WATER MARKETS IN THE LOWER ORANGE RIVER CATCHMENT OF SOUTH AFRICA

CG Gillitt[1], WL Nieuwoudt[2] & GR Backeberg[3]

Abstract

Irrigation farmers in the Lower Orange River were surveyed during October 2003 in order to study whether water marketing has promoted efficiency and to identify factors that affect future investment in irrigation farming. Econometric procedures (principal component and logit model) 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; have more livestock (probably liquidity factor) and have a less negative view of the five-year 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. An investment model using Ridge Regression indicates that the following variables are associated with future investment in irrigation farming; expected profitability, risk perception and risk aversion (Arrow/Pratt). Results confirm that farmers who are more risk averse 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 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 National Water Act (NWA) and specifically water licenses.*

1. INTRODUCTION

South Africa's available freshwater resources are fast becoming fully appropriated and under stress. As the building of more dams is prohibitive, attention has shifted towards demand management strategies. One such strategy is water marketing, as water is transferred to its highest valued use, while the market attaches an opportunity cost to water, which in turn provides

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[1] *SA Cane Growers Association and postgraduate student in Agricultural Economics, University of KwaZulu-Natal.*
[2] *Professor, Department of Agricultural Economics, University of Natal, Pietermaritzburg.*
[3] *Director, Water Research Commission, Pretoria.*

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; Mirrelees *et al*, 1994).

In the present study, the water market in the Lower Orange River is studied as the area has an active water market. This study links up with a study on water marketing in the Lower Orange River undertaken during 1997 by Armitage (1999). The dynamic water market situation can be studied by comparing the current study (2004) to the previous study. Farmers at the time of the previous study (1997) were concerned about the application of the proposed National Water Act (No 36 of 1998). When Armitage undertook this research, water marketing in the Lower Orange River came to a standstill.

The current study has the following objectives:

(a) Are efficiency objectives envisaged in 1999 (Armitage, 1999 study) realised? The purpose would be to assess whether water marketing has promoted efficiency. This will be studied by comparing who are buying and who are selling water.

(b) To study trends in the water market.

(c) To study factors that affect future investment in irrigation farming. Interest would also be focussed on farmers' perception of the security of the licence and the risk aversion of the farmer.

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. Data were analysed using Logit Regression, Ridge Regression and Principal Component Analysis.

2. TRADING OF WATER UNDER THE NATIONAL WATER ACT (NWA)

The transformation process from the old approach (prior to the NWA 36 of 1998) to the application of the NWA of 1998 involves declaring water use as practised under the old Act as an existing lawful use. The process requires steps such as the verification of existing lawful use in order to issue a license either in terms of a compulsory licensing procedure or an ad hoc procedure. It may take time to issue licenses and in the interim an existing license is not a prerequisite for a water market as the existing lawful use of water may be traded. Existing lawful use is defined in section 32 of the NWA and refers to water use which has taken place during a period of two years prior to the commencement of the NWA. The latter was amended to allow certain discontinued and contemplated use that do not fall within the two year period to be declared existing lawful water use. The implication for the study is that some sleeper water rights may still be declared as lawful use and may thus be traded.

Temporary and permanent transfers of water entitlements are provided for in terms of section 25 of the NWA 36 of 1998. 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. 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 (RSA, 2002).

3. THEORETICAL CONSIDERATIONS AND STATISTICAL PROCEDURES

Special attention is given to the theoretical measurement of risk, as it is important to the study. In the interest of space, econometric procedures (apart from Ridge Regression) will not be discussed and the interested reader is referred to the following econometric sources that have further bearing on the research in this paper: Principal Component Analysis (Jolliffe, 1986; Nieuwoudt, 1977:78) and Logistic Regression (Gujarati, 1995:554, 556). The present study links up with Armitage's (1999) study in the same area.

3.1 Economic theoretical considerations

The economic theoretical model was based on the hypothesis that water will 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. In a 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. 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).

3.2 Risk and risk aversion

It is hypothesised that investment decisions are influenced by risk behaviour of the individual. This is especially true in a situation of high risk and uncertainty as is experienced in the study area. The risk aversion of farmers included in the survey was measured using the Arrow/Pratt Absolute Risk Aversion Coefficient (APAR). The APAR is defined as $-U''(x)/U'(x)$ where $U''(x)$ and $U'(x)$ is 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 APAR (λ). This utility function is estimated in this study 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 and zero (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.

Although APAR 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 paper. Standardisation was undertaken by converting the distribution ($x_{min} \leq x \leq xmax$) 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.

3.3 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 (VIF)* 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. THE STUDY AREA AND SURVEY

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 2,200km ending up in the Atlantic Ocean at Alexander Bay. At the source of the Orange River the rainfall is approximately 2,000mm per annum and decreases 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 undertaken 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. 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 the 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 has been towards the growing of high value orchard crops and export grapes.

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, and applied to land that situated within a distance of 2,000 metres from the banks of the river, and within a height of 60 metres vertically above the riverbank. 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 target population 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. This population was then sampled according to availability of phone numbers and availability of farmers' time for interviews. An effort was made to personally interview all farmers who bought or sold water during this time.

5. DESCRIPTIVE DATA

5.1 Characteristics of Buyers and Sellers

An effort was made to interview all farmers who bought or sold water. A total of 37 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 Buyers and 18 were Sellers in the water market. Two farmers could not be classified as Buyer or Seller, since they had both purchased and sold water at different times. These farmers were included in the analysis as both Buyer and Seller bringing the total for Buyers to 15 and Sellers to 20.

Table 1 summarises the average available irrigation land and average water entitlements held by surveyed farmers showing that most farmers surveyed held more water entitlements than their actual irrigated area. The typical motive was that additional water was held for future expansion. All the farmers only had one farm under irrigation, and some farmers had additional land used for livestock farming. The livestock operations have been excluded from this analysis.

Table 1: Irrigation land and water entitlements of survey farmers in the Lower Orange Region, as at October 2003 (after any transactions described in this study)

	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 due to the fact that 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.

The cropping summary of the survey farmers is presented in Table 2. None of the survey farmers produced dryland crops, so all crops discussed are irrigated.

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 percentage area (53 percent) under wine, juice, and raisin grapes than Buyers (28 percent). This phenomenon 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. The crop types classified as horticultural and field crops are indicated as a note to Table 2.

Table 2: Land use of survey farmers in the Lower Orange Region, as at 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)

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

Crop diversification scores were calculated for Buyers and Sellers by using the Herfindahl index which is calculated as follows (Pope and Prescott, 1980):

$$\text{Herfindahl index} = \sum p_i^{\,2}$$

where $$p_i = \frac{A_i}{\sum_{i=1}^{N} A_i}$$

Ai = 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 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 farming risk than Sellers.

The types of irrigation systems used by the survey farmers shown in Table 3 consist of drip, micro and flood irrigation systems while two farmers utilise macro systems. Buyers' make most use of advanced irrigation systems (drip and micro). These two types of systems are used to irrigate almost 70 percent of their crops. A reason for this is that Buyers often develop additional 'outer' land, which cannot be irrigated using flood irrigation.

Table 3: Percentages of hectares of irrigation systems used by survey farmers in the Lower Orange River, October 2003

	Drip	Micro	Flood	Macro[1]
Buyers	42	27	31	0
Sellers	4.5	10	85	0.5
Total	24	19	57	0

Note: 1) Overhead sprinklers.

Few Sellers make use of advanced irrigation, and use mostly flood irrigation (85 percent) (some 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

A total of 49 transactions occurred for the period 1998 to 2003 amongst farmers surveyed[4]. 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 in nature, and no temporary trades had taken place amongst surveyed farmers. Two transactions were excluded from the price analysis. One of the transactions was water traded for land, and in the other transaction, the farmer could not remember the price of the transaction.

Table 4 summarises the transactions of the surveyed farmers. Purchases and sales do not necessarily match in each year since some of the sellers or buyers were located in an area outside of the areas surveyed. These data show that water prices fluctuate 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 total price paid for each transaction and weighted by the area transacted.

[4] *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 4: Trading prices of water in sections of the Lower Orange River, 1997 to October 2003

Year	Purchases[1]	Sales[1]	Average size	Average Transaction Price/ha	Std Dev[2]	Minimum Transaction Price/ha	Maximum Transaction Price/ha	Average Price/ha	Coefficient of variation[3]
			(ha)	(R)		(R)	(R)	(R)	(%)
1997[4]	9	21	55.5	4929	-	1157	7233	4888	-
1998	4	6	45.1	6327	3222	4064	13548	5839	50.9
1999	5	1	8.6	9801	2106	7726	12877	10404	21.5
2000	7	8	12.5	11552	2131	5499	14053	10425	18.4
2001	5	3	15.6	10333	1397	9249	12717	10101	13.5
2002	4	1	11	9276	1455	7201	10589	9424	15.7
2003	0	2	16.8	14000	5657	10000	18000	16328	40.4

Notes: 1) These columns represent number of purchases and sales recorded.
2) Standard deviation.
3) Standard deviation divided by mean (Spiegel, 1961:73).
4) Data from Armitage (1999).
All prices are in real (2003 rand) terms (using CPI).

The average size of the transactions was 21.19 hectares. The average transaction price per hectare of water (15,000m^3) for the period amounted to R9,882 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 1,038.1 hectares of water entitlements, which is an average price of R8,579 per hectare or R0.57 per cubic meter (weighted average price). The average transaction price per hectare recorded by Armitage (1999) was R4,929 per hectare, and the weighted average was R4,888 per hectare (or R0.326 per cubic meter) in terms of 2003 rands. This is substantially lower than prices indicated in Table 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 there has been a reduction in the supply of water entitlements as all additional 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 high costs of developing 'outer' land. Many farmers considering trading water made use of the DWAF offices in Upington for information regarding available water entitlements. Potential Buyers occasionally use

DWAF records to identify farmers with excess water entitlements. In addition, farmers intending to sell water inform the DWAF office of their intention. 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. This has probably affected the price as Buyers compete for fewer available entitlements.

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 product prices and hence profits increase. Table grape export prices are sensitive to the rand exchange rate. This weakened during the period studied which most likely caused an increase in the price of exported grapes. The strengthening of the Rand exchange during 2003 to 2004 has severely affected profits from export table grapes and it is expected that water prices will be depressed again.

Information about 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. It is usually by word of mouth that farmers ascertain prices for water use entitlements. 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 been declined somewhat from 1998 to 2003 (Table 4 last column), which is what one would expect if more information becomes available.

It is difficult to identify temporary transactions in the 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 long-term security of water for perennial crops. Farmers also have more permanent entitlements than used at present. These excess water entitlements are usually for future development, and not necessarily for insurance against water shortages. Few water shortages had occurred over the last 10 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 (APAR)

The first risk question estimates the risk aversion of the farmer where no unfavourable outcome (loss) is allowed (excludes downside risk). The median APAR obtained for Buyers was 2.44 (n=14) and Sellers 2.12 (n=20). A positive coefficient implies that farmers are risk averse. The minimum and a maximum values for both Buyers and Sellers were -1.18 and of 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 next minimums for Buyers and Sellers were -0.40 and 0 respectively. The maximums for each category were from two different farmers. Three Buyers were risk neutral, and two were risk preferrers. 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 (down-side risk) than anticipated in the questionnaire as almost all the farmers picked the most risk averse category. That is they did not pick a choice where money could be lost.

The median APAR 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 R0.0 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 tested in section 6 in an investment model. The downside APAR was not used in the regression models due to lack in variability of the estimates.

6. ECONOMETRIC RESULTS

A Principal Component Analysis (PCA) on the variables was first undertaken as a high degree of multicollinearity was suspected between the variables describing the crop portfolios of farmers and variables describing irrigation technology used and turnover per unit of water applied. To study whether a water market promotes efficiency in water use, a logit model of Buyers and Sellers of water rights was estimated. An investment model was also estimated to study variables that are associated (positive and negative) with future investment in irrigation farming. The first step in the analysis is the PCA, which is used to indicate the variables that are most likely to be related to the dependent variable, and also with other variables considered as independent variables.

6.1. Principal Component of variables associated with water marketing

The first three principal components account for 36.9, 17.0, and 11.5 percent of the total variation in original variables associated with water marketing. Table 5 shows the loadings of the first and third principal components extracted from the original variables (Component 2 is not shown as it had no economic meaning).

Table 5: First and third components of variables associated with water marketing

Variable	Definition	PC1	PC3
EXPINV	The farmers expected change in investment expressed as a percentage	0.512	**0.688**
TYPE	Dummy variable: =1 if respondent is a Buyer in the water market; =0 if respondent is a Seller in the market	**0.830**	0.216
PERCEXP	Percentage of entire crop planted to export grapes	**0.856**	0.070
PERCOTH	Percentage of entire crop planted to wine, juice and/or raisin grapes	**-0.723**	-0.081
PERCFLD	Percentage of entire crop planted to field[1] crops	-0.594	0.089
PERCHRT	Percentage of entire crop planted to horticultural[2] crops	0.568	-0.274
PIRRTEC	Percentage of irrigated area irrigated using advanced irrigation (drip or micro)	**0.950**	-0.023
TNVWAT	Turnover per cubic meter of water used for irrigation	**0.825**	0.063
LSTOCK	Number of commercial livestock owned	0.218	**0.496**
CROPDI	Crop diversification score	0.509	0.204
RISK	Arrow-Pratt risk aversion coefficient	0.412	**-0.359**
DEBT	Debt to Asset ratio	-0.272	0.058
REVIEW	Importance of five-year review on investment decision, seeded 0 to 100: 0 = no effect and 100 = major factor negatively affecting investment decision	0.446	-0.253
SECURE	Index measuring farmers' perception of security of licences	0.372	**-0.470**
PROFITS	Dummy variable: =1 if respondent expects profits to increase in the future; =0 otherwise	-0.308	**0.430**
DEVEL	Degree of development, measured as the ratio of the current farmed area to the total available farm area	**-0.671**	-0.315

Notes: 1) Lucerne, cotton, maize and wheat.
2) Citrus, pecan nuts, mangoes and melons.

The first component shows positive loadings amongst 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 negative loadings for percentage of cropland planted to other grapes (PERCOTH), degree of development (DEVEL), and percentage of land planted to field crops (PERCFLD). This component captures variables associated with the purchase of water entitlements and could be labeled Buyer. The second column in Table 5 shows the loadings of the third component from an analysis of the sample data to be used in the investment model. It shows positive loadings for expected investment (EXPINV), the number of livestock owned (LSTOCK), and expected profits (PROFITS). It shows negative loadings for the farmer's risk aversion coefficient (RISK) and the perceived security of licenses index (SECURE). These relationships are important findings, which will be further investigated with an investment model.

In order to overcome likely multicollinearity, a component (principal component) was constructed from the crop variables. A crop variable was chosen as the demand for water as factor of production is a derived demand, derived from 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 crops are shown in Table 6.

Table 6: First component of percentages under crops

Variable loading	Component	
	1	2
PERCEXP	0.899	-0.203
PERCOTH	-0.762	-0.585
PERCFLD	-0.601	0.765
PERCHRT	0.559	0.352

PC1 scores 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).

6.2. Logit model of Buyers and Sellers of water rights

The most significant variable (Table 7) was PC1 (Wald=6.8). The Wald statistic (which has a χ^2 distribution) can be approximated by t-squared, implying that the t=2.6 for the PC1 variable. The t statistic has a normal distribution but Wald can be approximated by t-squared for larger samples of at least 30 (Ndlovu, 2004). This indicates that Buyers of water rights produce proportionately more export grapes, to a lesser extent, horticultural crops while proportionately less 'other' grapes and field crops are produced. The Buyers of water rights appear to have more livestock (t=1.14), which is seen as a liquidity variable. The

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).

In Table 7, the following variables explained whether a farmer was a Buyer or Seller of water rights, PC1 (Table 6), Crop Diversification (CROPDI) and Livestock (LSTOCK).

Table 7: First logit regression of Buyers and Sellers of water rights

	B	SE	Wald	Df	Sig
PC1	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 it's 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 it's maximum in order to achieve a measure that ranges from zero to one. The –2 log likelihood or scaled deviance value is 15.217 which follows a chi-square distribution with one degree of freedom. This value is significant at the one percent level. The Pearson Goodness-of-Fit chi-square is 36.649 with 31 degrees of freedom, which yields a p value (significance) of 0.223. This tests the hypothesis that the model is a good fit and should not be rejected (i.e. $p > 0.05$).

The overall correct classification of the model was 91.4% while the classification for Buyers was 86.7% and Sellers was 95% (Table 8). 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.

Table 8: Classification of observed and predicted values of Buyers and Sellers of water

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

According to Table 9 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 rights has a negative impact on the purchase of water use rights. The model in Table 9 has the same classification as the model in Table 7.

Table 9: Second logit regression of Buyers and Sellers of water rights

	B	SE	Wald	Df	Sig
PC1	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 and 9 have identical classification rates, the equation in Table 9 is a somewhat better economic model as it has a less significant constant term. More is explained by variables studied and the Wald criteria of these variables are marginally higher. Some statistics of the model in Table 9 are marginally lower. The Cox and Snell R-Square is 60.2 and the Nagelkerke R-Square value is 80.8 percent.

6.3 Investment model

An investment model was estimated where Y is the percentage that farmers expect to increase or decrease their investment in irrigation. This regression suffered from high multicollinearity as measured by VIF values. A Ridge Regression was thus undertaken to reduce multicollinearity. The results of this regression are shown in Table 10. The model basically explains future investment as a function of expected profits, risk, and possibly liquidity. These variables are supported by economic theoretical considerations. 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 significant at the 1 percent level, indicating that all the variables are jointly significant. A ridge trace has shown that regression coefficients stabilize after k=0.15 while the multiple regression coefficient declines only modestly before this point.

Table 10: Ridge regression of factors affecting investment

	B	SE(B)	Standard Beta	B/SE(B) = t
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
RISK	-0.216	0.134	-0.195	-1.611
SECURE	-0.133	0.068	-0.239	-1.953
Constant	20.694	9.132	0.000	2.266

The crop variables 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 variables are expected as current income per hectare from table grapes (R130,000) significantly exceeds that of wine grapes (R40,000) or raisins (R30,000). Expectations are assumed to be based on past experience. The 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).

The more risk averse farmers are expected to invest less as the RISK coefficient (APAR) was negative. This study indicates that irrigation farmers along the Lower Orange River are highly risk averse, especially as far as down-side risk is concerned. The implication is that policies that increase the risk in agriculture will have a significant negative effect on future investment in irrigation as these farmers will attach a great cost to risk. Farmers who feel that water licenses are not secure (high scores for SECURE) are further expected to invest less. The fact that both the RISK variable and the SECURE variable entered is significant 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. According to NWA Section 27(1)(k) the probable duration of the investment period will be considered in licence applications. Farmers are not sufficiently informed about this concession.

7. DISCUSSION AND CONCLUSIONS

The water market in the Lower Orange River was studied to: determine whether water marketing has promoted efficiency by comparing who are buying and who are selling water; identify trends in the water market; identify factors that affect future investment in irrigation farming. The profile of a purchaser of water rights 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 review period.

The buyers of water rights tend to specialize in the production of few crops that are highly profitable such as export grapes. Buyers are often livestock owners. Livestock are seen as a liquid asset, which may be a means of financing water market purchases. The short five-year review period has a negative impact on the purchase of water rights. This could be explained by the fact that the planning horizons for grape producers exceeds five years and requires an assured supply of water for the duration of the crops 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 efficiency 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 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 rights. 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 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 is very thin (two observation), and likely to be unreliable. The water price increase is possibly due to the increase in the price of export grapes, which was caused by the weakening exchange rate. If this is the case, then it is expected that the price of water in the market will be depressed due to a decline in the export grape prices caused by a firmer Rand. 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 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 risk in agriculture will have a significant negative effect on future investment in irrigation. Results also show that farmers who feel that water licenses are not 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. It does, however, appear that the length of the investment period will be considered in licence applications (NWA section 27(1) (k)). This concession is not well known at the farm level and lack of information is a problem.

In addition, policy makers should make use of feedback from farmers to enable the pragmatic implementation of the NWA institutions.

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