The Potential Impact of Increased Irrigation Water Tariffs in South Africa

By

Gill, Tania and Punt, Cecilia

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Tania Gill[1]

Senior Agricultural Economist

Department of Agriculture: Western Cape

taniag@elsenburg.com

Cecilia Punt

Manager: Macro and Resource Economics

Department of Agriculture: Western Cape

ceciliap@elsenburg.com

[1] Corresponding author

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Abstract

In South Africa, a water scarce country, conflict between water users is mounting, while there are few remaining bulk water augmentation options. Water demand management is thus increasingly taking centre stage in water management debates. Water pricing is regarded as an important component of managing the demand for water resources. This article traces the efficacy of increasing irrigation water tariffs to save water and the impact thereof on the national economy and the Western Cape economy using the Computable General Equilibrium (CGE) model and Social Accounting Matrix (SAM) constructed by Hassan et al (2008). Two scenarios are investigated in which the water tariff is increased by 50 percent from a base of 2c/m^3. In the first scenario water demand is fixed in agriculture; thus, water needs to be fully utilized in agriculture. In the second scenario it is assumed that all water does not have to be utilized. The study finds that, for both scenarios, increasing water tariffs by 50% raises the risk profile of agriculture, threatens food security, decreases national welfare, increases imports of staple foods, increases the prices of staple foods, decreases household welfare and decreases employment in agriculture. These adverse effects are more severe in the second scenario than in the first scenario. The introduction of irrigation water pricing shocks should thus be approached with due caution and alternative demand management approaches should be investigated.

1 Introduction

As a scarce resource water may become the limiting factor to national development; and, the scarcity of water is set to increase in the future due to demographic pressures, socio-economic pressures and climate change (Blignaut & van Heerden, 2009). Water scarcity has severe implications for food security and the structure of agriculture. Water is already a key constraint to the development of agriculture in particular, but urban water users have a higher willingness to pay than agricultural water users. This encourages water allocations away from the agricultural sector either through markets or through centralized reallocations. Managing water so as to secure sustainable development, food security and rural livelihoods is becoming increasingly critical, while remaining bulk water supply augmentation schemes are becoming prohibitively costly in both environmental and economic terms. As a consequence water demand management is increasingly taking centre stage in water management debates.

Water pricing is regarded as an important component of managing the demand for water resources, yet experience with water pricing as an effective water management tool has been mixed at best. In the case of inelastic demand for irrigation water and limited scope for reducing on farm water consumption, increasing water prices may decrease agricultural production and food security with negligible quantities of irrigation water saved. The present study will attempt to investigate the efficacy of increasing irrigation water tariffs to save water and the impact thereof on the national and Western Cape economies using the Computable General Equilibrium (CGE) model and Social Accounting Matrix (SAM) constructed by Hassan *et al* (2008).

2 Water Management in South Africa

South Africa is divided into 19 Water Management Areas (WMA's). The four WMA's found in the Western Cape are the Olifants/Doorn WMA, the Berg WMA, the Gouritz WMA and the Breede WMA. In aggregate the Western Cape is experiencing a water deficit, with only the Breede WMA benefiting from a water surplus. The Western Cape is therefore facing a three tier problem: firstly, surface water resources are nearly fully utilized; secondly, there are limited bulk surface water augmentation options left; finally, water demand, especially in urban areas, is continually increasing. Water resource decision-making challenges are accordingly shifting to demand management.

Water pricing is an integral part of integrated water resource management (Louw & Van Sckalkwyk, 2001). In South Africa, since 1999, the water pricing strategy requires that the agricultural sector pays a raw water charge and in 2002 a water resource management charge was introduced (DWAF, 2001). The raw water charge now consists of an operation and maintenance charge, a charge for the depreciation of government schemes and a catchment management charge. Farmers will not necessarily pay all three charges, but the catchment management charge is paid by all. The catchment management charge is applied at the WMA level. A summary of the Department of Water Affair's (DWA) 2009/2010 catchment management charges and infrastructure operation and management charges for the Western Cape are given in Table 1.

Table 1: DWA Water Charges for 2009/2010

Catchment Management Charges	**c/m³**
Berg WMA	0.94
Breede WMA	0.80
Gouritz WMA	0.94
Olifants-Doorn WMA	0.88
Infrastructure Operation & Maintenance Charges	**c/m³**
Western Cape (Average)	4.85

(DWA, 2009)

3 Water Demand Management

Water demand management functions at the micro management level: the productive and allocative efficiency of water is improved by moving water to higher value uses via quotas, licenses, water prices and water markets and by securing efficiency gains via the adoption of more efficient water use practices. With growing water shortages economic benefit can be increased by increasing output per unit of water; in other words, by increasing water productivity (Barker *et al*, 2003).

Water demand management is regarded as important in South Africa and in the Western Cape. In the agricultural sector water conservation arguments are concerned with increasing water productivity by, for example, minimizing leakages, promoting better use of land and water and adopting water saving technologies. There is, however, no clear conception on how to approach agricultural demand management given the lack of accurate information on the quantity and character of agricultural water use. In this context pricing and water markets become attractive tools to manage water as these approaches are less dependent on centralized knowledge on agricultural water use and rather allow for a decentralized market selection of the most efficient use of water.

Water Markets

The requirements for the success of water markets are well-defined, secure and transferable water rights and the full costs and benefits of the market transfer must be borne by the market participants (Yesufu & Yesufu, 2006: 5). In addition, trading will only occur as long as the transaction costs do not exceed the tradable price of water; if transaction costs in the market are too high for buyers and sellers, the market will fail.

In the South African context, in which water is regarded as national property, the nature of water allocations and management institutions makes it difficult to meet the requirements of water markets. There are also fears that “the promotion of water markets puts inefficient users and related families outside of the productive sector” (Lahmandi-Ayed & Matoussi, 2003: 65). Water markets may thus be inequitable and hinder pro-poor development. These fears are especially acute in South Africa in which the national water policy priority is Water Allocation Reform and pro-poor development. There are thus considerable developmental and political barriers to the full implementation of water markets. Despite this, trading in water rights is permitted and some trading is taking place, albeit on a small scale.

Water Pricing

Three main reasons for increasing the price of irrigation water can be identified; namely, cost recovery, encouraging the efficient use of water resources and collecting financial resources to benefit the beneficiaries of water services (de Fraiture & Perry, 2007). Pricing as a policy is first and foremost a tool for cost recovery and there are few examples of the successful management of water via marginal water pricing (Molle & Berkoff, 2007; Montginoul, 2007; Dinar *et al*, 1997). Water pricing is a problematic policy tool: firstly, adjusting prices upwards will always be met with resistance; secondly, demand for irrigation water is inelastic; and thirdly, designing accurate pricing structures still requires accurate information on the quantity of water used as well as the true value of water – both pieces of information are notoriously difficult to obtain (Lahmandi-Ayed & Matoussi, 2003; Yesufu & Yesufu, 2006)).

The inelasticity of demand is one of the biggest stumbling blocks to the efficacy of pricing: elasticity values provide an indication of the level at which consumers will respond to price levels; and, low elasticity indicates that prices will have to be increased by a large amount before consumers will respond. Irrigation water demand may be inelastic due to its low share in production costs and the existence of few substitutes. Evidence at the household level suggests that economic incentives may have some impact on water consumption, but may not be sufficient by themselves to affect behaviour change (Clark & Finley, 2007).

Reliable empirical estimates of irrigation demand and the elasticity of irrigation demand are scarce, and the full labour and capital costs associated with changing water use is often not taken into account (Molle & Berkoff, 2007; Kim & Schaible, 2000). Markets for irrigation water are small and not yet well developed, which means that there are not sufficient buyers and sellers to give a reliable estimate of the price of irrigation water at different quantities. Linear programming and econometric models are thus developed to derive demand for irrigation water. Though results are mixed and scarce, the dominant finding is that demand for domestic and irrigation water is inelastic (Jansen & Schulz, 2006; Appels *et al*, 2004; Pagan *et al*, 1997; Amir & Fisher, 1999; Veck & Bill, 2000; Van Vuuren *et al*, 2004; Olmstead *et al*, 2007). Further empirical findings suggest the existence of water demand curves that have both elastic and inelastic segments (Jansen & Schulz, 2006; de Fraiture & Perry, 2007; Grové & Oosthuizen, 2009; Bontemps & Couture, 2002). There is a maximum amount of water an irrigator will take even if the water price is zero (de Fraiture & Perry, 2007; Grové & Oosthuizen, 2009). At low prices water demand is, therefore, constrained by agricultural requirements and so unresponsive to prices. As prices increase, water demand becomes relatively more responsive.

Irrigators can respond to an increased water price by leaving land uncultivated, by applying less water and accepting the risk of a lower yield, by changing cropping patterns and by investing in more efficient irrigation technology. As a water demand management tool, increased irrigation water prices may firstly result in adjustments in on-farm water management practices, followed by changes in cropping, followed by changes in irrigation technology and as a last resort the reallocation of water to other sectors (Molle & Berkoff, 2007: 33; Moore *et al*, 1994). Existing technology, past investment decisions, financial viability and labour and management costs all impact on substitution possibilities with labour and capital, which in turn impacts on the ability to change water management regimes and cropping patterns (de Fraiture & Perry, 2007: 96-97, Molle & Berkoff, 2007: 29, 70). Unless the ease of substitution between factors is high, changing water management regimes will entail high costs and may consequently not be feasible for low-income farmers and may be politically unpopular (Molle & Berkoff, 2007: 102).

Lack of information and lack of trust may also impact on irrigation water use – irrigators may not know how much to irrigate, trust information they are given, trust the authorities or have full information of technology choices (Feder *et al*, 2004: 274). Irrigators may also experience loss aversion, meaning that they would rather over-irrigate than risk under-irrigating and suffering adverse effects on crop and soil quality (Feder *et al*, 1985: 274; Leviston *et al*, 2005). Loss aversion may be particularly acute for irrigators inexperienced with more efficient technologies while also facing high cost and revenue uncertainties (Dalton *et al*, 2004: 221). More efficient technology adoption may also be influenced by experience such that adoptions increase with the age of irrigator; but evidence in this regard is mixed (Mateos-Planas, 2004; Lilienfeld & Asmild, 2007). When faced with extreme events such as droughts or sufficiently high prices, irrigators may be more likely to participate in markets in the short-run, to smooth consumption, or wait for new information than to make irreversible investment decisions (Carey & Zilberman, 2002; Mulder, 2005).

Given the inelasticity of water demand, limited substitutes for irrigation water, risk aversion and the low share of water in total costs, increasing irrigation tariffs may have a limited impact on decreasing quantities of irrigation water used on farms. The impact may also be less than expected at the basin level. On-farm water savings only translate into overall water demand reductions if the amount of irrigated land is not expanded; thus land and water must be managed together (Dinar & Mody, 2004: 113; Skaggs, 2001; Wester *et al*, 2007). If consumption is not decreased when prices increase, pricing as a management tool is ineffective and alternative demand management mechanisms will need to be explored (Jansen & Schulz, 2006: 594).

4 Model and data

The computable general equilibrium (CGE) model used in the study is a further development of the standard CGE model developed at IFPRI (International Food and Policy Research Institute). The model has a specific focus on agriculture and water, obtained through distinguishing 17 agricultural industry categories and the 19 WMA's of South Africa in the SAM for South Africa for 2002. The CGE model and SAM was constructed by Hassan *et al*

(2008) to trace the macro and micro water policy impacts on water use within the South African economy. The only adjustment that was made to the model for purposes of this study was the adjustment of the constant elasticity of substitution between different factors of production as discussed in section 6. The following discussion on the model and underlying data is based on the report by Hassan *et al* (2008) and some own interpretations based on the CGE model and SAM.

<u>Production</u>

40 sectors/commodities are modelled, of which 17 are agricultural and 15 are industrial. Three utility sectors are also identified, namely electricity, domestic water distribution and energy water distribution. The agricultural sector distinguishes production of field crops (summer cereals; winter cereals; oil crops and legumes; fodder crops; cotton and tobacco; and sugarcane), horticultural crops (vegetables; citrus fruit; subtropical fruit; deciduous fruit and viticulture; and other horticulture), various livestock categories, as well as fishing and forestry. Field crops are further separated into irrigated and dryland crops, but all horticultural crops are regarded as irrigated.

The novel feature of the model by Hassan et al (2008) is that production and consumption are modelled by WMA. All production sectors, labour, land, water and household categories are identified by WMA in the SAM, capturing the varying importance of agriculture and other sectors in the different parts of the country. This regional distinction in the underlying data is particularly relevant since water management and policy institutions in South Africa use the WMA as the principal geographic unit of planning. Commodities are not distinguished by WMA, i.e. the assumption is that producers in each region supply their output to a national commodity market from where the products are further distributed.

The model includes six factors of production that are available to the agricultural industries, namely three labour types (unskilled, skilled and highly skilled), capital, land and irrigation water. The payments for factors of production by different sectors are based on salaries and wages for labour, investment returns for capital and rental returns for land. Returns for irrigation water are based on estimated shadow prices of irrigation water for different irrigated crops per region, which are dependent on production levels, yields and productivity effects of water on crop yields. According to Hassan *et al* (2008) shadow prices were calculated by running Ordinary Least Square (OLS) regressions on an estimated quadratic water-yield response function, using the coefficients to estimate the value of the marginal product of water to agricultural production (VMP) and then subtracting the non-water irrigation costs from the VMP. The total shadow value of production of different crops is then estimated for each region by estimating region specific yields of different crops and multiplying this with the shadow price per hectare of land. Subtracting this shadow value from the capital value added of each crop allows for the use of agricultural water as a factor of production in the model.

Two additional factors of production are included: domestic water for the domestic water distribution sector, and energy water for the energy water distribution sector. The domestic water distribution sector supplies water to all sectors that use water as an intermediate good, as well as to households, whereas the energy water distribution sector supplies water solely to the electricity sector. Returns to factors are distributed to households based on their ownership of these factors and ownership of land is used as a proxy for ownership of irrigation water.

The agricultural activities have a unique production technology for each WMA based on regional information from Agricultural Census results, but the production technology of non-agricultural sectors was drawn from the national use tables published by Statistics South Africa with the implicit assumption that the production technology of non-agricultural sectors is not influenced by location. The production technology reflects the combination of inputs used in the production of a unit of output. In order to maintain these production technologies, each production sector uses intermediate inputs in fixed relative shares regardless the level of production according to a Leontief specification. It is also assumed that intermediate inputs cannot be substituted for factors of production, e.g. chemicals cannot be substituted for by labour. Composite intermediate inputs and composite factors of production are therefore also combined under a Leontief specification.

Limited substitution between the different production factors are allowed with a Constant Elasticity of Substitution (CES) function, e.g. labour can be substituted for capital, or land for water, etc. The elasticity of substitution is set exogenously and the selection of the elasticity for this study is discussed in more detail in section 6.

Domestic and International Trade

Producers are driven by their pursuit of higher returns and can do so in both the domestic and international market. Substitution between production for the domestic and foreign market occurs under the conditions of a Constant Elasticity of Transformation (CET) function and substitution between domestic and international goods for consumption occurs under the conditions of a Constant Elasticity of Substitution (CES) Armington specification. The choice of market is dependent on relative prices. Agricultural exports in South Africa are dominated by horticultural products, while total exports are dominated by mining and metals. A small-country assumption is adopted such that South Africa is faced with perfectly elastic world demand and supply and fixed world prices. South Africa is thus a price taker and a single supply price, export and import price and exchange rate are accordingly endogenously fixed in the model. Finally, in order to allow for the current account balance to be fixed in foreign currency a measure of the exchange rate is included which consists of an index of the relative price of tradables to non-tradables (Hassan et al, 2008)

Institutions

Institutions in this CGE model consist of households and government, since no enterprise account is included. Households are disaggregated across WMA, rural and urban areas and income quintiles, representing 190 different household groups. Households receive incomes from salaries and wages, returns to capital, land and water. The levels of income are dependent on the production levels of the sectors, as well as the distribution of factor ownership amongst households. Main expenditure items of households include consumption of products via a Linear Expenditure System (LES) of demand, direct taxes to government, savings based on their marginal propensity to save and transfers to the rest of the world. Considerable differences exist in per capita consumption patterns between regions: WMA's with the largest rural populations also have the lowest consumption, while consumption in agricultural is mainly subsistence based. The exception is cases where the WMA contains many large commercial farmers or is located in close proximity to a large urban centre (for instance, the Berg WMA). (Hassan et al, 2008)

With regard to the government, the point to note in the context of this study is that government receives income from taxes and tariffs. Included in the model is a tariff on irrigation water use, hence it is only paid by irrigation agricultural sectors. The tariff is included at 2c per cubic meter in the base case (2002 values), compared to the average of 5.8c per cubic meter in 2009 as discussed in section 2. The government also engages in the consumption of commodities, transfers to households and the rest of the world, and lastly savings.

Investment, capital and rest of the world

Investment is financed from all savings from households, enterprises, government and the rest of the world. There is also a capital and rest of world account. (Hassan et al, 2008)

Closure rules

All factors of production, excluding capital, are identified per region and are used by the sectors in the same region. A certain set of model assumptions (closure rules) can be used to allow land, water and labour to move between sectors within a WMA but not between WMA's. Only capital can move between sectors and WMA's. Closure rules also allow for assumptions between full employment and unemployment for factors of production. For purposes of this study higher skilled labour and capital are assumed to be fully employed with flexible real wages, while the supply of unskilled labour is perfectly elastic at fixed nominal wage rate, i.e. assuming some level of unemployment for unskilled and skilled labour. The assumptions for water are different for the two scenarios and will be discussed in section 6.

The three macroeconomic accounts (government balance, current account and savings and investment account) need to be brought into balance and this is achieved via closure rules. Hassan et al (2008) opt for a balanced closure rule which specifies a nominal change in total absorption that is evenly distributed between the spending and investment demand of the public and private sectors. Government spending can be increased via an increase in taxes. The closure rule thus ensures that adjustments in households' propensity to save are proportional such that savings and investment are in equilibrium. For the current account, the closure rule maintains fixed levels of foreign savings by adjustments in a measure of the real exchange rate. For the purposes of the current study the closures remain similar to those used by Hassan et al (2008), with the scenarios focusing on the increase in government tax (water tariff).

5 Scenarios

There are two main aims for deciding to increase irrigation water charges; to manage water demand and to improve the cost recovery of catchment management. These aims should be achieved with as little loss of welfare in agriculture (especially low-income agriculture) as possible and without threatening economic growth or food security. In the model only a single charge is given and therefore the percentage increase will be levied on the entire charge. The charge will be levied at the national level, and impacts will be examined nationally and in the four WMA's that are situated in the Western Cape, namely: the Berg WMA, the Olifants/Doorn WMA, the Breede WMA and the Gouritz WMA.

In this section two scenarios will be investigated. In both scenarios the water tariff is increased by 50 percent from a base of 2c/m³. In the first scenario water demand is fixed within agriculture within each WMA. This implies that as the water tariff increases agriculture is forced to take up the water, and water is only permitted to move between agricultural industries in the same WMA. The treatment of land and water is similar. The manner in which shifts will occur within agriculture is influenced by the shadow prices of water (factor returns) set for the different crops. In the second scenario it is assumed that all water does not have to be used, i.e. some level of 'unemployment' is allowed and water is still mobile between different agricultural crops within the same WMA.

One of the questions that this study aims to answer is by how much water consumption will be reduced nationally and in the Western Cape if prices are increased. There is a rigid water licensing structure in place accompanied by an ineffective water market, which means that irrigators have little incentive to reduce water consumption and may therefore rather use their full allocation. On the other hand, a structure for water markets is in place and it is possible for farmers to either sell water rights or not take up their water rights. The reality of the scope for movements in water in South Africa is therefore situated between the first and second scenarios.

In both scenarios a low elasticity of substitution between factors of 0.2 is set. This choice is justified in so far as there is a limited possibility for agriculture to substitute labour and capital for water. Substituting water with labour and capital may entail making irreversible long-term investment decisions, to which irrigators may be averse. At an elasticity of substitution of 0.2, the model cannot solve for increases in the water tariff greater than 250% (5c/m³) if water is fully employed.

6 Model results

The increase in the water tariff causes a shift from lower value field crops to higher value horticulture. In the first scenario it is assumed that there is still demand for all irrigation water despite the increase in the cost of water and the assumption is that water is only be mobile within a WMA, not between WMA's. Table 2 shows that on a national level 71.5 million m³ is reallocated from field crops to horticulture, while 46.2 million m³ is similarly reallocated in the Western Cape with the Gouritz WMA accounting for 50% (23.0 million m³) of the reallocation. In the Western Cape the bulk of the irrigation water is reallocated from lower value fodder (-56.7 million m³) to deciduous fruit (32.4 million m³) and vegetables (14.8 million m³). Hassan et al (2008) find that horticultural crops have a high willingness to pay for irrigated water; therefore, irrigation of horticultural crops does not decline with rising prices, but rather increases in all regions except the Berg WMA.

For scenario 2 it is assumed that as the cost of irrigation water increases the demand for irrigation water will decrease relative to supply. On a national level 463.4 million m³, or 6.4% of irrigation water, will remain unused, compared to 128.8 million m³ (7.5%) of irrigation water in the Western Cape. This unused water must be seen in the context of the 56 million m³ yield and 127 million m³ gross capacity of the Berg River Dam. This is a large quantity of potential water savings. Irrigation water can, however, not necessarily remain 'unused' to the extent that the model allows in scenario 2, and therefore real water savings if prices were to be increased would not necessarily be as high. It is unclear where on the scale between scenario 1 and scenario 2 South Africa is situated. In addition, this water 'saving' is scattered between WMA's and crops, and a large capital outlay for storage and pumping would be necessary for full use of the 'saved' water. The ability to use water for other crops is also dependent on factors other than water availability; for instance, soil quality, crop suitability, and climate.

On a national level the greatest decrease in demand for water is from field crops (384.4 million m³) compared to 79 million m³ for horticulture. This is in contrast to the Western Cape where field crops and horticulture's demand decreases by 65.1 and 63.7 million m3 respectively. Horticulture dominates agriculture in the Western Cape. Comparing the four WMA's of the Western Cape the Breede WMA will show the greatest decrease in demand for water, namely 53.8 million m3. Although all results included in this study are available at the WMA level, only the change in demand for water is reported at this level.

Table 2: Change in demand for water

		Scenario 1		**Scenario 2**	
	Base (Million m3)	**Change (Million m3)**	**Change (%)**	**Change (Million m3)**	**Change (%)**
South Africa	7 273.9	0.0	0.0	-463.4	-6.4
Field crops	4 155.8	-71.5	-1.7	-384.4	-9.3

Horticulture	3 118.1	71.5	2.3	-79.0	-2.5
Western Cape	1 708.6	0.0	0.0	-128.8	-7.5
Field crops	204.8	-46.2	-22.5	-65.1	-31.8
Summer Cereals	9.1	1.0	10.8	-0.5	-5.0
Winter Cereals	50.5	8.3	16.5	-1.6	-3.1
Oils and Legumes	3.1	0.3	9.3	-0.1	-3.6
Fodder	140.0	-56.7	-40.5	-63.1	-45.1
Cotton and Tobacco	2.1	1.0	44.8	0.1	6.3
Horticulture	1 503.8	46.2	3.1	-63.7	-4.2
Vegetables	206.6	14.8	7.1	3.6	1.8
Citrus Fruits	73.8	-0.3	-0.3	-2.6	-3.5
Subtropical Fruits	6.2	1.1	17.5	0.5	8.5
Deciduous Fruits	1 132.9	32.4	2.9	-59.9	-5.3
Other Horticulture	84.2	-1.9	-2.2	-5.4	-6.4
Gouritz	128.7	0.0	0.0	-31.9	-24.8
Field crops	78.2	-23.0	-29.3	-31.6	-40.3
Horticulture	50.4	23.0	45.5	-0.4	-0.8
Olifants/Doorn	497.0	0.0	0.0	-8.4	-1.7
Field crops	48.0	-15.4	-32.1	-17.3	-36.1
Horticulture	449.0	15.4	3.4	8.9	2.0
Breede	647.5	0.0	0.0	-53.8	-8.3
Field crops	49.9	-10.5	-21.1	-14.9	-30.0
Horticulture	597.6	10.5	1.8	-38.9	-6.5
Berg	435.4	0.0	0.0	-34.6	-8.0
Field crops	28.7	2.7	9.4	-1.3	-4.5
Horticulture	406.7	-2.7	-0.7	-33.3	-8.2

The changes in demand for water are also reflected in the demand for land for irrigation. The impact of reallocation of water between different crops can be seen in the changes in the areas of agricultural crops as reported in Table 3. On a national level and on WMA level land is assumed to be fully utilised in both scenarios. The only reallocation is therefore between dryland and irrigation. On a national level if water is fully utilized (scenario 1) 34 540 ha will revert to dryland, but 132 300 ha irrigated land will revert to dryland if water is not fully utilized (scenario 2). Similarly there is a shift from irrigated land to dryland in the Western Cape.

Table 3: Change in demand for land

		Scenario 1		Scenario 2	
	Base (1000 ha)	Change (1000 ha)	Change (%)	Change (1000 ha)	Change (%)
South Africa crops	7 628.71	0	0	0	0
Irrigated agriculture	1 560.72	-34.54	-2.21	-132.27	-8.47

Field crops	923.74	-40.46	-4.38	-111.31	-12.05
Horticulture	636.98	5.91	0.93	-20.96	-3.29
Dryland agriculture	6 067.99	34.54	0.57	132.27	2.18
Western Cape crops	1 116.98	0	0	0	0
Irrigated agriculture	406.01	-10.58	-2.61	-40.99	-10.10
Field crops	88.57	-17.06	-19.26	-25.07	-28.30
Horticulture	317.44	6.48	2.04	-15.93	-5.02
Dryland agriculture	710.97	10.58	1.49	40.99	5.77

The changes in demand for water and land are accompanied by changes in demand for labour as reported in table 4. The shift from irrigated land to dryland in the Western Cape if water is not fully utilized (scenario 2) is accompanied by a decline in employment of 3 561 persons in irrigated agriculture. If water is fully utilized in the Western Cape (scenario 1) employment increases in irrigated agriculture by 573 persons due to the reallocation of water to high value crops such as deciduous fruit and vegetables, while employment declines by 294 persons in dryland agriculture. On a national level, the employment declines in both scenarios, but there is a greater decline in employment if water is not fully utilized in agriculture (8 800 persons versus 1 829 persons).

Table 4: Change in demand for labour (numbers)

		Scenario 1		Scenario 2	
	Base	Change	Change (%)	Change	Change (%)
South Africa	8 238 848	-1 829	-0.02	-8 800	-0.11
Western Cape	1 336 530	90	0.01	-3 020	-0.23
Western Cape Agriculture	108 855	266	0.24	-3 408	-3.13
Irrigation	58 814	573	0.97	-3 561	-6.05
Dryland	8 972	-294	-3.28	182	2.03
Other agriculture	41 069	-13	-0.03	-29	-0.07
Western Cape Non agriculture	1 227 670	-177	-0.01	386	0.03

The change in the average output price and commodity supply price of all crops is reported in table 5. If water is fully utilized in agriculture (scenario 1), the average output price and commodity supply price of all crops, except vegetables, citrus fruit and deciduous fruit increases. If water is not fully utilized in agriculture (scenario 2), there is an increase in all these prices for all crops. Of particular concern in both scenarios is the increase in price of cereals as this has an impact on the prices of staple foods, which may have important implications for household welfare.

Table 5: Change in prices

	Scenario 1		Scenario 2	
	% Change in Average Output Price	% Change in Commodity Supply Price	% Change in Average Output Price	% Change in Commodity Supply Price
Summer Cereals	0.31	0.36	0.84	0.97
Winter Cereals	0.25	0.25	0.80	0.81
Oils	0.34	0.41	0.82	1.00
Fodder	1.25	1.29	1.59	1.64
Sugar	0.55	0.55	1.14	1.14
Cotton	0.46	0.53	0.84	0.96
Vegetables	-0.54	-0.56	0.45	0.48
Citrus Fruit	-0.40	-1.08	0.66	2.38
Subtropical Fruit	0.14	0.18	1.05	1.29
Deciduous Fruit	-0.11	-0.14	0.77	2.29
Other Horticulture	0.65	1.03	0.97	1.55

Household consumption expenditure is taken as a proxy for household welfare and is reported in table 6. Nationally, the household consumption expenditure declines across all urban and rural quintiles in both scenarios. The decline is greater for the lowest three rural quintiles than the lowest three urban quintiles, where the lower quintiles indicate poorer households.

In the Western Cape, if water is fully utilized (scenario 1), household consumption expenditure increases for the first four rural quintiles and first three urban quintiles. The increase in welfare of the lower urban quintiles in the Western Cape can perhaps be ascribed to the increase in horticultural activity in the region. Household consumption expenditure in the Western Cape declines for the rural quintile 5, which reflects an income effect from the increase in the water tariff; farmers are absorbing irrigation water at higher prices.

In the Western Cape, if water is not fully utilized (scenario 2), household consumption declines for all rural and urban quintiles; however, the decline is greater for urban households than rural households for all quintiles. The welfare of all households nationally and in the Western Cape is therefore adversely affected and the poverty impact may be noteworthy. For all rural and urban quintiles, the welfare impact is more severe if water is not fully utilized than if water is fully utilized.

Table 6: Change in household expenditure

		Scenario 1		Scenario 2	
	Base	Change (level)	Change (%)	Change (level)	Change (%)
South African Households	733.43	-0.53	-0.07	-1.40	-0.19
Rural households	153.27	-0.02	-0.02	-0.16	-0.11
Quintiles 1,2,3	57.99	-0.02	-0.03	-0.06	-0.10
Quintiles 4,5	95.28	-0.01	-0.01	-0.11	-0.11
Urban households	580.17	-0.51	-0.09	-1.24	-0.21
Quintiles 1,2,3	47.26	0.00	-0.01	-0.03	-0.07
Quintiles 4,5	532.91	-0.50	-0.09	-1.20	-0.23
Western Cape households	123.88	-0.07	-0.06	-0.32	-0.26
Rural households	9.90	0.02	0.16	-0.08	-0.79
Quintiles 1,2,3	1.75	0.00	0.18	-0.01	-0.29
Quintiles 4,5	8.15	0.01	0.15	-0.07	-0.89
Urban households	113.98	-0.09	-0.08	-0.25	-0.22
Quintiles 1,2,3	6.17	0.00	0.07	-0.01	-0.20
Quintiles 4,5	107.81	-0.09	-0.08	-0.23	-0.22

The percentage change in trade is reported in table 7. For the agricultural sector the result of concern is that more field crops are imported while less are exported, and this impact is more severe if water is not fully utilized in agriculture (scenario 2). This result, combined with the national decline in production of cereals (57 380mt in the case of scenario 1 and 59 230mt in the case of scenario 2) not shown here, raises concern in terms of food security as domestic supply of staple foods decreases and the price thereof increase. If water is not fully utilized in agriculture, there is also a decline in horticultural exports, particularly deciduous fruit (6.42%). If water is not fully utilized, agricultural exports decline by 2.73% compared to a 0.90% increase in agricultural imports, while industrial and service exports increase and imports decrease. If water is fully utilized, the imports and exports of industry and services increase, except for services exports.

Table 7: Change in trade (% change in quantity)

	Exports		Imports	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Summer Cereals	-0.70	-1.80	0.40	1.02
Winter Cereals	-1.77	-5.13	1.05	2.87
Oils and Legumes	-1.87	-4.37	0.49	1.11
Fodder	-4.74	-6.30	0	0
Cotton and Tobacco	-0.48	-1.21	0.11	-0.12
Vegetables	1.24	-1.71		0
Citrus Fruit	2.04	-5.25	-1.43	3.34
Subtropical Fruit	-0.59	-3.57	0	0
Deciduous Fruit	0.34	-6.42	0	0
Other Horticulture	-3.05	-4.92	0.76	0.91
Livestock	0.01	-0.05	-0.02	-0.12
Livestock products	0.03	0.03	0.03	0.00
Fishing	0.07	0.16	-0.02	-0.14
Forestry	0	0	-0.02	-0.04
Agriculture	0.16	-2.73	0.34	0.90
Industry	0.01	0.14	0.00	-0.06
Services	-0.01	0.01	0.00	-0.05
Total Exports	0.01	0.05	0.01	-0.04

Key macroeconomic indicators are reported in table 8. There is a decline in all key macroeconomic indicators, except for government income from the water tariff. The decline is greater if water is not fully utilized, and government income from the water tariff is less if water is not fully utilized than in the case of full utilization of water. These results are indicative of a decline in national welfare.

Table 8: Change in key indicators (nominal – Rmillion)

		Scenario 1		Scenario 2	
	Base	Change (level)	Change (%)	Change (level)	Change (%)
GDP (Market Prices)	1 168 390	-860	-0.074	-2 220	-0.190
Exports	378 890	-280	-0.074	-750	-0.198
Imports	338 200	-240	-0.071	-682	-0.202
Fixed Investment	175 930	-130	-0.074	-336	-0.191
Private Consumption	733 430	-530	-0.072	-1 403	-0.191
Government Consumption	215 300	-150	-0.070	-412	-0.191
Government water tariff income	145	73	50.34	59	40.91

7 Summary of Results: Implications for the Agricultural Sector

The reality in South Africa lies between the two scenarios under investigation. Although water markets do exist and water rights do not have to be taken up by farmers, water markets are still very rigid in South Africa and if farmers do not take up their water rights they risk losing their rights permanently.

If the reality is close to the first scenario, in which water is fully utilized, agriculture will be unable to 'save' water if water tariffs are increased by 50%; but, structural and production changes will occur within agriculture; there is a general trend of a reallocation of water from low value crops to high value crops. The same general trend is evident in the Western Cape. The Western Cape is dominated by horticultural crops and demand for land and water for horticulture increases for most of the Western Cape.

These structural shifts raise concern for the risk profile of agriculture and food security. On a macroeconomic level these structural changes lead to more field crops being imported and less exported. Taken together, these impacts lead to rising prices of agricultural commodities, and of special concern is the rising price of cereals. Rising prices of staple foods may have an important poverty impact. Indeed, nationally, urban and rural household consumption expenditure declines and the rural poor are more adversely affected than the urban poor. Finally, national welfare declines in nominal terms as evidenced by a decline in key macroeconomic indicators.

If the reality is closer to the second scenario, in which water is not fully utilized, irrigated agriculture will decline in scope in addition to structural changes, while water can be 'saved'. The impact of increasing the water tariff by 50% if water is not fully utilized is to decrease the quantity of land and water demanded, to decrease employment in agriculture, to increase prices, to decrease household welfare and increase the imports of field crops. In the lower quintiles, households are more severely affected in rural areas. This in turn adversely impacts on rural livelihoods and food security; especially when considering the sharp decline in irrigated field crops. Again, national welfare declines in nominal terms as evidenced by a decline in all key macroeconomic indicators. The amount of water that can be 'saved' (128.8 million m^3 of unused water in the Western Cape) may be of note, but the extent to which irrigation water can remain unused in reality is unclear, and the capital costs required to reallocate this water must be taken into account in addition to the feasibility of switching to alternative crops.

What is evident though is that, for both scenarios, the risk profile of agriculture increases, food security may be threatened, national welfare declines, imports of staple foods increase, prices of staple foods increase, household welfare declines and employment in agriculture declines. These adverse effects are more severe in the second scenario than in the first scenario.

8 Conclusion

The potential impact of increased irrigation water tariffs on the Western Cape economy is to decrease agricultural production and food security with the possibility of a limited impact on actual quantities of water saved (it is not clear where on the scale between scenario 1 and 2 South Africa is situated). In addition, the socio-economic effect of increasing tariffs is regressive. Thus, increasing water tariffs may not be a useful demand management tool in South Africa. Tariffs should rather be used as a tool for cost recovery for infrastructure and the management of catchments and should always be approached with caution. This result conforms to the international experience of limited success with the use of pricing for demand management and the recognition that pricing is first and foremost a cost recovery tool. Careful consideration must also be given to the rigidity of South Africa's water licensing and water markets. This rigidity implies that any alteration in the allocation of water may be fairly permanent and will have long-run implications for the security of agriculture and the Western Cape economy. Water is a key constraint to development in the Western Cape and is important for the maintenance of rural livelihoods; thus, when considering these results it is important that the introduction of irrigation water pricing shocks be approached with due caution and that alternative demand management approaches be investigated.

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