange River is a Government Water Scheme, which implies that farmers pay water tariffs for the area listed under irrigation (usually where the State built a dam). Only a part of the Crocodile River is a Government Water Scheme as other parts of the river (including tributaries such as the Lomati and Komati) are Government Water Control Areas. The latter mechanism is created to control the water use in areas where over-use is a problem. The payment of a water tariff is an aid to establish a lawful use but it does not make the use lawful automatically. Other regional problems are lack of qualified staff, which may explain delay in processing of applications as the region must visit and verify the volume of transfers. Joubert (2004) also states that a farmer may keep more water rights than what he actually uses in a particular year because he needs it as a security for drought. The point is that water must not be wasted and use must be beneficial. As licenses are not specifically described in the NWA he prefers to issue licences in terms of Chapter 4 of the NWA.

Comrie (2004) at the regional office of DWAF in Nelspruit supports the view of Joubert (2004). Comrie (2004) states that demand exceeds availability during dry periods. The Kwena dam contributes a relatively small part of the water needs of the entire area (Government Water Scheme), which means that a large part of the catchment area falls outside DWAF direct control. All permanent water transfers must be verified and supported by the regional DWAF office at Nelspruit. Transfers of water from tributaries of the Crocodile River would be irresponsible, as this will aggravate the situation of water scarcity and the only route that Comrie (2004) sees is compulsory licensing. The reason why no transfers take place is because there is no unused water to transfer. In future one would expect that used water would be transferred. He concurs with Joubert (2004) that a farmer could retain surplus water for dry periods.

6.4 Analysis of prices of permanent water transfers and rentals

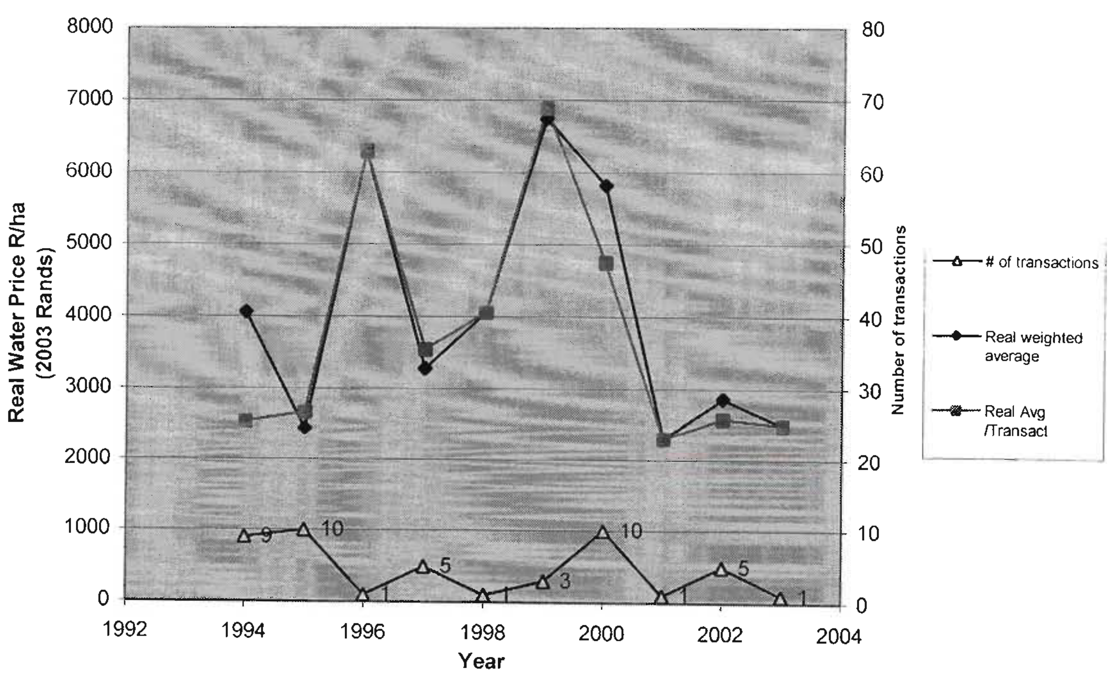
6.4.1 Price trends of permanent water transfers

Table 6.4 overleaf shows average trading prices of water from 1994 to 2003. Data for 1994 and 1995 were obtained from Bate *et al.* (1999), which also included two transactions in 1995 recorded during this study. The table shows both average price of the transactions, and average price of water weighted by area. The size of transactions (ha) and prices are defined in terms of area above the gorge, which allocates water at a rate of 8000 cubic meters per hectare per annum. Below the gorge the water allocation is 13000 cubic meters per hectare. The trends in average prices and number of transactions recorded are presented graphically in Figure 6.1 overleaf. The figure also includes the number of transactions that were recorded during the survey. The number of transfers shown in Table 6.3 for 2002 and 2003 are lower than the number of transactions observed in Table 6.4 for these years. These transactions in Table 6.4 have not necessarily been processed by the DWAF; the actual contracts between farmers have, however, been drawn up and signed.

Table 6.4: Real trading prices of water in the Crocodile River, 1995 to October 2003.

Year	Trans-actions (Number)	Total Size (ha)	Average transaction Price (R/ha)	Std Dev[1] (R/ha)	Min (R/ha)	Max (R/ha)	Average Water Price/Ha[2] (R/ha)	CV (%)[3]
1994[4]	9	5.9	2547.6	1907.6	688.1	7164.5	4064.9	77.3
1995[4]	10	14.6	2672.0	1204.2	847.6	5063.5	2445.5	45.1
1996	1	141.4	6290.9	NA	6290.9	6290.9	6290.9	NA
1997	5	59.2	3547.3	1097.9	2895.7	5429.5	3276.0	30.1
1998	1	28.5	4064.3	NA	4064.3	4064.3	4064.3	NA
1999	3	80.0	6890.7	897.3	6309.6	7924.1	6922.0	13.0
2000	10	505.5	4760.2	1851.9	2444.0	7520.0	5863.8	38.9
2001	1	7.7	2312.2	NA	2312.2	2312.2	2312.2	NA
2002	5	230.6	2588.2	363.2	2117.9	3137.6	2860.2	14.0
2003	1	27.0	2500.0	NA	2500.0	2500.0	2500.0	NA

1 – Standard deviation of the average transaction price
2 – Weighted average price: total price (R) divided by total area (ha)
3 – Coefficient of Variation = standard deviation divided by mean (Spiegel, 1961, p. 73)
4 – Data from Bate *et al.* (1999) included for these years. Two transactions for 1995 are from the current study
Note: All prices are expressed in real (2003) terms



Note: Data from Bate *et al.* (1999) included for the years 1994 and 1995

Figure 6.1: Trends in real water prices (2003 Rands) in the Crocodile River, 1994 to 2003 (Average transaction price (R/ha)).

There is no apparent trend in water prices during the period 1994 to 2003, although an increase during 1994 to 1999 and a decline during 1999 to 2003 are discernable. The high price for 1996 is questionable as it is based on only one transaction and may be misleading. The range, standard deviation, and coefficient of variation show that there has been a large variation in prices paid per hectare. It appears as if the coefficient of variation in prices has fallen over time, which will occur if information improves.

Prices paid by each *individual* buyer also vary substantially. Two respondents purchased water from 12 and 9 different sellers. The average price received was R3245.49 and R4468.32. The standard deviation was R1418.00 and R2220.73 respectively. Since there are few buyers and many sellers, it is likely that there is an asymmetrical distribution of information as buyers have better knowledge about availability and prices than sellers. The price is higher for larger transactions, which may indicate that the bigger the area offered by the seller, the more bargaining power the seller has and can thus negotiate a higher price. There is expected to be transaction costs involved during trading of water. The buyer may also pay a higher price per ha for a larger transaction than for many small transactions due to relatively fixed transaction costs. Some of these transaction costs include lawyer's fees, DWAF administration fees, search costs, and the cost of time spent on setting up the trade (negotiation, search, administration, etc).

Prices vary within each year, most notably 1994, 1995, and 2000, as well as over the entire period. This reinforces the notion that there is an asymmetry of information, and possibly a lack of information in the market. Farmers can gain information through word of mouth, the main irrigation board, and the use of attorneys. One major difference between this area and the Lower Orange River is that farmers make use of attorneys when transferring water, while farmers in the Lower Orange River primarily use the personnel at the Regional DWAF Offices in Upington to gain information and broker the deal.

6.4.2 Rental price, water tariff, opportunity cost, and rate of return

Farmers enter into legal contracts for rental agreements usually for a period of one year although in one case the rent period was stated as at least 40 years. One large lessee rented from 12 lessors. The average lease paid for the 12 contracts was R95.04 per hectare with a standard deviation of R21.26 per hectare. This is the price that the lessor receives for an entitlement of one hectare at 8000 cubic meters per annum[3], which is a price of 1.188 cents per cubic meter. In addition to this, the lessee pays the tariff that applies to the entitlement. The water tariff at present (2004) is R104.88 per hectare per year or 0.777 cents per m^3 below the gorge, and R68.40 per hectare per year or 0.855 cents per m^3 above the gorge. The following economic conclusions can be derived from these data: (a) it is clear that the lessee has asymmetric information as rentals prices vary. (b) The opportunity cost of the water is 1.965 cents per cubic meter (1.188 cents plus 0.777cents) for a water user below the gorge or R255.45 per year per ha (1ha=13000 cubic meter of water). This is the gain that the market attributes to the scarce resource water at the margin. (c) With a water rental of R95.04 and a water price of R2573.5 (average for 2002 to 2003), the real rate of return on an investment in water is 3.7% (from this calculation water tariff is excluded as it is a cost to the lessor). This statistic may be on the low side as farmers may pay more for permanent transfers in this area as it gives them more security of future use. This statistic, however, questions real discount

3 The water allocation above the gorge is lower as rainfall is higher. As cubic meters of water are transferred, a buyer below the gorge needs to purchase 1.625 hectares of water entitlement above the gorge in order to obtain one hectare of water entitlement.

rates in water studies of often as high as 13 percent (Louw, 2001: 204).

6.5 Further analysis of farmer responses

The responses of farmers regarding questions on their opinions of the NWA, and their perceptions regarding the five-year license review period are discussed in this section. Other responses gathered from the questionnaires are also analysed.

6.5.1 Farmers' perceptions of the NWA

Respondents were asked specific questions regarding the NWA. A five-category scale ranging from 'strongly agree' to 'strongly disagree' was used to elicit perceptions of the sample farmers regarding specific statements relating to the NWA. The responses are categorised as follows: SA – 'Strongly Agee'; A – 'Agree; U – 'Uncertain'; D – 'Disagree'; and SD – 'Strongly Disagree'. Table 6.5 summarises these responses in three rows, with each row representing a statement, which is given below the table.

Table 6.5: Summary of farmers' responses to statements made regarding the NWA, Crocodile River, 2003.

Statement	Category					Total = n
	SA	A	U	D	SD	
1	1	5	7	4	0	17
2	2	9	5	1	0	17
3	1	3	11	2	0	17

1 'My opinion of the New Water Act has become more positive since the Act was first published'

2 'The New Water Act provides increased protection for the environment, which sets it apart from the old Act'

3 'The New Water Act has made the trading of water use rights (licenses) a simpler process'

A total of 17 farmers responded to these statements. One farmer did not have enough time to answer this section. There is, like the Orange River area results, much uncertainty regarding the Act in this area. On average, 45 percent of respondents answered 'Uncertain' for the three questions. The responses tended to be more on the 'Agree' side of the scale than 'Disagree'. There are more farmers who feel more positive about the Act than those who feel negative. Part of this negative sentiment could stem from a lack of information available to farmers concerning aspects of the Act. There is a lot of information available from DWAF, and farmers are able to obtain a copy of the Act, however, much of the information may be too technical and cumbersome for a non-technical reader. The second statement reveals that farmers generally feel that the new Act offers more protection for the environment. The final statement shows that farmers are very unsure about trading of water under the new Act. This is probably due to some of the problems with trading as mentioned in section 9.3.

6.5.2 Farmers' perception of the five-year review period

Farmers were also asked to rate (on a scale from 0 to 100) the importance of the five-year review as a factor affecting their investment decisions (REVIEW in Table 6.6 overleaf). Ratings close to 100 indicated that the review period would be a major factor, and zero indicated no effect. Similarly, farmers were asked to rate (on a scale from 0 to 100) what effect the five-year review period would have on the security of water licenses (INSECURE in Table 6.6). Ratings of 100 indicate a high degree of uncertainty surrounding water licenses, and zero indicates that licences are secure. Table 6.6 summarises these responses. Some farmers were uncertain and did not give a rating.

Table 6.6: Categorised scale ratings of review and security of water licenses responses, Crocodile River farmers, 2003.

Aspect	Category					
	0-20	**21-40**	**41-60**	**61-80**	**81-100**	**Total**
REVIEW	6	0	5	0	2	13
INSECURE	5	1	7	2	1	16

There is a fairly even spread of ratings for both REVIEW and INSECURE, with most of the ratings falling within the middle and lowest categories. This indicates that farmers feel that the five-year review period will have little influence on their investment decisions, but some farmers are concerned and feel that the relatively short term of the review period will have some negative effect on their investment decisions. This stems from the uncertainty regarding the particulars of the Act, and regarding the practical implications of the review period. This uncertainty also effects the farmers' perceptions of the security of water licenses, and farmers mainly rate the security of water licenses as moderately insecure with only three farmers feeling that licenses would be completely secure (rating of zero). There seems to be a lot of confusion amongst respondents regarding the process of licensing and how the review period will be applied. The practical implications of the review period should be made clear to farmers as it may be hampering further investment in irrigation and development in the area.

The following chapter presents the results from an econometric analysis of the water markets in each of the study areas. The procedures used include Principal Component Analysis, Logistic Regression and Ridge Regression. There is some discussion of the results, but the main discussion is left to the final chapter, which follows the next chapter.

CHAPTER SEVEN

ECONOMETRIC RESULTS

This chapter discusses the econometric analysis results from the studies in each area. The results from the Lower Orange River will be discussed first followed by results from the Crocodile River study.

7.1 Lower Orange River Analysis

A Principal Component Analysis (PCA) was undertaken on the variables hypothesized to be important in the envisaged models as a high degree of multicollinearity between crop types produced was suspected. To study whether a water market promotes efficiency in water use, a logit model of Buyers and Sellers of water entitlements was estimated. An investment model was also estimated to study variables that are associated (positive and negative) with planned future investment in irrigation farming.

7.1.1 Principal Component Analysis of variables associated with water marketing

Table 7.1 overleaf shows the loadings of two principal components extracted from the original variables. The correlation matrix was used for the extraction, since the variables use different units of measurement. The first, second and third components with eigenvalues of 6.172, 1.905, and 1.608 respectively, account for 38.58, 11.91, and 10.05 percent of the total variation in original variables, respectively. The table shows the variable name, and an explanation of what that variable measures in the first two columns. The principal component loadings are shown in the last three columns.

Table 7.1: First three components of variables associated with water marketing in the Lower Orange River, 2003.

VARIABLE	Definition	PC1	PC2	PC3
EXPINV	The farmers expected change in irrigation investment expressed as a percentage of current investment	0.487	0.234	**0.688**
TYPE	Dummy variable: =1 if respondent is a Buyer in the water market; =0 if respondent is a Seller in the market	**0.853**	-0.137	0.216
PERCEXP	Percentage of entire crop planted to export grapes	**0.942**	-0.033	0.070
PERCOTH	Percentage of entire crop planted to wine, juice and/or raisin grapes	**-0.708**	-0.314	-0.081
PERCFLD	Percentage of entire crop planted to field[1] crops	-0.623	0.306	0.089
PERCHRT	Percentage of entire crop planted to horticultural[2] crops	0.481	0.267	-0.274
PIRRTEC	Percentage of irrigated area irrigated using advanced irrigation (drip or micro)	**0.962**	-0.110	-0.023
TNVWAT	Turnover per cubic meter of water used for irrigation	**0.939**	-0.082	0.063
LSTOCK	Number of commercial livestock owned	0.251	0.339	**0.496**
CROPDI	Crop diversification score	0.540	-0.353	0.204
RISKATT	Arrow-Pratt risk aversion coefficient	0.224	**-0.521**	-0.359
DEBT	Debt to Asset ratio	-0.370	0.454	0.058
REVIEW	Importance of five-year license review on investment decision, rated 0 to 100: 0 = no effect and 100 = major factor negatively affecting investment decision	0.377	**0.710**	-0.253
INSECURE	Index measuring farmers' perception of insecurity of licences	0.268	**0.528**	**-0.470**
PROFITS	Dummy variable: =1 if respondent expects profits to increase in the future; =0 otherwise	-0.465	0.146	**0.430**
DEVEL	Degree of development, measured as the ratio of the current farmed area to the total available farm area	0.649	0.162	-0.315

1 - Lucerne, cotton, maize and wheat
2 - Citrus, pecan nuts, mangoes and melons

The first component (Table 7.1) is the first PC from an analysis of the variables describing the sample of respondents to be used in the logit model. It shows positive loadings for the following variables; Buyers of water entitlements (TYPE =1); percentage of cropped area planted to export table grapes (PERCEXP); percentage of advanced irrigation technology used (PIRRTEC); turnover per cubic meter of water applied (TNVWAT). It also shows a negative loading for percentage of cropland planted to other grapes (PERCOTH). This component captures variables associated with the purchase of water entitlements and could be labeled “Buyer characteristics”. The second component shows positive loadings for REVIEW and INSECURE indicating that farmers who feel that the license review will have an impact on their investment decisions also tend to perceive that these licenses are insecure. These two measures are based on perceptions surrounding water licenses and it is understandable that they are related. The PC also indicates that these types of farmers are less risk averse (RISKATT), which is not an anticipated relationship. The third component in Table 7.1 shows the loadings of the third PC. It shows positive loadings for the change in expected investment (EXPINV), the number of livestock owned (LSTOCK), and expected profits (PROFITS). It shows negative loadings for the farmer’s risk aversion coefficient (RISKATT) and the perceived insecurity of licenses index (INSECURE). These relationships are important findings, which will be further investigated with an investment model.

In order to overcome likely multicollinearity between crops produced and to maintain degrees of freedom, an index (principal component) was constructed from the crop variables. The crop variables were chosen as the demand for water as a factor of production is a derived demand, derived from expected product prices. Since export grapes (PERCEXP) fetch premium prices, it is expected that producers of this product will be Buyers of water in the market as the strong association is evident in the first component. The loadings of the crop variables are shown in Table 7.2 overleaf.

Table 7.2: Principal component of percentage land under each crop type, Lower Orange River 2003.

Variable loading	Component
	EXPORTPC
PERCEXP	0.899
PERCOTH	-0.762
PERCFLD	-0.601
PERCHRT	0.559
Eigenvalue	2.063
Variance explained	51.57%

PC1 scores are labeled as EXPORTPC as they are higher for farmers who produce proportionately more export grapes (PERCEXP), and to a lesser extent, proportionately more horticultural crops (PERCHRT), and proportionately less 'other' grapes (PERCOTH) and field crops (PERCFLD).

7.1.2 Logit model of Buyers and Sellers of water entitlements

The dependent variable TYPE was regressed on the variables shown in Table 7.1 excluding the crop variables, which were included as a principal component. The PIRRTEC and TNVWAT variables were highly collinear with the EXPORTPC variable from the PCA, and were excluded from the model. The variable with the most statistically significant estimated coefficient (Table 7.3, overleaf) was EXPORTPC (Wald=6.8). The Wald statistic (which has a χ^2 distribution) can be approximated by the t-squared statistic, implying that the t statistic = 2.6 for the EXPORTPC variable. The t statistic has a normal distribution but Wald can be approximated by t-squared for larger samples of at least 30 cases (Ndlovu, 2004).

This indicates that Buyers of water entitlements produce proportionately more export grapes, to a lesser extent, horticultural crops while proportionately less 'other' grapes and field crops are produced. Buyers of water entitlements appear to have more livestock (t=1.14), which is seen as a liquidity variable. Buyers are also less diversified (t=1.24) and only use water on the high value crops. This captures the phenomenon that Buyers are the more specialized farmers (table grapes) and hence substitute excess water rights for crop diversification.

Table 7.3: First logit regression of Buyers and Sellers of water entitlements, Lower Orange River, 2003.

	Beta Coefficient Estimate	Standard Error (B)	Wald Statistic	Degrees of Freedom	Significance Level
EXPORTPC	2.937	1.129	6.763	1	.009
CROPDI	5.408	4.367	1.534	1	.216
LSTOCK	0.007	0.006	1.302	1	.254
Constant	-2.979	1.967	2.293	1	.130

The Cox and Snell R-Square value is 60.6 and the Nagelkerke R-Square value is 81.3 percent. Cox and Snell's R-Square is an attempt to imitate the interpretation of multiple R-Square based on the likelihood, but its maximum is often less than one. The Nagelkerke R-Square is a modification of the former, which divides the Cox and Snell R-square by its maximum in order to achieve a measure that ranges from zero to one (Ndlovu, 2004). The model chi-square value is 15.217 with three degrees of freedom, which is significant at the one percent level, and thus there is a significant relationship between the dependent variable and the set of independent variables. The Hosmer and Lemeshow (H-L) test chi-square value is 7.493, which yields a p value (significance) of 0.379. If the H-L goodness-of-fit test statistic is greater than .05, the null hypothesis that the data were generated by the model fitted is not rejected. This implies that the model's parameter estimates fit the data at an acceptable level. The model fits the data well, and the variation explained by the model is statistically significant. The overall correct classification of the model was 91.4% while the classification for Buyers was 86.7% and Sellers was 95% (Table 7.4). The model was not tested on new data, as the sample size was already small. The aim of this model is not prediction, so this information is useful as an indication of fit of the model. These estimates, however, are biased, as the same data were used to both estimate the model and to assess classification accuracy.

Table 7.4: Classification of observed and predicted values of Buyers and Sellers of water entitlements, Lower Orange River, 2003.

Observed	**Predicted**		
	Type		**Percentage Correct**
Type	**Seller (0)**	**Buyer (1)**	
Seller (0)	19	1	95.0
Buyer (1)	2	13	86.7
Overall percentage			91.4

The livestock variable measures the number of commercial livestock owned by the farmer. Most of the farmers that owned livestock had second farms in another area away from the main cropping farm. The variable may have some impact on farmers' decision making processes, but since the operation was geographically separate to the study area, it was felt that this variable should be dropped from the model. According to Table 7.5 overleaf, if the livestock variable is dropped then a variable capturing the short review period (REVIEW) enters. This implies that the short five-year review period of water licenses has a negative impact on the purchase of water use entitlements (licenses). The model in Table 7.5 has the same classification rate as the model in Table 7.3.

Table 7.5: Second logit regression of Buyers and Sellers of water entitlements, Lower Orange River, 2003.

	Beta Coefficient Estimate	Standard Error (B)	Wald Statistic	Degrees of Freedom	Significance Level
EXPORTPC	4.173	1.470	8.057	1	.005
CROPDI	6.585	5.398	1.488	1	.223
REVIEW	-0.030	.023	1.644	1	.200
Constant	-1.061	2.365	0.201	1	.654

Although models in tables 7.3 and 7.5 have identical classification rates, the equation in Table 7.5 is a somewhat better economic model as it has a less statistically significant constant term. More variation is explained by variables studied and the Wald criteria of these variables are marginally higher. Some statistics of the model in Table 7.5 are marginally lower. The Cox and Snell R-Square is 60.2 and the Nagelkerke R-Square value is 80.8 percent.

7.1.3 Irrigation investment model

An investment model was estimated where the dependent variable is the percentage that farmers expect to increase or decrease their investment (in Rands) in irrigation. This regression suffered from high multicollinearity as measured by VIF values. The VIF value for the variables PIRRTEC, TNVWAT, PERCEXP and TYPE were 32.249, 18.123, 12.936 and 11.518, respectively. These values are in excess of 10, which indicates an R^2 value, as measured in auxiliary regressions of each independent variable against the other independent variables, of over 0.90 (Kleinbaum *et al.*, 1988: 210). A Ridge Regression was thus undertaken to reduce multicollinearity. The results of this regression are shown in Table 7.6. The model basically explains future investment as a function of expected profits, farmers' risk attitude, and possibly liquidity. These variables are supported by economic theory. Future investments are also expected to be influenced by expected real interest rates. This variable was not included as farmers may not be sufficiently familiar with changes in macro-economic variables while different farmers face different opportunity costs of capital. The R-squared value is 0.553, which is considered good given the conceptual nature of the model. The F value for the model is 5.15, which is statistically significant at the 1 percent level, indicating that all the variables are jointly significant. A ridge trace has shown that regression coefficients stabilize after a biasing constant of K=0.15, while the multiple regression coefficient declines only modestly before this point.

Table 7.6: Ridge regression of factors affecting future irrigation investment, Lower Orange River, 2003.

	Beta Coefficient Estimate	**Standard Error(B) SE(B)**	**Standardized Beta**	**B/SE(B) = t statistic**
PERCEXP	0.098	0.079	0.176	1.237
PERCOTH	-0.224	0.089	-0.335	-2.522
LSTOCK	0.009	0.004	0.284	2.346
CROPDI	18.246	11.730	0.196	1.556
RISKATT	-0.216	0.134	-0.195	-1.611
INSECURE	-0.133	0.068	-0.239	-1.953
Constant	20.694	9.132	0.000	2.266

The crop variable coefficient estimates indicate that table grape producers (PERCEXP) will invest more and that producers of other grapes (PERCOTH) will invest less. Future investment is highly dependent on expected profits. The signs of these coefficients are expected as current income per hectare from table grapes (R130 000) significantly exceeds that of wine grapes (R40 000) or raisins (R30 000). Farmers with more livestock are expected to invest more. This may be attributed to a better liquidity position of these farmers (livestock is a liquid asset as it may be sold during adverse conditions).

More risk averse farmers are expected to invest less as the RISKATT coefficient (APARA) was negative. This study indicates that irrigation farmers along the Lower Orange River are highly risk averse, especially as far as downside risk is concerned. The implication is that policies that increase the risk in agriculture, such as a relatively short water license review period, will have a significant negative effect on future investment in irrigation as these farmers will attach a greater cost to this risk. The extent to which this will impact on future investment is difficult to determine since the risk aversion coefficient has no particular cost basis, and different farmers will place a different weighting to risk as a determinant of their future investment. Farmers who feel that water licenses are not secure (high scores for INSECURE) are further expected to invest less. The fact that both the RISKATT variable and the INSECURE variable entered is of interest as both variables measure different dimensions of risk. For instance a risk-neutral farmer will invest less if he feels less secure about his water license.

7.2 Crocodile River Analysis

In this section, the econometric analysis of the survey data from the Crocodile River is described and the results are presented.

7.2.1 Principal Component Analysis of variables associated with water trading

Variables associated with areas under irrigation by Buyers and Sellers were studied using Principal Component Analysis (PCA). The correlation matrix was used for the extraction of the components, since the variables use different units of measurement. This avoids the problem of assigning a greater weight to a variable simply because of a much larger variance in the variable. The first two components are shown in Table 7.7 overleaf. The variable name is given together with a description of what it measures and the loadings estimated for each variable for each component.

The first component shows that TYPE, CANE, and SIZE each have strong positive loadings. The NUT and SURPLUS variables have negative loadings. This indicates that observations that score a one for type (Buyers) also score highly for CANE and SIZE, which means that buyers are likely to be large sugar cane producers. At the same time buyers are less likely to produce nuts (macadamias and pecans). As discussed in section 9.1.2, sugar cane is an appealing crop to farmers because of the drought resistance, liquidity and marketing properties that sugar cane provides. In addition, due to the revealed risk averseness of the respondents, these properties of sugar cane are even more appealing because they serve to lower the risk faced from the farming operation by providing a relatively more stable source of income and allowing some production of more risky alternatives. The NPV variable has a relatively weak negative loading in this component. This indicates that farmers with a relatively high Net Present Value (NPV) from crop gross margins per cubic meter of water are more likely to be sellers of water entitlements.

Table 7.7: Definition of variables associated with water trading, and their principal component loadings, Crocodile River, 2003.

Variable	**Definition**	Component	
		1	**2**
TYPE	= 1 if participant is a buyer; 0 if non-buyer (Dependent variable)	**.740**	.443
CANE	Percentage of total crop planted to sugar cane	**.806**	.246
BANANA	Percentage of total crop planted to banana	.320	.184
CITRUS	Percentage of total crop planted to citrus	.188	.062
NUT	Percentage of total crop planted to macadamia or pecan trees	**-.747**	.417
VEGETBLE	Percentage of total crop planted to vegetable crops	-.046	**-.682**
OTHTREE	Percentage of total crop planted to avocado, litchi and/or mango trees	-.248	-.253
SURPLUS	The difference between total water entitlements owned and irrigated area prior to market transactions	**-.647**	-.206
CROPDI	Index measuring degree of crop diversification	-.438	**.690**
NPV	Net present value of gross margin stream of crops per cubic meter of water used	-.561	**.743**
SIZE	Size of cropped area in hectares	**.647**	.321
EIGENVALUE		3.301	2.171
PERCENTAGE OF VARIANCE EXPLAINED		30.010	19.734

It appears as if water has moved to lower risk users and that some income may be sacrificed. This supports Bate *et al.* (1999) conclusion. The remaining component does not indicate any further relationships with TYPE. The second component suggests that farmers who have a higher NPV are more specialized and produce less vegetables, with some evidence that they may produce more nuts (macadamia and/or pecan).

7.2.2 Estimated Arrow-Pratt Absolute Risk Aversion Coefficients

Arrow-Pratt Absolute Risk Aversion coefficients were calculated for five farmers. The elicitation of responses that were needed for calculation of these scores had to be done during personal interviews due to the nature of the questions. Of the seven farmers personally interviewed, one respondent was not the chief decision maker, and another farmer refused to answer the question. With this limited data, no comparisons between Buyers and Non-buyers can be made. The median APARA coefficient for the five Crocodile River farmers measured 1.28, which was slightly lower the estimate of 2.44 for the Orange River Study. It is clear that irrigation farmers are risk averse, and when downside risk is measured, the farmers are more risk averse than anticipated in the questionnaire, as almost all the farmers in the Crocodile study and in the Orange River study picked the most risk-averse category (an APARA coefficient of 3.28). Farmers would rather receive nothing (choice 1) than being given a 50 percent chance of winning R800 000 and 50 percent chance of losing R200 000 (choice 2). A risk neutral person will be indifferent between choice 2 and receiving R300000 with certainty. It is possible that only those who are risk averse have been able to survive in an uncertain environment.

When faced with the chance that money could be won or lost, the farmers chose not to take the risk but would rather take a certain amount with zero gain. They were not asked whether they would pay money to avoid taking the risk. The importance of these findings is that a cost is attached to risk and whether weather-induced or policy-induced (insecurity of licenses) this risk will negatively affect investment in irrigation.

7.2.3 Statistical modelling of Buyers and Non-buyers of water in the Crocodile River Area

Due to the dichotomous dependent variable, a Linear Probability Model (LPM) was used to estimate the relationship between explanatory variables and the dependent (TYPE) variable. Due to likely collinearity between the explanatory variables mentioned, ridge regression was employed in conjunction with the LPM. Once lease observations were included, the data consisted of eight Buyers and 13 Non-buyers.

7.2.4 Linear probability model of water Buyers versus Non-buyers

Although there are problems with using this technique, it is applied as a first step in the analysis. The problems in estimation of LPM are non-normality of disturbances (the error term follows a binomial distribution), heteroscedastic variances of disturbances, and predicted Y values do not necessarily fall within the range of zero to one. In addition, the computed R^2 value is not a good indication of model fit and is likely to be much lower than one (Gujarati, 1995: 542-546).

The variables in Table 7.7 were regressed against TYPE using ridge regression. The ridge trace indicated that regression coefficients stabilize after K=0.15 while the multiple regression coefficient declines by about only one percent before this point. Table 7.8 overleaf shows that the model correctly classifies all but one of the cases and has a classification rate of 95.2%. This classification rate is biased upwards as the same data is used to estimate the model and calculate classification rates. The R squared value for the model is 76.5 percent and the adjusted R squared value is 70.6 percent. For most practical purposes, the R squared ranges between 0.2 and 0.6 (Gujarati, 1995: 546). The F value for the model is 13.00, which is statistically significant at the 1 percent level, indicating that all the coefficient estimates are jointly significantly different from zero. These tests indicate a good fit for a LPM, but the model is subject to the major disadvantages described earlier.

Table 7.8: Classification of observed and predicted values of Buyers and Non-buyers of water entitlements, Crocodile River, 2003.

Observed	**Predicted**		
	Type		**Percentage Correct**
Type	**Non-Buyer (0)**	**Buyer (1)**	
Non-Buyer (0)	13	0	100.0
Buyer (1)	1	7	87.5
Overall percentage			95.2

Table 7.9 overleaf shows the results of the ridge regression. The estimated coefficients for CITRUS, NUT, VEGETBLE, OTHTREE, CROPDI and NPV were not statistically significant and were subsequently dropped from the model and not shown in the table. All of the remaining variables except CANE had estimated coefficients that were statistically significant at the one percent level. The table shows that the most important variable distinguishing whether the farmer will be a buyer or non-buyer is BANANA. The SURPLUS variable shows that farmers who have a surplus of water entitlements prior to the transaction are likely to be Non-buyers and farmers with no surplus or deficit are Buyers. Buyers tend to farm a larger area (SIZE), and are likely to produce sugar cane (CANE).

Table 7.9: Ridge regression of LPM of water Buyers versus Non-buyers, Crocodile River, 2003.

Variable	**Beta Coefficient Estimate**	**SE(B)**	Standardized Beta	**B/SE(B) = t**
BANANA	0.923	0.199	0.490	4.643
SURPLUS	-0.001	0.000	-0.337	-3.001
SIZE	0.0001	0.000	0.290	2.380
CANE	0.208	0.198	0.133	1.050
Constant	0.108	0.073	0.000	1.480

Note: Dependent variable = TYPE

In short, Buyers farm larger areas with relatively more banana and sugar cane crops and do not have a surplus of permanent water entitlements, and probably have a deficit. It is expected that farmers who had a deficit of water would be buyers in the market and the model confirms this. This is important since it indicates that farmers are striving to comply with the system, and also indicates the markets ability to deliver water entitlements to expanding farmers, although there are other constraints that reduce the markets performance.

It is interesting that the coefficient for the NPV variable is not statistically significantly different from zero. This measure is not collected from individual data due to the time-span of the survey and the volume of information required, but derived from the areas of crops produced by respondents, and projected incomes and costs for each crop from the NOWAC (1999) study and from the Macadamia Kwekers Vereniging (2004). The model suggests that there is no significant difference in the NPV of gross margins per cubic meter of water between Buyers and Non-buyers. This finding implies that the market does not lead to a higher value use of water[4]. However, the market does allow farmers to transfer water entitlements in order to plant more crops that are more suited to their risk preference (sugar cane has lower income but less risk) thus allowing better management of risk.

7.2.5 Logit model of water Buyers versus Non-buyers

A logit model using the variables from the ridge regression model fails due to a near perfect fit. The crop and crop diversification variables were used in a logit model to determine the effect of crop production patterns of on the water trading decisions of Buyers and Non-buyers. The economic rationale for this is that the other variables such as SURPLUS and SIZE showed clear differences between farmers above and below the gorge, and self evidently show their effect on the water market. It is obvious that farmers with a deficit of water will be buyers of water in the market. Due to the topography of the land, farmers above the gorge produce crops on relatively smaller parcels of land compared with growers below the gorge. For this reason, SIZE is also excluded from the model as it is also self-evident that these larger growers below the gorge are able to expand production and hence be buyers of water in the market. Since there is correlation between crops grown, the crop variables were combined using a PCA. Table 7.10 overleaf shows the component loadings of the crop variables, and their associated eigenvalues and percentage of variation explained.

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4 This finding should be considered cautiously due to problems in measuring the NPV of crops per cubic meter of water. Problems encountered were the different time horizons of crops, rainfall differences between areas, yield variation, differing costs of abstraction of water in different areas, and different irrigation systems. In order to collect the relevant data, individual information about areas of crops grown using different irrigation methods, the amount of water applied under each type of use, and yield, cost and marketing data are required. This may yield a different result in the analysis.

Table 7.10: Principal component loadings of crop variables, Crocodile River, 2003.

	Component	
Variable	**CANEPC**	**BANANAPC**
CANE	**.758**	-.004
BANANA	.293	**.670**
CITRUS	**.603**	-.433
NUT	**-.825**	-.110
VEGETBLE	-.243	.482
OTHTREE	-.160	**-.593**
Eigenvalue	1.79	1.23
Variation explained	29.8 %	20.5 %

The first crop PC (CANEPC) has higher loadings for farmers that produce relatively more sugar cane and, to a lesser extent, citrus and lower loadings for farmers that produce relatively more macadamia and pecan nuts. The second crop PC (BANANAPC) scores highly for farmers with a higher proportion of banana, and a lower proportion of litchi, mango, and avocado trees. These crop PC's were regressed on the dependent variable TYPE using a logit regression model. The Cox and Snell R-Square value is 40.6 and the Nagelkerke R-Square value is 55.2 percent. The model chi-square value is 16.972 with two degrees of freedom, which is statistically significant at the one percent level, and thus there is a significant relationship between the dependent variable and the set of independent variables. The Hosmer and Lemeshow (H-L) test chi-square value is 9.892, which yields a p value (significance) of 0.195. This tests the null hypothesis that the data were generated by the model fitted. If the H-L goodness-of-fit test statistic is greater than .05, the null hypothesis that there is no difference between the observed and model-predicted values of the dependent is not rejected, implying that the model's estimates fit the data at an acceptable level. This does not mean that the model necessarily explains much of the variance in the dependent variable, only that however much or little it does explain is statistically significant.

This indicates that the model fits the data moderately well, and the variation explained by the model is significant. Table 7.11 shows the classification rate of the model's prediction rate of Buyers and Non-buyers.

Table 7.11: Classification of observed and predicted values of Buyers and Non-buyers of water, Crocodile River, 2003.

Observed	**Predicted**		
	Type		**Percentage Correct**
Type	**Non-Buyer (0)**	**Buyer (1)**	
Non-Buyer (0)	11	2	84.6
Buyer (1)	1	7	87.5
Overall percentage			85.7

The overall classification rate is 85 percent, with 84 percent of Non-buyers and 87 percent of Buyers being correctly classified. The aim of this model is not prediction, so this information is only useful as an indication of fit of the model, although since the same data is used to estimate the model and to test its classification rate, these rates are upwardly biased and should not be the only measure of fit used. In conjunction with the tests of goodness of fit described on the previous page, it can be concluded that the model fit is satisfactory. Table 7.12 overleaf shows the results of the logit regression of these two crop PC's on the dependent variable TYPE.

Table 7.12: Logit regression of Buyers and Non-buyers of water rights, Crocodile River, 2003.

Variable	Beta Coefficient Estimate	Standard Error (B)	Wald	Degrees of Freedom	Significance Level
CANEPC	1.640	.789	4.321	1	.038
BANANAPC	1.433	.794	3.255	1	.071
Constant	-0.983	.731	1.808	1	.179

Note: Dependent variable = TYPE

The CANEPC coefficient estimate is statistically significant at the five percent level, and the BANANAPC coefficient estimate is statistically significant at the 10 percent level. The beta coefficient estimate for CANEPC is positive which indicates that farmers that produce relatively more sugar cane and citrus, with relatively less macadamia and pecan nuts are likely to be buyers of water entitlements. The beta coefficient for BANANAPC is also positive and shows that farmers with relatively more banana crop and less other tree crops (litchi, mango, and avocado) are also likely to be buyers of water entitlements in the market. The CROPDI beta coefficient estimate was not statistically significantly different from zero and was excluded from the final model. The model supports the findings of the ridge regression model shown in Table 7.9. Although the sample size is small, these results are in line with *a priori* expectations and confirm a relatively apparent trend in the study area. These results and the results from the Lower Orange River region will be discussed and summarised in the next chapter.

DISCUSSION AND CONCLUSION

Water transfers in the Lower Orange River and Crocodile River were studied to determine whether water marketing has promoted efficiency by comparing which farmers are buying and which farmers are selling water. Farmers in these areas were surveyed during October/November 2003 while a follow up telephonic survey was undertaken in the second area during March 2004. This study complements a study on water marketing in the Lower Orange River undertaken during 1997 by Armitage (1999) and a study by Bate *et al.* (1999) in the Lower Crocodile River. The dynamic water market situation can be studied by comparing the current study (2004) to the previous studies. The study also links up with the current WRC study on the "Supportive role of the market mechanism in implementing the provisions of the new Water Act" (WRC, 2004). Econometric procedures used included principal component analysis, and logit and ridge regression. Results from the two areas will be discussed separately. Results from the Orange River will be discussed first.

Water Marketing in the Lower Orange River

The profile of a buyer of water entitlements was a farmer who grows relatively more export grapes and horticultural crops with relatively less raisin, wine or juice grapes and less field crops; is more specialised in production; has more livestock and has a less negative view of the five-year water license review period. The buyers of water entitlements tend to specialize in the production of few crops that are highly profitable such as export grapes. Buyers appear more likely to own livestock. Livestock are seen as a liquid asset, which may be a means of financing water market purchases. The five-year water license review period appears to have a negative impact on the purchase of water entitlements. This could be explained by the fact that the planning horizons for grape producers exceed five years and these farmers require an assured supply of water for the duration of the crop's lifespan.

Export grapes and horticultural crops are seen as more profitable alternatives, which require intensive investment in advanced irrigation systems. High quality export grapes require heat and water, with no heavy rainstorms that can damage the grapes. Areas such as Kakamas are more suited to the production of table grapes than other areas such as Boegoeberg and water tends to be purchased by farmers in Kakamas. The water market has facilitated a transfer of water use from relatively lower value crops to relatively higher value crops, and also promoted the use of more advanced irrigation, although this is an indirect effect, since the irrigation type is dependent on the requirements of the crop and strategy of the farmer. From this evidence, it is apparent that the water market meets the objective of improving the efficiency of water use and allows flexibility of water allocations. The transfer of water out of Boegoeberg has no negative employment effects on this area, as the transferred water was not previously used for irrigation. Sellers are compensated through the selling price of the water and are only selling excess water and not ceasing irrigation.

Transfers often result in the use of more water from the resource, since farmers who do not use excess water are usually the first to sell and the unused water gets put to use. For this reason it is important that the water resource can support the initial allocation of entitlements. In addition, it may be necessary to have clear rules regarding transfers of water during drought years as transfers of unused water will increase the pressure on the already stressed resource during these times.

Water prices in real terms have increased gradually from 1997 to 1999 with the price settling at around R10 000 (2003 rands) per hectare from 1999 to 2002. The price data for 2003 are very thin (two observations), and likely to be unreliable. The water price increase is possibly derived from the increase in the price of export grapes, which was caused by the weakening Rand exchange rate. If this is the case, then it is expected that the price of water in the market will fall due to a decline in the export grape prices caused by a firmer Rand. The extent of the price decline is lessened by the declining availability of unused water entitlements, which drives the price higher. The range of prices experienced within each year has decreased over time as shown by the coefficient of variation. This is expected if more information becomes available.

A Ridge Regression was fitted to estimate variables associated with planned future investment in irrigation farming. Factors which affect expected future investment were shown to be expected profitability, risk perception and risk aversion. Export grape producers expect to invest relatively more, while producers with a higher proportion of other grapes expect to invest relatively less. Farmers who own more livestock also expect to invest more in the future. Livestock is a liquid asset, and these farmers may expect to be in a better liquidity position and able to make investments. Results indicate that farmers who are more risk averse expect to invest less in the future. Policies that increase perceived risk in irrigated agriculture, such as the 5-year water license review period, will have a significant negative effect on future investment in irrigation. For this reason, uncertainty surrounding the practical implications of such policies should be made clear through good communication strategies.

Results also show that farmers who feel that water licenses are less secure expect to invest less in the future. This has important policy implications, and measures should be taken to improve the perceived security of water licenses. This could be achieved by keeping farmers more informed about the practical implications of the NWA and, specifically, water licenses. The lack of information available to farmers is evident from the responses obtained during the survey. The DWAF does supply information to farmers, and much information is available via their website, however, relevant, simplified, and practical information should also be supplied to farmers. In addition, policy makers should make use of feedback from farmers to enable the pragmatic implementation of the NWA institutions.

Water Marketing in the Lower Crocodile River

In addition to the survey, information was also obtained from various other role players (horticulturists, DWAF, legal experts, Irrigation Boards). Almost all the water trades (permanent and rentals) observed in this study were from farmers above the gorge to farmers below the gorge. Horticultural experts familiar with this area attribute this movement of water to the better crop production conditions below the gorge. Temperatures above the gorge are not hot enough for the heat loving crops (sugar cane mangoes, grapefruit, Valencia's and bananas) and not cool enough for temperate crops that require cooler conditions. A major problem in citrus orchards above the gorge is the bacteria *Citrus psylla* causing greening in citrus. Crops that do well above the gorge are tobacco and macadamias (although White River appears more suited for Macadamias).

The average real water price in this area in recent years (2002 to 2003) was between R2000 and R3000 per ha (1ha = 8000 cubic meter) with no clear trend in real prices of water during the period 1994 to 2003. It appears as if the coefficient of variation in prices has fallen, which is attributed to better information about market prices being available in more recent years. The Buyers are large progressive farmers that purchase (and rent) from many sellers (or lessees). Two respondents purchased water from 12 and 9 sellers while one farmer leased from 12 lessors. As the prices paid by a single buyer (or lessee) vary it is concluded that information is asymmetrical. Prices are higher for larger deals, which may indicate better information by larger sellers and probably lower transaction cost on larger deals.

In order to study whether the water market promotes efficiency the data were subjected to several statistical analyses (principal components, ridge regression and Logit regression). It is concluded that in the transfer of water some attributes in the purchasing area such as lower production risk (reflected by larger areas under sugar cane) and lower financial risk and better cash flow (bananas and sugar cane) were more important than the income per cubic meter of water. Water supply in this area is highly irregular, while farmers were found to be extremely risk averse, especially as far as down-side risk is concerned. The standardised Arrow/Pratt absolute risk aversion coefficient for down-side risk was at least 3.28. The latter number means that a respondent would rather receive nothing (choice 1) than being given a 50 percent chance of winning R800 000 and 50 percent chance of losing R200 000 (choice 2).

Ridge Regression indicates that buyers of water are water-deficit farmers, large farmers, and producers of sugar cane and bananas. Although this conclusion is self-evident it is interesting that the estimated coefficient for the Net Present Value of gross margin per cubic meter of water used (NPV) was not significant. In a principal component analysis, the NPV variable was mildly negatively associated with buyers of water, which implies that Buyers have a lower NPV than Non-buyers.

More farmers feel more positive than negative about the Act although there is much uncertainty regarding the Act. On average, 45 percent of respondents answered 'Uncertain' for their opinion regarding the Act. Farmers were asked to rate (on a scale from 0 to 100) the importance of the five-year review as a factor affecting their investment decisions and the effect the five-year review period would have on the security of water licenses. Ratings close to 100 indicate that it is a major factor, and zero indicated no effect. Most farmers indicated a rating between 0 to 60%, which indicates a moderate impact.

Possible reasons for difference in transfer time between study areas

Whereas the time taken to complete a permanent transfer in the Orange River is short (one week to two months) almost no permanent transfers have taken place in the Crocodile River in recent years and the process has stalled. Some experts are of the opinion that due to the irregular flow of the Crocodile, the demand for water sometimes exceeds supply and that there is no water to transfer. This is a contrast with the reliable flow of the Orange River. Another expert is of the opinion that farmers below the gorge simply expanded production without having allocations to support it. His view is that water allocations are not greater than availability. Data collected show that Buyers below the gorge indeed significantly exceeded their water entitlements and a main reason for buying and renting in water was to reduce this deficit. Another reason for the short transfer period in the Orange River is that it is a Government Water Scheme and reliable data are available on water users (they have to pay tariffs). Data are thus available to establish existing lawful use, which is necessary to facilitate transfers. Only a part of the Crocodile River is a Government Water Scheme as other parts are Government Water Control Areas (less is known about water use in these areas). It is concluded that there are reasons why transfers at present are not processed and role players should discuss these reasons and possible solutions before further action is taken. This situation is clearly sensitive and should be treated in such a manner. Allowing more trades from previously unused water in the wake of possible water scarcity may aggravate future shortages.

This dissertation has found that water markets increase the efficiency of water use and allocation of water entitlements (licenses) and serve to move water from a lower value use to a higher value use. The main change that has occurred since the previous studies on water markets in the two areas is that the wide range of prices has narrowed in both areas. This may be due to more information being available in the market as the players gain experience through market participation and through time. Farmers generally feel positive about the NWA although there is much uncertainty surrounding the practical implementation of water licenses, which needs to be made clear by the authorities since policies that increase risk will have a significant impact on investment in irrigation technology.

The contrast in the difference in the operation of water markets in the Lower Orange and Crocodile River regions highlights the need for future research to be directed towards the institutional constraints that increase the transaction costs of participation in the market to unacceptable levels. The inability of the market to perform during conditions of drought in the Crocodile River region is a serious problem, and a well-functioning market should provide farmers with a tool to effectively manage drought by being able to lease additional water during such times. Staff at the regional DWAF offices indicate that trades were not being processed due to the ongoing determination of the reserve. The allocation of these instream flows needs to be studied in both hydrological and economical terms.

The expansion of production area beyond farmers' water entitlement availability is of concern and raises the question of policing and corrective action. Increasing the availability of information about water users and their allocations may induce self-regulation and compliance as pressure from other users is increased if water allocations are public knowledge. The apparent lack of information in the market also needs to be studied, and methods for improved communication between all parties involved must be determined. This information would not only be useful to market participants, but would also serve to better study and understand the operation of water markets, which would, in turn, provide further opportunities for the enhancement of their operation.

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LIST OF APPENDICES

APPENDIX 1: Characteristics of Expansionary and Mature Phases of the Water Economy.

	Item	Expansionary phase	Mature phase
1	Long-run supply of impounded water	Elastic	Inelastic
2	Demand for delivered water	Low, but growing; elastic at low prices, inelastic at high prices	High and growing; elastic at low prices, inelastic at high prices
3	Physical condition of impoundment and delivery systems	Most is fairly new and in good condition	A substantial portion is aging and in need of expensive repair and renovation
4	Competition for water among sectors and instream flow maintenance	Minimal	Intense
5	Externality an other problems	Minimal	Pressing: rising water tables, land salinisation, saline return flow, groundwater salinisation, water pollution
6	Social cost of subsidising increased water use	Fairly low	High, and rising

Source: Randall, 1981: p. 196)

APPENDIX 2: Permissible Use of Water in South Africa.

Schedule 1 (National Water Act, 1998)

1. A person may, subject to this Act -

(a) take water for reasonable domestic use in that person's household, directly from any water resource to which that person has lawful access;

(b) take water for use on land owned or occupied by that person, for -

(i) reasonable domestic use;

(ii) small gardening not for commercial purposes; and

(iii) the watering of animals (excluding feedlots) which graze on that land within the grazing capacity of that land, from any water resource which is situated on or forms a boundary of that land, if the use is not excessive in relation to the capacity of the water resource and the needs of other users;

(c) store and use run-off water from a roof;

(d) in emergency situations, take water from any water resource for human consumption or firefighting;

(e) for recreational purposes -

(iii) use the water or the water surface of a water resource to which that person has lawful access; or

(ii) portage any boat or canoe on any land adjacent to a watercourse in order to continue boating on that watercourse; and

(f) discharge -

(i) waste or water containing waste; or

(ii) run-off water, including stormwater from any residential, recreational, commercial or industrial site, into a canal, sea outfall or other conduit controlled by another person authorised to undertake the purification, treatment or disposal of waste or water containing waste, subject to the approval of the person controlling the canal, sea outfall or other conduit.

2. An entitlement under this Schedule does not override any other law, ordinance, bylaw or regulation, and is subject to any limitation or prohibition there under.

APPENDIX 3: Authority to Continue With Existing Lawful Water Use in South Africa.

Section 34 (National Water Act, 1998)

34. (1) A person, or that person's successor-in-title, may continue with an existing lawful water use, subject to:

(a) any existing conditions or obligations attaching to that use;

(b) its replacement by a licence in terms of this Act; or

(c) any other limitation or prohibition by or under this Act.

(2) A responsible authority may, subject to any regulation made under section 26(1)(c). require the registration of an existing lawful water use.

APPENDIX 4: Review and Amendment of Water Licences in South Africa.

Section 49 (National Water Act, 1998)

49. (1) A responsible authority may review a licence only at the time periods stipulated for that purpose in the licence.

(2) on reviewing a licence, a responsible authority may amend any condition of the licence, other than the period thereof if:

(a) it is necessary or desirable to prevent deterioration or further deterioration of the quality of the water resource;

(b) there is insufficient water in the water resource to accommodate all authorised water uses after allowing for the Reserve and international obligations; or

(c) it is necessary or desirable to accommodate demands brought about by changes in socio-economic circumstances and it is in the public interest to meet those demands.

(3) An amendment contemplated in subsection (2) may only be made if the conditions of other licences for similar water use from the same water resource in the same vicinity, all as determined by the responsible authority, have also been amended in an equitable manner through a general review process.

(4) If an amendment of a licence condition on review severely prejudices the economic viability of any undertaking in respect of which the licence was issued, the provisions of section 22(6) to (10) apply.

(5) A responsible authority must afford the licensee an opportunity to be heard before amending any licence condition on review.

APPENDIX 5: Map of Water Management Areas in South Africa.

Source: RSA (2002)

APPENDIX 6: Farmer Questionnaire.

2003
UNIVERSITY OF NATAL
DEPARTMENT OF AGRICULTURAL ECONOMICS
WATER QUESTIONNAIRE

YOUR ANSWERS TO THIS QUESTIONNAIRE WILL BE HELD IN STRICT CONFIDENTIALITY

The main purpose of this investigation is to determine whether transfers (buy/sell) of water promote efficiency.
The questionnaire is to be answered by the farm's principal decision-maker.

SECTION A: PARTICULARS OF FARM

1.1) Farm name: ______________________ Farmer Name: ______________________

Telephone Number: ______________________ Years of farming experience: __________

Years of irrigation farming experience: __________ Age of farmer: __________

1.2) Total water allocation: ______________________ Actual water usage: ______________________

1.3) What is the farm's debt/asset ratio as at 28 Feb 2003? ______________

1.4) Total number of livestock on farm: ____________

1.5) What is your water tariff? (R/Ha): ____

1.6) Farm water use:

If you grow a crop for different products, please specify the type of product (such as table, raisin or wine grapes) and the hectares for each.

Crop	Ha	Irrigation system	Irrigation Season		Average expected yield/Ha	Water Application Rate m^3/Ha	Annual Turnover (Rand/Ha)
			From	Until			

1.7) Land Use

Land	Total (Ha)	Own (Ha)	Lease in (Ha)	Lease out (Ha)
Under Irrigation				
Dryland				
Fallow				
Total				

1.8) How many more hectares can still be irrigated? ____________

SECTION B: WATERRIGHTS PURCHASE OR SALE

2.1) Have you bought or sold any water rights during the past 5 years? YES / NO

2.2) Details of purchase/sale:

► Please begin with your most recent purchase/sale (2003. 2002, 2001, ...)

Transaction	Type of transaction (Purchase/Sale)	Year	Volume of water	Units of transaction (Eg. Ha)	Price per unit	Name of buyer/seller
Number 1						
Number 2						
Number 3						

2.3) Is the buyer (seller) upstream or downstream from you?

	Transaction 1	Transaction 2	Transaction 3
Upstream			
Downstream			

Indicate with (√)

How far (approximately):

Distance			

Km

2.4) Reasons for purchase or sale:

Transaction 1: ____

____

____

Transaction 2: ____

____

____

Transaction 3: ____

____

____

2.5.) What is/was/will the purchased water (be) used for?

Transaction	Crop	Hectares	Irrigation system	Soil Characteristics•	Expected turnover per hectare
Number 1					
Number 2					
Number 3					

• Specify quality: excellent/good/poor and problems: drainage/salinity/slope/…

2.6) Transactions costs from transfer(what does it cost to trade water)

	Transaction 1	**Transaction 2**	**Transaction 3**
Legal costs (registration)	R	R	R
Agent commission	R	R	R
Feasibility study/plan	R	R	R
Environmental impact assessment	R	R	R
Timespan of transaction			
Irrigation board costs	R	R	R
Other Costs	R	R	R

Please specify what other costs there were: ______________________________

2.7) Where did you get information about potential buyers or sellers? ______________________________

____

2.8) Did you buy/sell water rights from/to the same person on separate occasions? Yes/No: ________

2.9) (If yes) Why? ____

2.10) Is the transfer subject to the approval of the Irrigation Board? Yes/No: __________

2.11) Is the transfer subject to the approval of other water users? Yes/No: __________

How are they notified? ____

2.12) Have you made any investments in infrastructure in order to obtain new water? YES/NO: ____________

How much? R_______________

Changes in irrigation methods

2.13) If you have changed irrigation methods (since 1998) which lead to a reduction in your water consumption (such as a change from sprinkler to drip), did you:

a) Sell water rights that were conserved through the change?
b) Irrigate a larger area?
c) Retain use rights for security purposes (for dry years)?
d) Since (c) may not be possible anymore, will you use water on a low-income crop (such as Lucerne) to be diverted to another use in a dry year?

Please specify any of the above and elaborate:

____

____

____

____

SECTION C: TEMPORARY TRANSACTIONS (WATER LEASING)

3.1) Have you leased any water? Yes / No

► If no, go to section D.

3.2) Details of transaction(s):

► Please begin with your most recent transaction (2003, 2002, 2001...)

Transaction	Year	Volume of water	Specify (Lease in/Lease out)	Price (Specify unit - eg. per 15000 m^3)
Number 1				
Number 2				
Number 3				

3.3) Is the Lessee/Lessor upstream or downstream from you?

	Number 1	Number 2	Number 3
Upstream			
Downstream			

Indicate with (√)

How far: (approximately)

Distance			

Km

3.4) What is/was/will the leased water (be) used for?

Transaction	Crop	Hectares	Irrigation system	Soil Characteristics•
Number 1				
Number 2				
Number 3				

• Specify quality: excellent/good/poor and problems: drainage/salinity/slope/…

3.5) Why did you lease water?

SECTION D: EXPECTATIONS

4.1) Do you expect to change your investment in irrigation within the next 5 years? Y / N

4.1.1) If yes, by how much? (percentage change in rands invested)? See box below:

+ 50% Increase by half the amount already invested
(eg. R500 000 – will increase by R250 000 to R750 000 total)

0%- No change

-50% Will decrease investment by half

► __________% (Please select any percentage)

4.2) Do you expect profits from irrigation farming to increase or decrease during the next 5 years? ________________ %

eg. +5%, -5%, +10%, ...

4.3) Have you made any significant investments in agriculture during the past 5 years? Yes / No

4.3.1) How much? R______________

SECTION E: WATER USE RECOGNISED BY THE 1998 WATER ACT

WATER USE LICENSES

Water use licenses must be reviewed at least every 5 years and are valid for a period no longer than 40 years.

5.1) How will/has this affect(ed) your investment decision?

Do you think that the 5 year period is to short and will have a negative impact on your investment decision? Yes/No: ______________

Do you think that it is unlikely that licenses will be revoked? Yes/No: ________________

Rate on a scale of 0 to 100 in order of importance:

100 -	Will be a major factor affecting my investment decision
50 -	Decreasing order of importance
0 -	Will not affect my investment decision

► ____________________% (0 – 100)

5.2) The new Water Act and more specifically the 5 year review period will have the following effect on the security of water use licenses

Rate on a scale of 0 to 100 in order of importance:

100 -	There is a high degree of uncertainty surrounding the security of water use licenses
50 -	Decreasing order of uncertainty
0 -	Licenses are secure

▶ ______________% (0 – 100)

The following questions relate to the farmer's opinion of the New Water Act (1998).

5.3) My opinion of the New Water Act has become more positive since the Act was first published.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

5.4) The New Water Act provides increased protection for the environment, which sets it apart from the old Act.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

5.5) The New Water Act has made the trading of water use rights (licenses) a simpler process.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

SECTION F: YOUR OPINION OF WATER TRANSFERS

6.1) Do you think that transfers of water have promoted more efficient use during the past 5 years? Yes/No: ___________

6.2) Have your expectations regarding transfers from 5 years ago been realized? Yes/No: ___________

6.3) Have your expectations changed during the last 5 years?

More positive	Neutral	More negative

Explain: ____

____

6.4) Has there been a shift from permanent to temporary transfers or vice versa? ___________

Why? ____

____

6.5) Are you concerned that you may not have enough water, and if so how do you counter this:

- ▶ Plant a low-income crop from which water can be diverted Yes/No: ___________
- ▶ Hold more water rights than needed Yes/No: ___________

Other methods: ____

____

6.6) How have transfers effected the environment? ____

____

SECTION G: FARMER'S RISK PREFERENCE ASSESSMENT

The following questions relate to hypothetical situations in which you are faced with the option of taking a gamble or choosing a certain outcome. The object is to determine that certain outcome for which you are indifferent between the gamble and the certain amount for each of the following questions.

In each question the gamble (*option 1*) is based on a flip of a coin with heads or tails having different outcomes. You are then asked for various values of *option 2* whether you prefer *option 1* or *option 2* until a value is found where you are indifferent between the two options.

8.1) If you were faced with an option to take a gamble and the option to receive a sure amount, which do you prefer:

OPTION 1: A coin is tossed

HEADS: You win R 1 000 000

TAILS: You receive nothing

OR

OPTION 2: You receive (with certainty):

R 200 000	R 250 000	R 300 000	R 350 000	R 400 000	R 450 000	R 500 000	R 550 000

8.2) If you were faced with an option to take a gamble and the option to receive a sure amount, which do you prefer:

OPTION 1: A coin is tossed

HEADS: You win R 800 000

TAILS: You lose R 200 000

OR

OPTION 2: You receive (with certainty):

R 50 000	R 100 000	R 150 000	R 200 000	R 250 000	R 300 000	R 350 000	R 400 000

APPENDIX 7: Farmer Questionnaire - Afrikaans.

2003
UNIVERSITEIT VAN NATAL
DEPARTEMENT LANDBOU-EKONOMIE
WATERBEMARKING

U ANTWOORDE BY HIERDIE ONDERSOEK SAL KONFIDENSIEËL BESKOU WORD

Die hoofdoel van hierdie ondersoek is om te bepaal of die koop/verkoop van water, die doeltreffende verbruik daarvan bevorder. Die boer wat die primêre besluitneming vir die plaas maak moet asseblief hierdie vraelys beantwoord.

AFDELING A: BESONDERHEDE VAN PLAAS

1.1) Plaasnaam: ______________________ Boer Naam: ______________________

Telefoon Nommer: ______________________ Jare boerdery ondervinding: __________

Jare besproeiingsboerdery ondervinding: __________ Ouderdom van boer: __________

1.2) Hoeveelheid water aanwysing: ______________________ Hoeveelheid water verbruik: ______________________

1.3) Wat is u boerdery se skuld/bate verhouding vir die jaar tot 28 Feb 2003? ______________

(engels: "Debt/Asset ratio")

1.4) Aantal lewendehawe: ____________

1.5) Wat is u waterbelasting? (R/Ha): ______________________________________

1.6) Watertoedeling op die plaas

As u druiwe verbou, spesifiseer asseblief watter tipe produk die oes voor gebruik word (bv. Tafel -, rosyne - of wyndruiwe) en die hektaar van elk.

Gewas	Ha	Besproeiingstipe	Besproeiings-seisoen		Gemiddelde verwagte opbrengs/ha	Watergebruik m^3/Ha	Jaarlikse omset (Rand/Ha)
			Vanaf	Tot			

1.7) Grond (Land) gebruik

Grond	Totaal (Ha)	U eiendom (Ha)	Huur (Ha)	Verhuur (Ha)
Onder besproeiing				
Droëland geploeg				
Weiveld				
Totaal				
byv.	100	80	30	10

1.8) Hoeveel hektaar kan nog besproei word? ____________

AFDELING B: WATERREGTE GEKOOP OF VERKOOP

2.1) Het u enige waterregte **gekoop of verkoop** gedurende die afgelope vyf jaar? JA / NEE

▶ Indien nee, gaan na Afdeling C.

2.2) Besonderhede van aankope/verkope:

▶ Begin asseblief by die mees onlangste aankope/verkope (2003, 2002, 2001, ...)

Transaksie	Tipe transaksie (Koop/Verkoop)	Jaar	Hoeveelheid water	Eenhede van transaksie (byv. Ha)	Prys per eenheid	Naam van koper/verkoper
Nommer 1						
Nommer 2						
Nommer 3						

2.5) Is die koper (verkoper) stroomaf of stroomop van u?

	Transaksie 1	Transaksie 2	Transaksie 3
Stroomop			
Stroomaf			

Dui aan met (√)

Hoevêr: (by benadering)

Afstand			

Km

2.4) Redes vir water aankope of verkope:

Transaksie 1: ____

____

____

Transaksie 2: ____

____

____

Transaksie 3: ____

____

____

2.5.) Waarvoor is/word/was die gekoopte of verkoopte waterregte gebruik?

Transaksie	Gewas	Hektaar	Besproeiingstipe	Grondeienskappe•	Verwagte omset per Ha
Nommer 1					
Nommer 2					
Nommer 3					

• Spesifiseer kwaliteit: uitstekend/goed/swak en probleme: dreinering/soutinhoud/helling/…

	Transaksie 1	Transaksie 2	Transaksie 3
Wetlike koste (registrasie)	R	R	R
Agentkommissie	R	R	R
Bepaling van volhaalbaarheid of uitvoerbaarheid	R	R	R
Omgewingsgeskiktheid bepaling	R	R	R
Tydverloop van transaksie			
Besproeiingsraad koste	R	R	R
Ander Koste	R	R	R

Spesifiseer asseblief wat die ander koste is: ____________________

2.7) Waar het u die inligting oor die potensiële koper of verkoper gekry? ____________________

____

2.8) Het u waterregte verkoop/gekoop aan/van dieselfde boer? Ja/Nee: ________

2.9) (Indien ja) Hoekom? ____________________

2.10) MOET DIE BESPROEIINGSRAAD DIE OORDRAG GOEDKEUR? JA/NEE: ________

2.11) Moet ander waterverbruikers die oordrag goedkeur? Ja/Nee: ________

Hoe word hul inkennis gestel: ____________________

2.12) HET U BELÊ IN DIE INFRASTRUKTUUR IN 'N POGING OM MEER WATER TE BEKOM? JA/NEE: ________

HOEVEEL? R________

2.13) Indien u waterbesparingsmaatreëls sedert 1998 toepas (byv. drupbesproeiing), beantwoord asseblief:

e) Het u die water wat u so gespaar het verkoop?
f) Besproei u nou 'n groter area met die water wat gespaar is?
g) Hou u die gespaarde water vir sekuriteit in 'n droë jaar?
h) Sedert (c) nie meer moontlik is nie, sal u die water op 'n lae inkomste gewas (sê lusern) aanwend wat dan gebruik kan word in waterskaars tye?

Verduidelik asseblief u antwoorde:

AFDELING C: KORTTERMYN TRANSAKSIES (HUUR)

3.1) Het u water gehuur of verhuur? JA / NEE

► Indien nee, gaan na Afdeling D.

3.2) Besonderhede van transaksies:

► Begin asseblief by die mees onlangste transaksie (2003, 2002, 2001, ...)

Transaksie	Jaar	Hoeveelheid water	Spesifeer Huur/Verhuur	Prys (spesifiseer eenheid)
Nommer 1				
Nommer 2				
Nommer 3				

3.3) Is huurder/verhuurder stroomaf of stroomop van u?

	Nommer 1	Nommer 2	Nommer 3
Stroomop			
Stroomaf			

Dui aan met (√)

Hoevêr: (by benardering)

Afstand			

Km

3.4) Waarvoor was die verhuurde/gehuurde water gebruik?

Transaksie	Gewas	Hektaar	Besproeiingstipe	Grondeienskappe*
Nommer 1				
Nommer 2				
Nommer 3				

• Spesifiseer kwaliteit: uitstekend/goed/swak en probleme: dreinering/soutinhoud/helling/...

3.5) Hoekom het u water verhuur of gehuur?

AFDELING D: VERWAGTINGS

4.1) Is u van plan om u belegging t.o.v. besproeiing te vergroot binne die volgende vyf jaar? J / N

4.1.1) Indien Ja, met hoeveel? (persentasie verandering in u belegging)?

+ 50% Belegging sal met die helfte toeneem
(bv. R500 000 – sal vermeerder met R250 000 tot R750 000 totaal)

0%- Geen verandering

-50% Belegging sal verminder met helfte

► __________% (Kies asseblief enige persentasie)

4.2) Verwag u dat u wins uit besproeiing in die volgende vyf jaar sal vermeerder of verminder? ________________ %

byv. +5%, -5%, +10%, ...

4.3) Het u enige betekenisvolle belegging in besproeiing gedurende die afgelope vyf jaar gemaak? Ja / Nee

4.3.1) Hoeveel? R_______________

AFDELING E: WATERGEBRUIKE ERKEN DEUR DIE WATERWET VAN 1998

Watergebruiklisensies

Waterlisensies moet minstens elke 5 jaar hersien word en is geldig vir 'n periode wat nie 40 jaar mag oorskry nie.

5.1) Hoe sal dit u beleggingbesluit beïnvloed?

Beskou u dat die 5 jaar periode te kort is en sal dit u beleggingbesluit nadelig beïnvloed? Ja/Nee: ____________________

Dink u dat dit onwaarskynlik is dat lisensies herroep sal word. Ja/Nee: __________________

Gebruik 'n skaal van 0 tot 100 in volgorde van belangrikheid:

100 -	Sal 'n groot faktor wees wat my beleggings-besluit affekteer.
50 -	Verminderde volgorde van belangrikheid.
0 -	Sal nie my beleggingsbesluit beïnvloed nie

► ______________________% (0 – 100)

5.2) Die Nuwe Waterwet en meer spesifiek die vyf jaarlikse hersieningsperiode sal die volgende effek hê op sekuriteit van watergebruike.

Gebruik 'n skaal van 0 tot 100 in volgorde van belangrikheid:

100 -	Daar is 'n hoë graad van onsekerheid rondom die sekuriteit van waterlisensies
50 -	Verminderde volgorde van onsekerheid
0 -	Geen onsekerheid

▶ ____________% (0 – 100)

Die volgende vrae handel oor die boer se mening van die Nuwe Waterwet (1998).

5.3) My mening van die toepassing van die nuwe Waterwet het meer positief geword vandat die Wet die eerste (1998/1999) maal publiseer is.

Stem beslis saam	Stem saam	Onseker	Stem nie saam nie	Stem beslis nie saam nie

5.4) Die Nuwe Waterwet voorsien meer beskerming aan die omgewing as die vorige Wet.

Stem beslis saam	Stem saam	Onseker	Stem nie saam nie	Stem beslis nie saam nie

5.5) Die Nuwe Waterwet sal die verhandeling van water gebruiksregte 'n makliker proses maak.

Stem beslis saam	Stem saam	Onseker	Stem nie saam nie	Stem beslis nie saam nie

AFDELING F: U MENING VAN OORDRAGTE

6.1) Dink u dat wateroordragte die meer doeltreffende gebruik van water bevorder het gedurende die afgelope 5 jaar? Ja/Nee: ____________

6.2) Is u verwagtings met betrekking tot oordragte wat u 5 jaar gelede gehad het gerealiseer? Ja/Nee: ____________

6.3) Hoe het u verwagtings verander gedurende die afgelope 5 jaar?

Meer positief	Neutraal	Meer negatief

Verduidelik: ____

____

6.4) Is daar verskuiwing van permanente na tydelike oordragte (huur) of andersom? Ja/Nee: ____________

Waarom? ____

____

6.5) Is u bekommer dat u nie voldoende water het nie, en indien wel wat doen u daaromtrent.

- ▶ Plant 'n lae-inkomste gewas waarvan water verskuif kan word. Ja/Nee: ____________
- ▶ Hou meer waterregte as wat ek nodig het Ja/Nee: ____________

Ander metodes: ____

____

6.6) Watter invloed het oordragte op die omgewing? ____

____

____

AFDELING G: RISIKO-GEDRAG BEPALING

Die volgende vraag is slegs hipoteties. Die doel is te bepaal of risiko u beleggingsbesluite beïnvloed en tot welke mate. Gestel u het 'n keuse tussen 'n bedrag wat u kan kry met sekerheid of 'n bedrag wat u kan kry met onsekerheid. Watter keuse sal u maak in die volgende gevalle.

8.1) Keuse 1: 'n Muntstuk word opgegooi

Kop: U wen R 1 000 000
Stert: U wen niks

OF

Keuse 2: U kan met sekerheid die volgende bedrag wen. Watter van die volgende bedrae sal u liewers verkies en watter bedrae nie kies nie?

R 200 000	R 250 000	R 300 000	R 350 000	R 400 000	R 450 000	R 500 000	R 550 000

8.2) 'n Soortgelyke vraag

Keuse 1: 'n Muntstuk word opgegooi

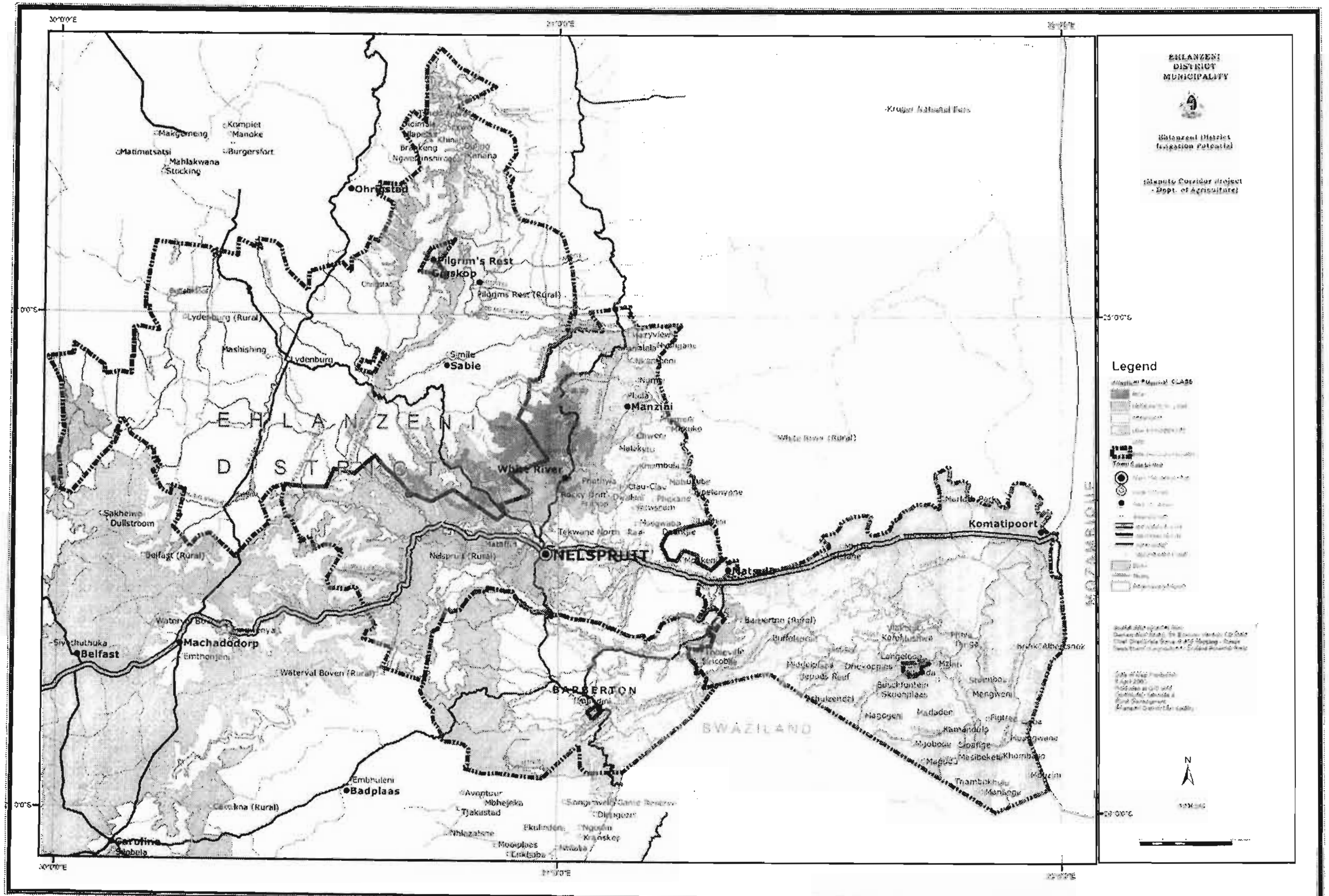
Kop: U wen R 800 000
Stert: U verloor R200 000 (u moet dit inbetaal)

OF

Keuse 2: U kan met sekerheid die volgende bedrag wen. Watter van die volgende bedrae sal u liewers verkies en watter bedrae nie kies nie?

R 50 000	R 100 000	R 150 000	R 200 000	R 250 000	R 300 000	R 350 000	R 400 000

APPENDIX 8: Additional map of Nkomati Basin - Mpumalanga.



Source: Department of Agriculture.