Variability in smallholders' irrigation water values: study in North-West Province, South Africa

S. Speelman [a] *, A. Frija [a], S. Perret [b], M. D'Haese [a] , S. Farolfi [c] , L. D'Haese [a,d]

[a] *Department of Agricultural Economics, Ghent University*

[b] *CIRAD, UMR G Eau and Asian Institute of Technology, Thailand*

[c] *CIRAD, UMR G Eau and Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria, South Africa*

[d] *Department of Applied Biological Sciences, University of Antwerp*

ABSTRACT

Capturing the economic value of water use is an integral part in the design of economic incentives and institutional arrangements that can ensure sustainable, efficient and equitable allocation of water. Irrigation water values of small-scale irrigators are however seldom studied and too little attention is paid to the determinants of the variability of the water values. In South Africa issues like the call for more efficient water allocation resulting from growing water scarcity, the approaching introduction of water charges for smallholders and the crucial role in rural development attributed to small-scale schemes, render this knowledge even more important. This study therefore first assesses irrigation water values at small-scale irrigation schemes in South Africa using the residual imputation method. Results reveal that, without input subsidies smallholders have difficulties to generate a profit from certain irrigated crops. This raises doubts about the capacity of smallholders to pay for water. The average economic value of irrigation water in this study is 0.188US$/m³. The water values are however shown to be highly variable. The General Linear Model shows that this variability can be mainly attributed to the crop choice and to the irrigation scheme design and institutional setting.

KEY WORDS: Water valuation, small-scale irrigation, South Africa, variability analysis.

RESUME

Le calcul de la valeur économique, relative à l'usage de l'eau, est une tâche essentielle pour les opérations de design des incitations économiques et des arrangements institutionnels qui peuvent assurer la durabilité, l'efficience et l'équité de l'allocation de l'eau. Les informations concernant les valeurs de l'eau d'irrigation à l'échelle des petites exploitations irriguées sont parfois limitées. En plus, peu d'attention est accordée à leurs déterminants de variabilité. En Afrique de Sud, l'appel à une allocation plus efficace de l'eau qui est due à sa rareté accrue, à l'application planifiée des tarifs d'irrigation, et au rôle de l'irrigation dans le développement rural, accroît l'importance d'informations concernant la valeur de l'eau utilisée en agriculture et sa variabilité. Dans ce contexte, notre étude s'intéresse à la détermination de ces valeurs à l'échelle des petites exploitations irriguées en Afrique de Sud en utilisant la méthode d'imputation résiduelle. Les résultats montrent que, sans subventionnement de l'eau d'irrigation et des autres inputs, les petits exploitants auront des difficultés à générer un profit de certaines cultures. Ceci génère un doute concernant la capacité des agriculteurs à payer

*Corresponding author. Stijn Speelman, Department of Agricultural Economics, Ghent University, Coupure Links 653, 9000 Gent, Belgium; Tel: +32 9 264 62 04; fax: + 32 9 264 62 46.
E-mail address: stijn.speelman@ugent.be

l'eau d'irrigation une fois des charges seront introduites. La valeur moyenne de l'eau d'irrigation estimée par notre étude est de 0.188US$/m³. Les valeurs de l'eau enregistrent, cependant, une large variabilité. Un modèle linéaire généralisé montre que cette variabilité est principalement due aux choix des cultures, au design du système d'irrigation, et au cadre institutionnel appliqué dans la zone irriguée.

MOTS CLES : Valorisation de l'eau, irrigation à petite échelle, Afrique de Sud, Analyse de variabilité.

1. INTRODUCTION

Water management policy is a critical component of South Africa's development strategy. The country is water-stressed with an average annual rainfall of only 500mm, which in addition is extremely uneven both in space and time. Moreover, most sectors in the economy are highly dependent on water. In wide areas of the country agricultural production for instance, relies entirely on irrigation. The current water scarcity and the limited options for augmenting supply to meet the needs of the growing economy and population, furthermore strongly suggest that water resource management should focus on more efficient usage of existing resources (Ashton and Haasbroek, 2002; Perret, 2002; DWAF, 2004). Decision-making to achieve more efficient water use requires reliable estimates of the economic value of water (Ward and Michelsen, 2002; Latinopoulos et al., 2004; Hellegers, 2005; Hellegers and Perry, 2006; Hussain et al., 2007). Knowledge of the economic value of water is necessary when making investment decisions in water resources development, drawing policies for sustainable water use and water allocations or when the socio-economic impacts of water management decisions must be determined (Hussain et al., 2007). It should furthermore be noted that water values are highly variable over space and time (Montazar and Rahimiko, 2008; Faulkner et al., 2008; Hussain et al., 2007; Lange, 2007). A wide range of factors, such as the crops grown, irrigation techniques used, and differences in soils and in management practices, influences irrigation water values. Although quantification of the factors responsible for the variability in water values can improve decision-making, this aspect has received little attention.

This study therefore first estimates the values of water in small-scale irrigation schemes in North West Province, South Africa using the residual imputation approach. Focus on variability in a partial analysis, values are then determined on crop, farm and scheme level after which Analysis Of Variance (ANOVA) is employed to test if differences in water values are significant. Finally the contribution of the factors responsible for the variability in the water values is quantified in a General Linear Model (GLM).

2. SMALL-SCALE IRRIGATION IN SOUTH AFRICA

Small-scale irrigation in South Africa originated mostly from a food security perspective and two types of schemes can historically be distinguished: 1) former Bantustan[1] schemes, currently accounting for 46,000 to 47,500 ha and 2) community schemes or garden schemes, representing about 50,000 ha (Backeberg, 2006; Perret, 2002). The first type of schemes dates from the 1950's and 1960's. Their objective was to provide farmers in the homelands with opportunities to produce their own food and possibly a surplus for sale. The size of these schemes varied significantly, ranging from 30 to 2000 ha, with an average size of about 200 ha, and a fixed farm size per beneficiary of about 1.5 ha (Perret, 2002). These schemes however were neither financially viable nor self-sustaining since capital or operation costs

[1] A homeland or Bantustan, was territory set aside for black inhabitants of South Africa as part of the policy of apartheid. Ten Bantustans were established in South Africa to enforce a rigid system of racial classification and segregation

were never covered by operation outputs and profit. Instead, under-pricing and government subsidisation of water infrastructure and services, and management by parastatal agencies generated dependency and ignorance on the farmers' side (Perret and Geyser, 2007). After reinstallation of democracy in South Africa, policies, including those for agriculture were reformed and the homelands were reincorporated in the State. At that time, the provincial governments decided to dismantle the agricultural homeland parastatals they had inherited (Tren and Schur 2000). Because no transition plan was in place, farmers were left stranded, both technically and financially, and schemes were often left behind with large debts. The effect of the parastatals' abrupt withdrawal on smallholders was telling, with an almost immediate partial or total collapse of production.

Nevertheless, because of their perceived role in rural development, in most provinces recently rehabilitation programmes for these schemes were put in place. Such programmes include transfer of ownership to local communities, education and training to generate awareness on good practices and promotion of affordable technologies. The challenge of these programmes is to increase the options for farmers to achieve productivity improvements (Perret, 2002; Backeberg and Sanewe, 2006).

Beside the state owned small-scale irrigation schemes, during the 1990s, NGOs and various other donor organisations also initiated community schemes or garden schemes with the objective of poverty alleviation and improved food security. There are many schemes of this type in South Africa and they are usually very small in size (Perret, 2002). Subsistence clearly is the major objective underlying such schemes. Short-term results of these initiatives are often good, but not all schemes remain successful in the long term. At some sites, maintenance and management problems caused schemes to collapse because communities did not have the capacities to take over management, following the withdrawal of support services (IPTRID, 2000). At other sites maintenance shifted from the donors to the community users or their representatives after a couple of years without any problem.

The current situation of the small-scale irrigation schemes still reflects the origins and evolution as described above.

3. METHODOLOGY

3.1. Estimation of water value

As stated above, conceptually correct and empirically accurate estimates of the economic value of water are essential for rational allocation of scarce water across locations, uses, users, and time periods. Neoclassical economic theory predicts that in a competitive market the economic value of a good corresponds to its market price. For water however, due to the limited role played by markets, valuation techniques must be used (Young, 1996; Agudelo, 2001). Several methodologies for estimating the value of water have been developed. They can be grouped according to whether they rely on observed market behaviour and data to infer economic value (indirect techniques), or alternatively use survey methods to obtain valuation information directly from water users (direct techniques) (Agudelo, 2001).

Examples of indirect techniques used for valuing irrigation water can be found in following studies: Kulshreshtha and Tewari (1991) used derived demand functions, Faux and Perry (1999) and later Latinopoulos et al. (2004) used an hedonic pricing approach and several authors, among whom Lange (2007), Agudelo and Hoekstra (2001) and McGregor et al. (2000), used residual imputation approaches to estimate water values. Other indirect techniques such as the averting behaviour method, the travel cost method, the income multiplier approach and the replacement cost/cost savings methods are less relevant for irrigation water valuing.

Direct valuation techniques on the other hand seek to elicit preferences directly through questioning individuals on their willingness to pay for a good or a service. These techniques

include the contingent valuation method, contingent ranking and conjoint analysis (Turner et al., 2004). Hassan and Farolfi (2005) for example used the contingent valuation method to estimate water demand functions of different users in the Steelpoort sub-basin, South Africa and Salman and Al-Karablieh (2004) determined farmers' willingness to pay for groundwater in the highland areas of Jordan. A detailed discussion of valuation methodologies can be found in Young (1996) and more recently in Lange and Hassan (2007).
Although all approaches listed above are based on sound theoretical economic concepts, the more they are based on actual market behaviour and information, the more scientifically accepted they are (Hussain et al., 2007). Since in South Africa, the subsistence farmers are currently not paying for water, it is impossible to establish a relationship between price and demand from actual behaviour to generate demand functions. Therefore, following Lange (2007), the residual imputation method (RIM) was used in this study.

This method determines the incremental contribution of each input in a production process. It assumes that if appropriate prices can be assigned, presumably by market forces, to all inputs but one, the remainder of total value of product is attributed to the remaining or residual input, which in this specific case is water (Young, 1996; Agudelo, 2001; Lange and Hassan, 2007). The technique is based on two principal axioms (Young, 1996):
1) The prices of all resources should equal returns at the margin. This is a well-known condition for competitive equilibrium, i.e. as would occur if perfectly competitive markets were to exist for agricultural inputs;
2) The total value of production can be divided into shares, in such a way that each resource is paid according to its marginal productivity and the total product is completely exhausted. This is satisfied when the total value function is a linear homogeneous production function. Euler's theorem shows that this is the case when a production function involves constant returns to scale.

Following this method the total value of production (*TVP*) thus equals exactly the opportunity costs of all the inputs (Agudelo, 2001):

$$TVP = \sum_i VMP_i Q_i + VMP_w Q_w \qquad (1)$$

Where

TVP= total value of the commodity produced;
P_i= price of resource i; subscript "w" for water inputs;
VMP_i= value of marginal product of resource i;
Q_i= quantity of resource i used in production.

When the opportunity costs of non-water inputs are given by their market prices (or their estimated shadow prices), the shadow price of water can be calculated as the difference (the residual) between the total value of output (*TVP*) and the costs of all non-water inputs to production:

$$VMP_w = \frac{TVP - \sum_i P_i Q_i}{Q_w} \qquad (2)$$

The residual obtained by subtracting the non-water input costs from total annual crop revenue can be interpreted as the maximum amount the farmer could pay for water and still cover costs of production. This gross margin represents the at-site value of water. This value, divided by the total quantity of water used on the crop, determines the maximum average willingness to pay for water for that crop (Agudelo, 2001).

Two issues are critical for a correct application of the RIM and render it only suitable for situations, like irrigated agriculture in semi-arid areas, where the residual input contributes a large fraction of the output value: first the specification of the production function and secondly the market and policy environment (i.e. the pricing of outputs and non-residual inputs) (Young, 1996; Lange and Hassan, 2007). If inputs to production are omitted or underestimated (incorrect production function) or if there are inputs that are unpriced or not competitively priced, then the RIM will generate inaccurate estimates. The first issue is easy to resolve by including all relevant inputs in the model. The second issue can be overcome by determining shadow prices for the inputs that are not correctly priced.

3.2. Data collection, processing and analysis

Data were collected from small-scale irrigation schemes located in Zeerust Municipality, North West Province, South Africa from July to September 2005. This municipality is part of the Crocodile West-Marico water management area. In this area development and utilisation of surface water has already reached its full potential. However mining developments and population and economic growth, mainly around Johannesburg and Pretoria, are expected to continue strongly (DWAF, 2004). This enhances the need for improved water management in this area and puts the agricultural water use under pressure. Moreover it is also a relevant study area because promotion of small-scale irrigation has been explicitly identified as a development policy for the region.

Questionnaires were used to collect data. Spread over 13 small-scale irrigation schemes, 60 farmers were interviewed. The total number of farmers at the randomly selected schemes was 189 or about 15% of the estimated smallholder population in the study area. The interviews gathered information on the irrigation schemes, household characteristics, farm activities, quantities and costs of inputs used in production, quantities and value of output, quantity of water consumed and irrigation practices. In the absence of water metering per farmer, estimation of water use was based on the reported duration and frequency of irrigation events together with irrigation infrastructure characteristics. Expert knowledge of the extension staff of the North West Province Agricultural Department was used as a supplement and crosscheck for farmers' answers. This was particularly helpful for the estimation of water use and prices of inputs and outputs.

To determine water value at crop level using the RIM, the revenue for each crop was calculated by multiplying production with market prices. By doing so also the self-consumed part of production was valued. In terms of inputs, costs of fertilizers, pesticides, herbicides, fuel and labour were taken into account. These were considered the relevant inputs in the production process. For fertilizers, pesticides and herbicides, competitive market prices were used to determine costs, even when extension services provided these inputs for free to farmers. For these inputs and the output, market prices are thus considered to equal shadow price. For the costs of family labour on the other hand, a shadow price was calculated based on discussions with farmers and extension personnel and on the scarce data on wage labour in the dataset. A value of 1.5 US$ per day was used[2]. Given the high unemployment in the study

[2] The average ZAR/US$ exchange rate for the period July-September 2005 was used for conversion: 1 ZAR= 0.1504US$ (source: IMF, 2006)

area, up to 40% according to PROVIDE (2005), the minimum wage of 5.3 US$ per day would not be a correct reflection of the cost of family labour. This kind of price corrections, proposed by Lange and Hassan (2007), is necessary to fulfil the assumptions of the RIM.

Next, the estimated water values were compared over crops using one-way ANOVA tests. Using the same methodology, the value of water was also calculated at farm and at scheme level and it was tested if significant differences could be observed between the different farms and schemes. Finally, a General Linear Model (GLM) was used to assess the importance of both quantitative and categorical factors influencing the variability in water value. The Variance Components procedure option estimates the contribution of the different factors included in the GLM (crops, irrigation technologies, irrigation schemes, educational background, farmer's age, gender and plot area) to the variance of the dependent variable (value of water).

4. RESULTS AND DISCUSSION

4.1. Descriptive overview

The number of farmers by scheme ranges from 1 to 45. The finding of an aging farming population reported by Tren and Schur (2000) and Perret (2002) is confirmed in this study. The average age of the surveyed farmers is 57 years. Moreover the education level of the sample population is found to be poor, with less than 6 years of schooling on average.

The two types of small-scale irrigation schemes identified above were also encountered in the sample: 1) Governmental schemes modelled after the Bantustan schemes: These schemes have an average area per farmer of about 1.6 ha and the scheme size is generally larger; 2) Food gardens or community schemes: This type of schemes assembles more farmers on smaller areas and consequently the area per farmer is smaller, mostly well below 1 ha. Typically in this type of schemes farmers are highly involved in scheme management.

Besides these two types some farmers also started irrigating on private pieces of land on an individual basis. The fact that these smallholders all started up their business after 2002 reveals that this is a recent phenomenon, enabled by the new policy framework.

The irrigation technology used by the farmers is usually uniform within a scheme. Furrow irrigation is the most frequently used method, with 40% of the studied farmers adopting it. The use of hosepipes and bucket irrigation accounts for 20% and 33% respectively. Such low cost irrigation methods are typical for small-scale irrigation schemes. Sprinkler irrigation is not very common (only 4 farmers in the sample). However, the farmers irrigating on an individual basis have all invested in sprinkler irrigation.

The degree of fragmentation is quite high because most farmers divide their field into many plots, growing about 6 different vegetable crops on average. Furthermore, the variation in input use and output produced is considerably large. The range in land sizes, from less than 100 m² to 2.8 ha, is obviously a reason for this. Furthermore, many farmers seem to use a low input strategy. The descriptive statistics of the inputs and outputs used in the calculation of the water values are presented in Table 1.

INSERT TABLE 1 ABOUT HERE

4.2 Estimated irrigation water values per crop, farm and scheme

Irrigation water values are calculated per crop, per scheme and scheme type and finally per farm. As also reported by Speelman et al. (2008), for more than a quarter (27%) of the 320 observed plots, negative gross margins were obtained in the calculation, leaving no residual value to attribute to water. Also frequently grown crops like beetroot, onions and spinach often yielded negative gross margins. A first reason for the negative gross margins can be found in the poor overall performance of small-scale irrigation in South Africa (Perret, 2002).

Secondly, the importance of these negative gross margins has to be put into perspective. Negative gross margins here do not necessary imply that farmers' profit for that specific crop was negative. Gross margins are theoretical, because in their calculation market prices were used for all inputs, while on the farm, some inputs are often not fully charged or even provided for free by extension services. A positive willingness to pay for irrigation water in spite of calculated negative gross margins, found in a study by Perret et al. (2003), seems to confirm this explanation. The negative gross margins at market prices nevertheless clearly indicate that at this moment, without government support on inputs, production would not be economically viable.
The aggregate average water value for the vegetable crops in this research is 0.188 US$/m³ if a value of zero is attributed to the cases with negative gross margins. This is a lower than results of other studies. Hussain et al. (2007) reported values up to 0.37 US$/m³ for high value crops in some African countries and Molden et al. (1998) stated that for vegetable production, water values are usually higher than 0.2 US$/m³. Finally, Schiffler (1998) in Jordan and Bouhia (2001) in Morocco even found a value for vegetables respectively of 0.665 US$/m³ and 0.686 US$/m³.

INSERT TABLE 2 ABOUT HERE

Water value estimates or ranges for individual vegetable crops like those in Table 2 are seldom reported in literature. Generally aggregate values for several vegetable crops are presented at farm or even scheme level. As an exception, Bader (2004) reports a value of 1.22 US$/m³ for winter tomatoes in Egypt and Ntsonto (2005) reports average values for smallholders in South Africa for a number of crops as shown in Table 2. In the table also water values calculated from secondary Combud data[3] (Combud, 2002) are reported. In general, for the crops for which comparison is possible, water values calculated in this study are of the same order of magnitude as those in other studies. Another observation is that although the study only looks at vegetable crops, computed values prove to be highly variable. This was also the case in similar studies by Ntsonto (2005) or Conradie and Hoag (2004). As indicated earlier, explaining the variability is one of the major objectives of this study. The values per crop were shown to differ significantly ($p<0.001$) using one-way ANOVA, with $F(10;309)=20.841$. In order to also explore the inter-schemes water value variability, average water values per irrigation scheme and scheme type were calculated and compared. An ANOVA analysis revealed that using irrigation scheme as factor the irrigation water values differ significantly at the 0.05% level ($F(13;306)=2.029$).

Hermans et al. (2006) and Faulkner et al. (2008) suggest that the institutional settings, management and design principles of the schemes can be important explicatory factors for such differences. Figure 1 shows the average water values for the different types of schemes discussed above. The values found are of the same size as those reported by Molden (1998) for schemes producing vegetables in other African countries. The highest average value was found for food gardens (0.321 US$/m³). An F-value of 6.19 confirms the significance of the differences between scheme types ($F(2;317)$ and $p=0.002$) and a post hoc test showed that for the schemes modelled after the former Bantustan schemes, the mean water values were lower than for the food gardens and for the irrigators on private land respectively at the 99% and 90% significance level. In line with the results of studies by Perret and Geyser (2007),

[3] These are detailed enterprise budgets (COMBUD from COMmodity BUDgets) for each province in South Africa published on a regular basis by the Provincial Departments of Agriculture. The budgets do not contain water use, but crop irrigation requirements for the budgeted crops could be calculated with the irrigation scheduling tool SAPWAT (SAPWAT, 2003)

Backeberg (2006) and Perret (2002), the performance of the Bantustan type schemes was thus found to be poor at this moment.

INSERT FIGURE 1 ABOUT HERE

The higher values for the food gardens can be explained by the more intensive production on the smaller plots. Other possible reasons for the higher values in the food gardens are the higher involvement and the lower degree of dependency, which lead to better management. These factors could also explain the higher water values for the farmers irrigating on an individual basis. A similar impact of water management factors on water values was also reported by Hussain et al. (2007) and by Tren and Schur (2000).

Finally, the cumulative distribution of irrigation water values per farm is presented in Figure 2. Values range between 0 and 1.11 US$/m³, with an average of 0.188 US$/m³. Most of the farmers encounter a water value below 0.4 US$/m³ For eight farmers (13%) negative gross margins were even obtained, indicating that at the market prices used in the calculations these farmers would not make profit out of their farm activities.
Again using ANOVA, gender ($F(1;57)=0.356$ and $p=0.533$), number of crops ($F(8;50)=1.259$ and $p=0.286$) or the education level of the family head ($F(3;55)=1.555$ and $p=0.211$) could not be found to significantly influence the water values at farm level. Also farmer's age and farm size had no significant effect on the water value. It was tested if differences in cropping pattern could perhaps mask the relationship between farmers' characteristics and water values, but also at crop level no significant results were found, indicating that individual characteristics of farmers appear to have limited effects on the water values.

INSERT FIGURE 2 ABOUT HERE

4.3 Explaining variance in computed values

The last part of the analysis aimed at estimating the contribution of different factors (crops, irrigation technologies, irrigation schemes, educational background, farmer's age, gender and plot area) to the variance of the water value. For this purpose, the Variance Components Procedure option of GLM was used. Approximately 60% of the variability in water values was found to be explained by the variables included in the GLM. The model was also highly significant (Table 3).

INSERT TABLE 3 ABOUT HERE

The partial Eta squared statistic in Table 3 describes the proportion of total variance attributable to a factor. The crop choice clearly has the largest effect, accounting for nearly 40% of the variability in the values. Variability can also be attributed for about 10% to the effect of the irrigation schemes. This effect can be explained by physical differences such as soil characteristics or differences in terms of scheme management. In line with the analyses above, farmer's characteristics like educational background[4], farmer's age or gender appear to be less important; the first two factors accounting for 1.9% each and the last for only 0.5%. Moreover farmer's age and gender were not significant at 95% level. This confirms that personal characteristics of the farmers have only a marginal influence on variability in water

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[4] For educational background 4 categories were created: no schooling, only elementary education, secondary education, tertiary or vocational education.

values. Surprisingly, and in contrast with findings of Faulkner et al. (2008) the effect of irrigation technology is even smaller. A possible explanation is that nearly all farmers in the sample use low efficiency technologies like furrow irrigation, bucket irrigation or hosepipes and thus variability in water values cannot be attributed to this factor.

5. CONCLUSIONS

While smallholder irrigation schemes are at one hand considered important tools in the fight against poverty, with governments investing huge amounts in them, growing water scarcity has at the other hand led to a more economic approach of water management. This has brought about the introduction of pricing policies to improve water allocation and efficiency of use, but also seeking to reach cost-recovery. The high percentage of negative gross margins at plot level found in this study reveals that the smallholder sector in South Africa would still have problems to be viable without government support. This weak performance clearly undermines the capacity to achieve cost-recovery (Perret and Geyser, 2007).

Water values were also shown to be highly variable. In the GLM it was shown that the variability could primarily be attributed to the institutional differences between irrigation schemes and to the crops grown. Improving the institutional setting of the schemes towards more participative management can thus be identified as a manner to improve water use efficiency. Furthermore water use efficiency can also be increased when extension services help farmers in selecting crops generating higher water values. The importance of the cropping patterns was also stressed in the study of Montazar and Rahimiko (2008). Finally, regarding the finding that irrigation technology is not that important as explanatory factor for the differences in water values, more research on a less homogenous sample is necessary.

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Table 1 Descriptive statistics on output produced and inputs used per farm (n=60)

	Output (US $)	**Inputs**					
		Labour ($)	Pesticides ($)	Fertilizers ($)	Fuel ($)	Water (m³)	Land (ha)
Average	423.52	43.62	10.83	9.63	23.16	1287	0.16
St dev	1706.74	114.3	12.33	13.69	139.27	3299	0.4
Minimum	22.56	7.42	0	0	0	82.9	0.01
Maximum	13114.88	900.9	54.14	72.24	1082.9	22150	2.8

Table 2 Computed water values per crop ($/m³)

Crop	# cases	Average water value[a]	Range	Water values from literature for comparison
Beans	32	0.836	0.00-3.081	2.03[b]
Beetroot	52	0.074	0.00-1.26	0.99 [b] /0.01-0.40 [c]
Butternuts	16	0.024	0.00-0.183	0.02-0.27[c]
Cabbage	17	0.368	0.003-1.663	0.78 [b]/0.07-0.44 [c]
Carrots	47	0.080	0.00-0.678	0.003-0.21 [c]
Green peppers	11	0.101	0.00-1.677	n.a
Lettuce	7	1.532	0.109-3.008	n.a
Onions	46	0.097	0.00-1.494	n.a
Peas	8	0.103	0.00-0.417	n.a
Spinach	48	0.040	0.00-0.293	n.a
Tomatoes	36	0.231	0.00-1.281	0.27-1.22[d]
TOTAL	320	0.188	0.00-3.081	

[a] Average was calculated assuming a value of 0 for the cases with a negative gross margin
[b] Values derived from Combud crop budgets (Combud, 2002)
[c] Average water values found by Ntsonto (2005), the range indicating different management styles
[d] Average water values found by Bader (2004), the range indicating different locations
n.a.: no values found to compare

Table 3 GLM model decomposing water value variance into factors

	df	F	Partial Eta Squared[a]
Crops	10	13.63***	0.394
Irrigation technology	1	0.41	0.002
Irrigation scheme	11	1.88**	0.090
Educational background (4 categories)	3	1.33	0.019
Farmer’s age (years)	1	4.09**	0.019
Gender (0=male)	1	0.96	0.005
Plot area (m^2)	1	0.03	0.000
Error	210		
Total	241		
Model	31	9.90***	0.594

*** indicates a 99% significance level ** a 95% significance level and * a 90% significance level

[a] Partial Eta squared calculated here is based on the marginal sums of squares (type III). These are preferred since they correspond to the variation attributable to an effect after correcting for any other effects in the model. A normal outcome of this is that the partial Eta squared of the factors do not sum to that of the model.