THE VALUE OF WATER IN THE SOUTH AFRICAN ECONOMY: SOME IMPLICATIONS

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Abstract

The South African Water Research Commission (WRC) initiated a number of research projects aimed at determining the value of water in different sectors of the economy and in different parts of the country. This research is reviewed. Water values were found to differ significantly between sectors, between geographic areas and within geographic areas. As agriculture is a large consumer of water several studies along different rivers were undertaken, including studies on water quality. Average ratios indicate that agriculture is an inefficient user of water in terms of gross income generated per unit of water and also in terms of jobs created per unit of water. Irrigation farming is, however, an important employer of labour while it contributes 30% to the value of farm output. A marginal approach and water demand elasticities also indicate that non-agriculture generally places a high value on water assurance but little value on more than what it already uses. This may indicate that although water is expected to transfer out of agriculture in the longer run, in the short run agriculture may be its best use. Water efficiency could be significantly enhanced if transfers within and between river reaches are promoted, as water shadow prices differ. Inputs from the Department of Water Affairs and Forestry (DWAF) are important in water allocation due to socio-economic and environmental externalities of water allocation.

1. INTRODUCTION

As South Africa is a drought prone, water poor region it seems probable that water shortages will redirect economic development. As water scarcity increases, the need to manage water as a national asset and for overall social benefit becomes imperative. During the past number of years the South African Water Research Commission (WRC) and the Department of Water Affairs have initiated a number of economic research projects aimed at determining the value of water in different sectors of the economy and in different parts of the country.

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The purpose of this article is to review existing information and experience in order to obtain the best current estimate of the value of water in different sectors of the South African economy, and to establish the role that water plays in regional economies within the country. Knowledge of basic human needs, the assurance of supply, and the value of water in different sectors and basins can aid in demand management in times of shortages. This information is required to optimise scarce water resources for the social benefit of all people. In addition to this Command and Control (CAC) procedure, economic incentives and institutions can assist in promoting conservation of water within the ambit of the law. Economic institutions and incentives have internationally promoted conservation and the efficient use of water by using knowledge that is decentralised.

2. THE SOUTH AFRICAN WATER RESOURCE STRATEGY

The National Water Act (No 36 of 1998) specifies that Government, as the trustee of the nation's water resources, must ensure that water is protected, used, developed, conserved, managed and controlled in an equitable and sustainable manner for the benefit of all people. The Act requires that the Department of Water Affairs and Forestry (DWAF) should act as custodian of the country's water resources (RSA, 2002), and guarantees basic human needs and ecological use (the reserve) as rights along with international obligations. Irrigation and other commercial agricultural activities are excluded from this allocation (Louw, 2001:18; RSA, 1998). The New Act thus gives priority to basic human needs and ecological sustainability above that of agriculture and other industries. The New Act respects pre-existing water rights and farmers may continue using water until a call is made for the application of water licences. Water licences have a maximum span of 40 years and are subject for review at intervals not exceeding five years.

The implementation framework for the National Water Act of 1998 is provided for in the National Water Resource Strategy (NWRS). The NWRS has four objectives, which include the establishment of the framework for catchment management strategies. A catchment management strategy is the framework of water resource management in a water management area (RSA, 2002).

In the preamble to the Act it is clear that water management is to a large extent under the control of the state. However, Section 25(1) of the Act makes provision for the temporary transfer of water entitlement between users, which raises the possibility of complementary actions between government and the private sector. The Act also contains other important provisions that will support a water market. First, a distinction is drawn between land and water rights. Second, the management of catchments will eventually be assigned to Catchment Management Agencies (CMA) and it will be possible for CMAs, with the approval of the Minister, to include water markets as an allocation strategy within a catchment.

3. ECONOMIC PRINCIPLES

Water has two main uses: either consumed directly as a consumption good or used as a factor of production in agriculture, forestry and industry, etc. The economic foundation of the demand for these two consumption uses differs, and is discussed separately below.

3.1 Water as a consumption good

Residential demand is the only water use category where water is consumed directly. Residential water competes directly with other items in the household budget. In this regard, consumer choice can be modelled as utility maximisation given a budget constraint, from which a downward sloping demand for water can be derived. Some characteristics of water resemble that of 'normal' economic goods, implying that demand affects the price, while in other respects demand is expected to be highly inelastic, reflecting the fact that water is an essential good. The Espey *et al* (1997) survey of 124 estimates of price elasticity of demand for residential water supports this view. They report a median short-term price elasticity of –0.38 and a long run price elasticity of –0.64. This shows that residential water is not price responsive in the short run, confirming its status as an essential good.

Apart from the time horizon, price elasticity is affected by type of use. Evidence from Europe, USA and Africa indicates that households are willing to pay much more for drinking water and basic needs than water used to irrigate gardens (Foster & Beattie, 1979; Zabel *et al*, 1998; Rogerson, 1996). Veck and Bill (2000) record a similar result for Alberton–Thokoza in South Africa where the price elasticity of demand is estimated to be –0.13, for indoors and –0.38 for outdoors use. The lower elasticity for indoor use indicates that this is less price responsive, and hence more of an essential good.

From an empirical perspective, the total value of water for residential use can be quantified by the consumer surplus (area under demand for water but above the water price). The marginal value for water (marginal utility), i.e. its scarcity value, is reflected by the price of water. A condition for economic efficiency in consumption is that marginal utility must be equated for all consumers, which is achieved as all consumers in a given area face the same price.

Quantity demanded is a function of willingness-to-pay as well as the ability to pay and while poor consumers may be willing to pay an infinite amount for basic needs water they may be unable to do so and be excluded from the resource (McMaster & MacKay, 1998). Present legislation supports the basic needs position and includes a provision of 25 litres of water per person per day for drinking, food preparation and personal hygiene.

Several studies in poor communities have, however, indicated that poor people are willing to pay for water and that this willingness-to-pay indicates the opportunity for efficient allocation through price (Conradie, 2002). An extensive study of domestic water demand in low-income communities in the northern parts of South Africa has found that demand in squatter camps obeys the same rules as demand in formal settlements. As in formal settlements, quantity demanded in squatter camps is a function of income, price of water, the presence of gardens, awareness of scarcity, time of the day, season, number of household members and the number of visitors (Van Schalkwyk, 1996).

3.2 Water as a factor of production

Theoretically the demand for irrigation water is a derived input demand, as irrigation water is a factor of production. An input demand is derived from the demand of the product (profitability of crops, etc), the production function (water plant efficiency), and the supply conditions of other factors of production (water saving technologies). The total income generated by the application of water (total value) can be measured by the integral of the area under the input demand function of water. The value of an additional unit of water can be expressed by the value of the marginal product. These concepts are shown in Figure 1 where DD is the demand for water, Qa the availability of water (supply is SS), A+B the total value of water and B = Rent or Residual.

In this situation no cost is shown for water. If costs exist then it will be deducted from value. The total per unit value is (A+B)/Q which is an average concept, while the rent or residual value per unit is B/Q = Pw (which is a marginal concept). In a functioning water market, the price of water rights is captured by Pw. These rights can be expressed as rental income (annual income) or a capitalised value (capital value of an asset). In a water market the price of water rights represents the contribution of water after all costs have been deducted, including water charges. The total value (Area A+B) and marginal value (B) provide different information to stakeholders. In a Cost/Benefit Analysis the area A+B is compared with the cost of providing water (building dams) to ascertain whether benefits exceed costs. The marginal value is critical in utilising the resource in an efficient manner. For instance reallocation of use will promote societies' income if water has a greater efficiency of use (marginal value) in one area than in another.

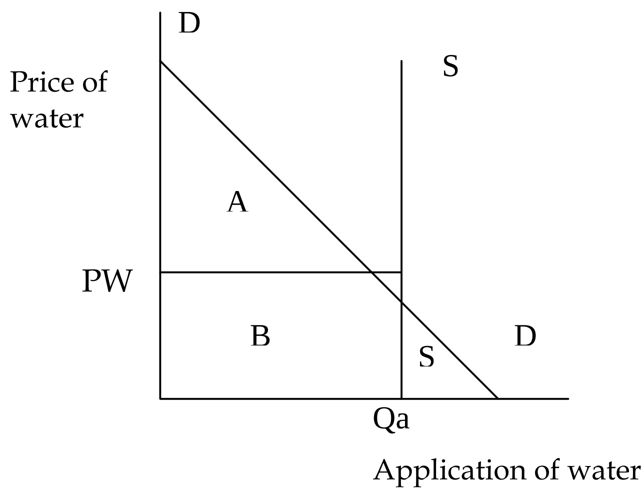

Figure 1: Resource demand for water

Whether the total contribution or the marginal contribution is estimated in a study depends on the technique used. In a crop budget total cost is deducted from total income yielding the total and average contribution of water (Area A+B). Programming techniques provide information on the Value of the Marginal Product (VMP) of water given by the shadow price of the water, which is the marginal value (B/Q). The latter technique can also be used to derive the total and average value of water. Production functions provide information on the VMP of water although average value can also be derived. The Willingness to Pay (WTP) approach estimates average consumer surplus, which is an approximation of market values and thus estimates marginal value B/Q. If water is rented then the trading price is B/Q or if it is sold then the selling price is the capitalised value of area B or B/Q (if expressed per m^3).

4. THE CONTRIBUTION OF WATER TO DIFFERENT SECTORS

In order to decide which sectors should be given preference in water allocation during scarcity, information is needed on the value of water in these sectors. Various sources of information will be critically evaluated.

4.1 The importance of water in supporting income and creating jobs

Agriculture is an inefficient user of water, as it supports the lowest GDP per million m^3 while it creates the fewest jobs per million m^3. One cubic meter of water adds R1.5 in agriculture, R157.4 in industry, R39.5 in mining and R44.4 in eco-tourism (Conningarth Consultants, 2001). Large differences also appear in agriculture, with the highest contribution per m^3 in livestock and game farming followed by orchards and lastly fodder crops. One million m^3 of water supports 250 jobs in agriculture but 1,785,000 jobs in glass products (BKS, 1999). However, these data do not show forward and backward linkages between sectors, for instance between agriculture and other sectors. Crop failures usually have ripple effects through the economy.

Some comments of caution are raised in interpreting these data, as they are average relationships derived from Input/Output tables. In the face of scarcity, water use should be allocated between sectors based on marginal benefits and not on average benefits. That is, water efficiency for the industry sector is high because output is high and water use low. Also, production is based on many other factors, and not on water only. It is, however, expected that supply assurance for water is high in mining and industry compared to agriculture. The input elasticity of demand for water is expected to be low in sectors where the cost of water is a relatively small share of the value of the final product and where water cannot be replaced by other factors of production (Friedman, 1962:153). A low price elasticity of demand implies that a high premium is placed on sufficient water and a high level of assurance.

The marginal contribution of water in industry is expected to be much lower than the R157.4 per million m^3 mentioned earlier. Water use by these sectors is not rationed in South Africa and they are able to acquire as much water as they need at current municipal prices. That is, profit-maximizing firms in industry will purchase water from municipalities until the contribution that the last unit of water makes to the firm (VMP) is equal to the price of water (about R1.26/m^3 in the case of the Nelson Mandela Metropole). Economic logic thus indicates that the marginal contribution of water could be as low as R1.26/m^3. Some sectors place a higher premium on sufficient water and marginal contributions cannot be the only criterion of allocation between sectors.

4.2 The importance of water in job creation

Although agriculture creates few jobs per unit of water compared to other sectors, it generates more jobs per value of output than other sectors (Conningarth Consultants, 2001). For instance production of R1 million in agriculture creates 24 jobs in total (direct and induced effects), while mining creates 10.9 jobs per R1 million and manufacturing 9.0 jobs per R1 million. Agriculture also generates more jobs per R1 million investment (8.06) than the other sectors. This number has more relevance to irrigation agriculture than other branches of agriculture. That is, investment in dryland maize farming is constrained by suitable land area while investment in irrigation could create more jobs in the fruit and vegetable enterprises (where water rather than land is often the main constraint).

Agriculture, however, requires large quantities of water as only 108 jobs are created per 1 million m^3 of water in agriculture while industry creates 4,269 jobs. The mining sector creates 150 jobs per 1 million m^3, which is almost in the same order of magnitude as agriculture. South African agriculture is labour intensive, especially the irrigated sectors (fruit and vegetable farming).

In the allocation of water between agriculture and the other sectors it could be taken into account that industry can sometimes grow where water is abundant while some of the best fruit and vegetable growing areas are situated in areas where water is scarce. Some will question this, as industry also requires other resources such as labour and infrastructure, which may be available where water is scarce. Market forces will encourage industry location where resources including water are relatively abundant, thus the State should not subsidise certain resources.

5. THE VALUE OF WATER IN NON-AGRICULTURAL SECTORS

Studies of water use in non-agricultural sectors include: municipal use (Conradie, 2002), commercial forestry (Tewari, 2003), environmental use (Hosking *et al*, 2002) and alien vegetation use (Hosking *et al*, 2002).

5.1 Municipal water value

Conradie (2002) estimated demand functions for water for household, commercial and industrial consumption in the Nelson Mandela Metropolitan Municipality. Conradie (2002) estimates the marginal benefit of water to consumers at R2.40 /m^3, which is equivalent to an annual rental value of R21,600/ha for a 9,000 m^3 allocation. Bulk sales of treated water to lesser municipalities are priced at R1.26/m^3. The city purchases water from the Department of Water Affairs and Forestry at an annual rate of R0.256/m^3. There is no doubt that, like irrigation, municipalities capture the residual value of the resource, but the reserve price at which agriculture will start losing water to municipal use in that area is R1.26/m^3 minus treatment costs in 1999 terms.

In order to increase income variability of households in the data set, observations from the more affluent residential areas and townships (low income consumers) were pooled. Using a regression model, the water price elasticity was estimated at –0.47 (t = -3.10) which is low and indicates that this use is not sensitive to price increases. A similar estimate (-0.40) was reported for Australia (Australian Academy of Technological Sciences and Engineering, 1999).

5.2 Commercial forestry

Water is the most important limiting factor of production in commercial forestry in South Africa. Commercial forestry uses water in two forms: evapotranspiration (ET) and stream flow reduction (SFR). In terms of stream flow reduction water use is estimated to be in the region of 1.4 billion m^3 per annum or roughly 8 & of the total utilisable water in South Africa. Since commercial afforestation has been declared as a stream flow reduction activity (SFRA), it is to be regulated by means of a SFRA Water Use Licensing System in terms of Chapter 4, Section 36 of the National Water Act (No 36 of 1998).

The value of the two uses of water (ET and SFR) in forestry was further estimated using two methods, namely the Residual Value (RV) method and the Marginal Value Product (MVP) method. The residual value method is based on the premise that the residual value obtained as total revenue minus total cost, including compensation for capital and management, is attributed to water. The marginal value product method is based on the assumption that water is rewarded according to its MVP. Both approaches were used to estimate water values in selected sites of eucalyptus and pine in the eastern seaboard of South Africa. These two species were selected as they dominate South African forestry, especially on the east coast. Results of the estimates of water values are presented in Table 1. It is shown that water values estimated vary depending on method of estimation and type of use.

ET values estimated by the RV method for eucalyptus vary from 4c to 13c per m^3 of water, with the former found in low rainfall areas such as Baynesfield and the latter in a high rainfall area such as Kwambonambi. The average value comes to 8c per m^3. The ET value for pine, estimated by the RV method, averages at 1.7c per m^3. Water value estimates for pine species are much lower than for eucalyptus. The difference can be explained in terms of the growth pattern of the two tree species; eucalyptus grows faster and uses water more efficiently.

Table 1: A comparison of types of annual water values in commercial forestry

Name of Sites	ET value by RV Method R/m³/year	ET value by MVP Method R/m³/year	SFR value by MVP Method R/m³/year
Eucalyptus			
Kia-Ora	0.06	0.34	4.44
Tanhurst	0.10	0.25	1.90
Kwambonambi	0.13	0.60	3.92
Baynesfield	0.04	0.04	-
Average	0.08	0.31	3.42
Pine			
Richmond	0.013	0.15	1.27
Greytown	0.008	0.11	2.20
Usutu	0.031	0.21	1.89
Average	0.017	0.15	1.79

Source: Tewari, 2003

The ET value estimates by the MVP method vary between 4 to 60c per m^3 of water and are roughly 4 times the estimates by the RV method. The RV method measures the residual net value attributed to water after paying for all other inputs in the production process. As the MVP of water was derived from production functions (Table 1), it measures the value before other costs have been deducted. In the other studies reported in this paper the MVP was estimated from programming techniques after other costs have been deducted. The MVP estimates in Table 1 will thus be ignored in the further discussion in this paper.

This argument also applies to SFR values of water estimated by the MVP method. These values, nevertheless, need mentioning. SFR values vary from R1.90 to R4.44 per m^3, roughly 40 times the ET values estimated by the RV method. According to Tewari (2003:56) runoff on natural vegetation is 20% and in a plantation 10%. This implies that the value of water in terms of SFR value is about 10 times the value in terms of ET. It is concluded that the value of water in commercial forestry is greater than its average ET value, estimated in Table 1. If the uncertainty of this estimate is accepted then a figure of 8c per m^3 is suggested.

5.3 The environmental use of water

Hosking *et al* (2002) estimated the value of freshwater inflows in the Keurboom Estuary using the Contingent Valuation Method (CVM). The method entailed asking respondents how much they were willing to pay (WTP) to prevent the loss of environmental services provided by the estuary due to reduce freshwater inflows, given that reduced inflow from the

Tsitsikamma Catchment could lead to closure of the estuary mouth, where inflows have already been reduced by infestation of water-consuming alien vegetation. The removal of this vegetation was initiated under the Working for Water (WfW) programme. In the WTP study the target population was identified as users of the estuary who included anglers, baiters, swimmers, birdwatchers, bathers and those who benefited from water frontage/access and the scenic value.

The willingness to pay to prevent the negative consequences of cutting off freshwater inflow was estimated at R274 per user (Standard deviation R262), based on a sample of 150 respondents. The total recreational value of water was estimated at R3,626,128 or 4.6c/m^3/annum (Hosking *et al*, 2002), substantially less than the willingness to pay for water for farming of 12.5c/m^3. According to the researchers the benefits derived by those above the estuary were not included. Other benefits such as fire damage reduction and preservation of biodiversity were also not included. In this study the environmental value of water was estimated at about 5c/m^3/annum. It can be expected that this value will vary significantly between areas.

6. THE VALUE OF WATER IN AGRICULTURE

In Table 2, the irrigated area in agriculture and the direct contribution of water to agricultural income are shown for different agricultural enterprises. Irrigation water is essential to South Africa's fruit industry, which ranks amongst the most important export commodities. The value of commercial crop production under irrigation is estimated at R14,700 million annually according to Table 2. This figure excludes enterprises such as wine grapes for which area under irrigation was not available. It is thus estimated that 30% of the value of South African agriculture is produced under irrigation, similar to the contribution of water to rural value added in Australia, which was also 30% (Australian Academy of Technological Sciences and Engineering, 1999).

Since agriculture is the most important consumer of water (54% of total use), studies in the following regions were undertaken; Fish-Sundays Scheme in Eastern Cape (Conradie, 2002), Berg River (Louw, 2001), Crocodile River Catchment (Bate *et al,* 1999), Lower Orange River (Armitage, 1999) and Eastern and Southern Cape (Hosking *et al*, 2002).

Table 2: The contribution of irrigation to commercial crop production, 2000/01

Crop	Area irrigated		Production	
	'000 ha	% of total area planted to crop	Rm	% of national production
Maize	110	3	626	10
Wheat	170	12	739	30
Other small grains	52	3	16	6
Potatoes	39	70	1373	80
Vegetables	108	66	2296	90
Table Grapes	103	90	1504	90
Citrus	35	85	1462	90
Other fruit	95	80	4148	90
Oilseeds	54	10	199	15
Sugarcane	60	15	779	25
Cotton (Lint)	18	17	92	42
Tobacco	12	85	559	90
Lucerne	203	70	657	80
Other pastures & forages	104	15	250	25
Total			**14700**	

Source: Backeberg & Odendaal, 1998 and RSA, 2002

6.1 Existing farming area

In this section the contribution of water is captured by its marginal contribution to net income (VMP).

6.1.1 Fish-Sundays River Scheme

The Fish-Sundays River is supplied by an inter-basin transfer of 560 million m^3/year water from the Gariep Dam on the Orange River. During the past five years the Orange River delivered between 65 and 95% of the water used in the Fish-Sundays Scheme.

Conradie (2002) constructed linear programming models for 16 model types of farm situations in this area, also allowing for risk using MOTAD. In models where risk was ignored, the model simulated more specialisation in crops than what is actually occurring. Inclusion of risk has lead to more diversification and a more realistic model. Estimates of the value of water were sensitive to assumed risk aversion values, indicating that the degree of confidence that can be placed on estimates is not very high.

Estimates of the value of water also differ significantly amongst the different representative farms (Table 3). This is expected if the transaction cost of water transfers is high. Table 3 shows that three farm types attach a zero marginal value to water. For the remainder, marginal willingness to pay for water ranges between R0.0003/m^3 and R0.2115/m^3. Municipal bulk rates for the area are R0.256/m^3. The current allocation of water is not efficient due to wide differences between areas. Table 3 also lists the purchase price of a cubic meter and a hectare's worth of water across farm types.

Table 3: Marginal water values for the Fish-Sundays at current allocation

Representative farm	Water rental		Purchase price	
	R/m^3	R/ha	R/m^3	R/ha
Type 1 Upper Fish irrigation	0.0011	15	0.02	297
Type 2 Upper Fish stock farm	0.0067	90	0.13	1809
Type 3 Upper Fish farm business	0.0106	143	0.21	2862
Type 4 Upper Fish dairy farm	0.0412	556	0.82	11124
Type 5 Middle Fish irrigation	0.0003	4	0.01	81
Type 6 Middle Fish stock farm	-	-	-	-
Type 7 Middle Fish farm business	0.0120	162	0.24	3240
Type 8 Middle Fish dairy farm	0.0427	576	0.85	11529
Type 9 Lower Fish irrigation	-	-	-	-
Type 10 Lower Fish stock farm	0.0014	18	0.03	350
Type 11 Lower Fish farm business	0.0163	204	0.33	4075
Type 12 Lower Fish dairy farm	0.0378	473	0.76	9450
Type 13 Sundays Small mixed	0.1702	1532	3.40	30636
Type 14 Large stable citrus	0.2115	1904	4.23	38070
Type 15 Small expanding citrus	0.0815	734	1.63	14670
Type 16 Large expanding citrus	-	-	-	-

Source: Conradie (2002:148)

Table 3 indicates that citrus producers as a group are able to bid water away from fodder producers, while water will migrate from the Fish to the Sundays River. As some resource areas have zero opportunity cost of water, it is estimated that 77 million m^3/year or 13% of the resource can be redistributed away from irrigation at zero opportunity cost. Two thirds of the current allocation can be bid away at a price of R0.035/m^3. Thus equity objectives can be satisfied at zero or very low opportunity cost to commercial irrigation. Conradie (2002) concludes that the Fish-Sundays may be a possible source of cheap water that should be further investigated.

The total water value for the scheme is estimated to be R27 million in 1999 Rand while irrigation shadow prices range from zero to 21c/m^3. The value of water in the small scale farming area (Tyefu) was also estimated. If the water tariff is included as a cost then the value is estimated as negative in this scheme.

6.1.2 Berg River Basin

Louw (2001) developed a positive mathematical programming model to study the impact of water markets in the Berg River Basin. The novelty of the technique is that it is calibrated to simulate the base period, which avoids the introduction of inflexible bounds. Louw (2001) showed that the capitalised marginal value of water differs from as low as R0.0/m^3 to as high as R20.0/m^3 within sub-sectors of the river basin. The median capitalised market value of water is estimated at R1.6/m^3 (rental rate of R0.21/m^3) if no trade is assumed and R0.30/m^3 if trade is assumed. Louw (2001) used a capitalization rate of 13%, which appears high. The median capitalised water right is estimated in the base analysis at R8,000 per ha (5,000 m^3 per ha * R1.60/m^3) for a water right of 5,000 m^3. The observed water rights in the Upper Berg ranged from R4,000 to R6,000 per ha, which were lower than recorded in 2000. The significant differences in the value of water between areas within the basin indicate that significant gains are possible from trade between these areas.

6.2 New irrigation

6.2.1 Crocodile River Catchment

Bate *et al* (1999) studied the trading of water in the basin and observed a capitalised value of water between 18.75c/m^3 and 22.75/m^3 (Table 4). A wide range of trade prices (rental value) for water was observed, ranging from zero to 6c/m^3 with a modal of 2.5c/m^3. There were only a handful of buyers (four accounted for 90% 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. A zero price trade does not imply zero value as the buyer must pay the water rates, which are as high as 0.84c/m^3. Most of the trades (97% by volume) are from farmers in the upper/middle Crocodile River selling to farmers in the lower Crocodile River. This is important as trades from up to down river increase stream flow and is desirable for the environment.

The highest value of water was estimated in tropical fruits and the lowest in sugar cane. Sugar cane production, however, increased in spite of relatively lower returns per ha of land. This was attributed to the fact that the industry was more stable, 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.

Table 4: Water trades in Crocodile River Catchment

General Trade Information	Permanent	Temporary
Number of trades	23.00	46.00
Number of zero price trades	4.00	23.00
Area traded (ha)	563.3	2140.69
Volume of water traded (million m^3)	5.36	21.04
Trade price (capital value) of water c/m^3)	18.75	-
Trade price (capital value) of water c/m^{3*})	22.75	-

Note: * = Non-zero trade price
Source: Bate *et al* (1999)

Bate *et al* (1999) estimated gains from trade at R12.8 million annually. 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 water traded, 8 million m^3 is actually used. As is the case in other areas, the cost farmers pay for water is substantially less than what urban consumers pay. The full economic cost (excluding financing) of providing water from the Kwena dam is 46c/m^3, while farmers pay 0.7c/m^3 and urban consumers R1/m^3. The latter users and taxpayers clearly subsidise agriculture.

6.2.2 Lower Orange River

According to Moller (2003), a prominent farmer between Kakamas and Keimoes, water rights during February 2003 sold for between R8,000 and R10,000 per ha (15,000m^3) with an average of 60c/m^3. All the water trades were of a permanent nature. No renting of water takes place, as farmers need security of use for their long run investment in table and wine grapes. According to Engelbrecht (as reported by Hosking *et al* (2002)) water rights in the Sundays River trade for about R2,000 per ha (quota is 9,000m^3) or 22.2c/m^3. The market price of water is about a third in the Sundays River compared to the Orange (22.2c/m^3 compared to 60c/m^3) and water would move from the Fish/Sundays to the lower Orange if transfers were permitted. Moller (2003) further estimates that water would probably rent for about R450 per ha or 3cm^3/m (the rent of R450 per ha on an investment of R9,000 per ha represents a return or discount rate of 5%). He further indicated that farmers could rely on the reliability of the river flow. Because of the latter, farmers have stopped planting low value crops which they could use as a water reserve in times of drought.

Moller (2003) also states that selling prices of water are responsive to economic conditions (price of the product etc). Water prices in this area have more than doubled since the Armitage (1999) study. Armitage (1999) reported an average price (asset value) for water trades in the Lower Orange of R3,407 per ha or 22.7c/m³. The average water price varies from as little as R800/ha to as high as R5,000/ha. Closer examination of the data shows that there were fewer buyers (9) and more sellers (21), where the number of contracts per buyer varied from one to 14, while 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). The same phenomenon is observed by Bate *et al* (1999) for the Crocodile River Catchment. It appears as if this range has narrowed if Moller's (2003) prices are compared with Armitage (1999). This is expected to happen if farmers have better information.

A discriminant analysis undertaken between buyers and sellers of water rights showed that the most important variable discriminating between the two groups was that buyers were table grape farmers (F = 18.3) and secondly that buyers had a higher return per unit of water (F = 14.9). This shows that the water-market in the Lower Orange promotes the efficiency of water use.

6.3 The value of water in the Eastern and Southern Cape

Water values were estimated in order to arrive at benefits from removing water-consuming alien vegetation. This study was undertaken under the Working for Water (WfW) programme, the biggest conservation project in terms of manpower use currently being undertaken in South Africa. Over 250 projects have been implemented since its inception in 1995 and during 1998, about 40,000 jobs were created (Hosking *et al,* 2002). In this study the conservation value of water was approximated by its agricultural and urban use value (best alternative use value), as reflected in Table 5. The runoff from the Tsitsikamma Mountain Catchment that does not flow into the sea is used for irrigation farming and livestock watering.

Table 5: Values of water for WfH projects in the Eastern and Southern Cape (2000)[1]

Site	Value of water (c/m³)	Valuation Method
Tsitsikamma	12.5	Willingness to pay
Port Elizabeth Driftsands	0.0	Potential user response
Albany	0.0	User response
Kat River	15.7	Willingness to pay
Pott River	0.0	Non-scarce resource

Note: [1] = Agricultural willingness to pay
Source: Hosking *et al* (2002)

The actual user charge on this water is 5.3c/m^3, which is an annual cost. According to Hosking *et al* (2002) this represents the true cost of supplying the water. The rental value of agricultural water according to Willingness to Pay amounted to 12.5c/m^3 excluding storage and transfer cost (Table 5).

In the following areas water values were zero: Port Elizabeth Driftsands (no potential for municipal supply), Albany (high salinity content) and Pott River (not used for recreation). In the Kat River farmers were willing to pay 15.7c/m^3 for water. Hosking *et al* (2002) concluded that the cost of clearing alien vegetation on these sites would exceed the benefit if non-metropolitan use is considered.

7. THE VALUE ATTACHED TO ASSURANCE OF SUPPLY OF WATER, WATER QUALITY AND TOLERANCE TO RISK

7.1 Assurance to supply and tolerance to risk

In the USA the urban sector attaches a high value to assurance of water supply. In Western USA, cities such as Denver buy senior water rights (with a high certainty of supply) from farmers and then rent the surplus water back to farmers at low prices. The low estimates of the price elasticity of demand for urban water support this phenomenon that urban users attach a high value to assurance and a low value to additional water. Mirrilees *et al* (1994:21) also state that urban users require a high level of assurance. Conradie (2002) estimates the price elasticity of demand for household, commercial and industrial consumption as -0.47 (t = -3.10) in the Nelson Mandela Metropole. A low (numerically less than 1.0) price elasticity means that the marginal benefit of water increases steeply with scarcity but falls quickly with increased supply. As urban water in South Africa is purchased from municipalities one can approximate the marginal value of urban water by the prices paid to the municipalities (R1 to R2/m^3).

The linear programming models reported in this article generally estimate fairly elastic input demands for agricultural water (Conradie, 2002; Louw, 2001). These estimates will vary from area to area and from crop to crop but it may be possible in agriculture to use water saving technologies or switch to more water efficient crops. The fact that agriculture is also a more water intensive user than industry indicates a higher elasticity of input demand for agriculture (Friedman, 1962).

In agriculture high assurance of supply is needed where capital value invested in orchards and vineyards is high and crops are of a long-term nature. Table grape farmers along the Lower Orange do not rent water because the investment in table grapes is high (R250,000 per ha) and more assurance is required. More renting of water takes place in Australia in areas where annual crops are grown (Australian Academy of Technological Sciences and Engineering, 1999). Water marketing can promote assurance. In a study in the Crocodile River, the most important reason buyers of water rights have given is that they require a steady flow, as they are concerned about drought (Bate *et al*, 1999).

The water law that operates in South Africa and Australia (derived from riparian principles) does not provide farmers as much security of water use as in the case of prior appropriation water law operating in the Western USA. Under prior appropriation, requirements of senior water right holders must first be satisfied before more junior water right holders. Under riparian principles the apportionment of all irrigators is reduced by the same fraction when water flow decreases.

To overcome the lack of assurance in water rights, South African farmers typically retain surplus water rights for drought years in the Lower Orange River where capital investment in table grapes is high. South African farmers may not be able to do this in future if non-use rights (sleepers) are lost. Another practice is to include a low-income crop such as lucerne in their production portfolio. In a drought year, water can be diverted from this crop at relatively low cost. If South African farmers lose sleeper rights then they can fall back on the second option. According to a prominent farmer (Moller, 2003) in this river reach (Lower Orange), the flow in this river has been fairly stable in recent years (due to dams) and these practices are not so common at present.

7.2 Water quality

Water quality is a major concern in certain areas and sectors in South Africa. For instance in the Eastern Cape, the Fish River is frequently flushed as the return flow is not suitable for irrigation.

7.2.1 Salinity in the Middle Vaal River area

The direct and indirect costs of salination in the Middle Vaal River area were estimated by Urban Econ (2000), using an Input-Output technique. As the average salinity level experienced in the area is 500 mg/1 TDS, a reduction below this is a cost saving while an increase above this level leads to an increase in cost. It is estimated that direct costs of R80.5 million will be saved if present levels drop to 200 mg/l TDS. Increasing salinity to 1,200 mg/l TDS will increase salinity cost to R183 million. These cost data are not representative of other sectors of the South African economy, as high urban, mining and industrial concentration occurs in this area. The data, however, show that salinity is a major cost to urban water users, especially the household sector.

7.2.2 Sulphate pollution in the Witbank Catchment

South Africa has previously regulated pollution through Command and Control (CAC) methods whereby industries are prescribed the technology or processes that must be used. While this approach may have merit, a more cost efficient way is to provide polluters with an incentive to reduce pollution. Since 1994 South Africa's legal and policy framework has evolved so that it is more suitable to economic approaches such as the Polluter Pays Principle (Taviv *et al*, 1999).

Taviv *et al* (1999) studied sulphate pollution in the Witbank Catchment and estimated that within a year revenue of between R3 million and R9 million could be raised from pollution charges, which was less than the estimated cost of pollution. They estimate that full cost recovery can be achieved within four years. A main concern in South Africa is employment, and to mitigate the loss of jobs if pollution is taxed it is recommended that firms should be given incentives to reduce cost in such a way that jobs are not sacrificed (Taviv *et al*, 1999).

Another study on sulphate pollution in the Olifants River near Witbank was undertaken by Economic Project Evaluation (1998). The latter researchers differed in their approach to the pollution problem in the catchment. They alleged that this type of pollution is a non-point source (not easily monitored and measured). Market based research tools have proved to be effective in dealing with point source pollution, as it is easily monitored and measured, but less effective in dealing with non-point pollution. In the latter study (Economic Project Evaluation, 1998), a marginal cost model was used to simulate green taxes and a simulation model to simulate tradable permits. Permits were traded within a geographic area also referred to as a bubble. The trading partners were five coalmines who are responsible for the sulphate pollution. The market price of permits for the two approaches (marginal cost and simulation) for a given level of pollution abatement was similar.

Taxes and tradable pollution rights have different impacts on polluters. Taxes can have a detrimental effect on profits and employment in some industries, especially where the price of the product is set internationally. In the latter case the tax cannot be partially shifted. Tradable permits also have welfare implications, as those polluters who can modify their plant and equipment and sell permits are affected differently from those who cannot and must purchase permits. The modelling exercise demonstrated economic efficiency of economic measures and it was recommended that a pilot study using tradable permits and green taxes be undertaken (Economic Project Evaluation, 1998).

8. SYNTHESIS

Input/output and multiplier analyses indicate that South African agriculture is an inefficient user of water in term of gross income generated per unit of water and also in terms of jobs created per unit of water. South African agriculture is, however, an important employer of labour as it is labour intensive especially in the fruit and vegetable growing sectors. Evidence is provided that indicates that non-agriculture generally places a high value on sufficient water but little value on more than what it already uses. From this it is concluded that water may have to be transferred in future from agriculture to non-agriculture, but not at present (although providing water for disadvantaged groups will always be a top priority in South Africa). With an urban demand elasticity for water of about -.40, municipalities can only sell 4% more water in urban areas if they reduce the price by 10%. This means that the income of municipalities from water sales will fall drastically if they try to sell more water through lower prices. They may be reluctant to do that and the suspicion is that municipalities as monopoly suppliers of water use price discrimination to increase revenues.

Water values differ significantly between sectors, between geographic areas and within geographic areas. The following estimates of the rental value (annual value) of water were reported; existing irrigation: Berg River (21c/m^3), Fish/Sundays River (0.0c/m^3 to 21c/m^3); new irrigation: Lower Orange (3c/m^3), Crocodile River (2.5c/m^3), Eastern and Southern Cape (12.5c/m^3); Forestry (8c/m^3); Environment (5c/m^3) and Urban (74c/m^3 and R2.40/m^3).

The problem of comparing water values between these geographic regions is that different measurement tools were used. The tools used are more appropriate to study water values for different resource areas within a given study area. For instance market trading indicates the capital value of water as 60c/m^3 in the Lower Orange (Moller, 2003) and 22c/m^3 in the Sundays/Fish

River (Hosking *et al*, 2002), which indicates that water has a higher use in the former area.

A partnership between Government and the private initiative can further promote water use efficiency. Water efficiency could be enhanced significantly if water transfers within river reaches are promoted. Water transfers should not only be permitted, but institutions need to be created that promote transfers (within the ambit of the Water Act). Institutions will also reduce the transaction cost of transfers. Socio-economic aspects and the impact of transfers on the environment need to be considered. The transfer of water values between major rivers such as the Orange, Vaal and Sundays/Fish River could promote water efficiency, while the external impacts of such transfers requires further study. In the latter instance water may move out of areas with poor soils (high salinity) to areas with good soils and high-income crops. It is also possible that communities will be adversely affected, thus information is required on the maximum volume of water that may be transferred without having a material impact on the community at source. Conradie (2002) indicates that some surplus water may be available in the Sundays/Fish River. This may imply that less water needs to be diverted from the Orange to these rivers.

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