



## Triple dividends of water consumption charges in South Africa

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[1] The South African government is exploring ways to address water scarcity problems by introducing a water resource management charge on the quantity of water used in sectors such as irrigated agriculture, mining, and forestry. It is expected that a more efficient water allocation, lower use, and a positive impact on poverty can be achieved. This paper reports on the validity of these claims by applying a computable general equilibrium model to analyze the triple dividend of water consumption charges in South Africa: reduced water use, more rapid economic growth, and a more equal income distribution. It is shown that an appropriate budget-neutral combination of water charges, particularly on irrigated agriculture and coal mining, and reduced indirect taxes, particularly on food, would yield triple dividends, that is, less water use, more growth, and less poverty.

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### 1. Introduction

[2] Water scarcity, poverty, and unequal distribution of income are but three, albeit very important, challenges facing South Africa. One way to reduce water use is by levying charges. A reduction in water use could be considered as the first dividend of such a policy. The revenues from these water charges could be used to stimulate economic growth and reduce unemployment. These benefits would be the second dividend. From the double dividend literature [e.g., *Goulder et al.*, 1997], it is evident that achieving this outcome requires careful policy design. A third dividend is also plausible being improved income distribution due to the faster economic growth and higher employment. As consumption taxes typically are regressive, this would require even more care in policy design. In this paper, we explore the three potential dividends of water charges in South Africa.

[3] We phrase water charges and revenue recycling in terms of triple dividends in line with economic literature. In business administration [e.g., *Gray and Bebbington*, 2003], this is phrased as the triple bottom line: care for people (our third dividend), profit (our second) and the planet (our first).

In the literature on sustainable development [e.g., *Bell and Morse*, 2003], the same question is phrased as the three pillars of sustainability, viz., environmental quality (planet), economic growth (profit), and social justice (people).

[4] This paper analyses the proposal of the South African government to reduce water consumption by increasing the water resource management charges. This is not a Pigouvian tax [*Pigou*, 1920]; we analyze the water charges currently discussed by the government. The costs and benefits of these additional water charges to the South African economy are estimated with a particular emphasis on poverty reduction, through recycling the water charges revenue into higher real income to the poor. Note that we only address poverty reduction and not inequality reduction per se. Though inequality is important for social justice, South Africa also faces absolute poverty.

[5] For the analysis, we use a computable general equilibrium model of the South African economy. The model is standard in many ways. It is here extended with water use. This is nonstandard as water is typically excluded from the national accounts: Water in the national accounts in the service of distributing water, not water as a resource. The model is nonstandard is also nonstandard in that many different consumers are distinguished; this is necessary to look at poverty. The model is calibrated to the official data of the government of South Africa. This facilitates policy advice. Although the model, its parameters, and the data used are all standard, this does not imply that the results are necessarily robust. In fact, the literature review and the simulations show that double and triple dividends are exceptions rather than the rule. We show, however, that such exceptions exist – and that sometimes you can have your cake and eat it twice. This study, however, should be replicated with other models to test the robustness of our findings.

[6] The literature on the use and availability of water, socioeconomic indicators, and water policies in South

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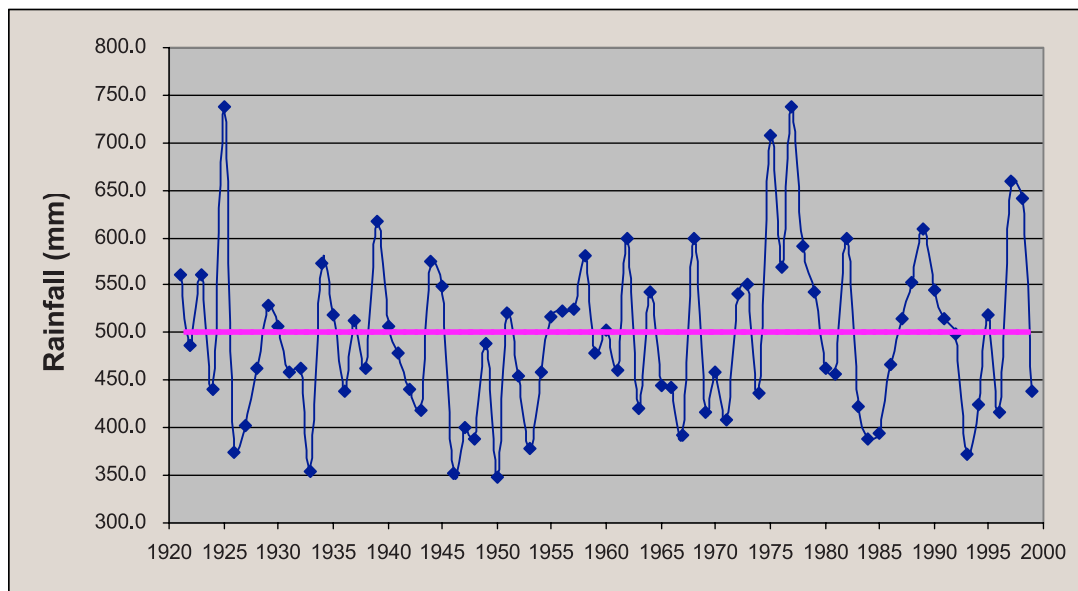
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**Figure 1.** Precipitation in South Africa (1922–1999). From CSIR [2001], with permission.

Africa is reviewed in section 2. Section 3 focuses on the concept of double dividend and its application to environmental taxation. The model and data used in this paper are presented in section 4. Simulation results are presented in section 5 and discussed in section 6. Section 7 concludes the paper.

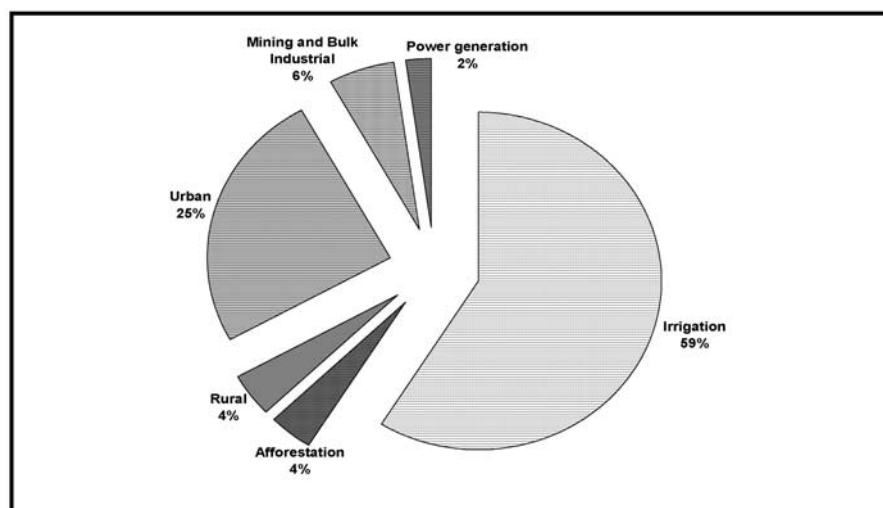
## 2. Water Scarcity and Poverty in South Africa

[7] South Africa is a semiarid country. Precipitation has fluctuated over the years (see Figure 1) with an average of 500 mm per annum, well below the world average of about 860 mm per year [Department of Water Affairs and Forestry (DWAF), 2002]. The total flow of all the rivers in the country amounts to approximately 49,200 million  $m^3$  per year. The National Water Resource Strategy estimates the total water requirement for the year 2000 at 13,280 million  $m^3$ ,

excluding environmental requirements. In addition, South Africa is poorly endowed with groundwater because most of the country is underlain by hard rock formations that do not contain any major groundwater aquifers [DWAF, 2002].

[8] Figure 2 describes water requirements by sector in South Africa. Agriculture is the largest consumer at 59%. Large-scale farmers use 95% of irrigation water, leaving small-scale farmers the remainder [Schreiner and van Koppen, 2002]. Afforestation uses 4% of the total water; rural and urban populations 4% and 25%. Mining and bulk industrial, and power generation use 8% in aggregate.

[9] Access to water resources is essential to transform society toward social and environmental justice and poverty eradication [Schreiner and van Koppen, 2002]. Rural people need water for drinking, hygiene, and cooking; but also for productive purposes such as farming, livestock, forestry, fisheries, and small-scale industries. Such production



**Figure 2.** Water requirements by sector in South Africa: 2000 (source is South Africa Department of Water Affairs and Forestry).

**Table 1.** Selected Socioeconomic Indicators: 2001<sup>a</sup>

	National	Rural
Unemployment rate, %		
Official (restricted) definition	26.4	33.9
Unofficial (expanded) definition	37.0	52.2
Portion of household, %		
With piped water in the dwelling or on site	65.7	24.3
Using mainly wood for cooking	19.6	53.8
Using mainly electricity for cooking	52.5	18.3
Using mainly paraffin for cooking	21.1	19.2
With access to hygienic sanitation	62.2	18.0
Where refuse/rubbish is removed by a local authority	54.8	15.5
With access to telephone	33.7	22.3
Within 14 mins of nearest clinic	36.3	20.8
Within 14 min of nearest primary school	54.3	41.7
Within 14 min of nearest food market	50.9	40.1
Dependent on remittances	13.8	23.5
Dependent on pensions and grants	17.8	32.2
With a radio	79.1	72.2
With a TV	56.4	35.0

<sup>a</sup>Source: *Statistics South Africa* [2002].

reduces income poverty. Almost 50% of the South African population is poor in terms of income, spending less than R353 per adult equivalent per month. About 70% of these poor live in rural areas [Schreiner and van Koppen, 2002].

[10] Table 1 shows selected socioeconomic indicators in South Africa in 2001. About 23% of the rural population depend on remittances and pensions, and 32% depend on pensions and grants. In addition, only 24% of rural people have access to piped water on site, while only 15% have access to sanitation. An additional charge on water used by economic sectors might lead to more effective allocation, a lower use of water resources and a positive impact on poverty alleviation. It translates into more water available for drinking, hygiene and productive activities, which might increase income for the poor and reduce the number of people affected by poverty.

[11] The above discussion sketches the scarcity of water in South Africa as well as the prevalence of poverty. The next question is how water resources are managed. To that effect, consensus was reached at the Dublin Conference on Water and the Environment that water should be regarded as an economic good [Briscoe, 1996; Perry et al., 1997]. There are two schools of thought on the economic value of water [Perry et al., 1997]. The first school maintains that water should be allocated to its best uses by being priced at its economic value, the same as other private goods that are allocated through competitive markets. The second school maintains that water should be exempted from competitive market pricing and treated as a basic human need, which does not necessarily involve financial transactions. This paper adopts the position that water should be priced at its economic value, while still ensuring access to water resources to poor people. The value of water is the maximum amount water users are willing to pay for the use of this resource such that marginal cost and marginal benefit are equal [Briscoe, 1996; Perry et al., 1997].

[12] In South Africa, according to the National Water Act (Act 36 of 1998), the government is regarded as the public trustee of the nation's water resources and "must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner, for the

benefit of all persons" [MacKay, 2003]. Under previous legislation, pricing of water did not generally take into account the real cost of managing water, the cost of water supply and the scarcity value of water [MacKay, 2003, p. 64]. The government financed the capital costs of the water schemes supplying agricultural water users, some urban bulk water suppliers and industrial users. In addition, operation and maintenance costs were often not fully recovered from these water users [MacKay, 2003, pp. 64–65].

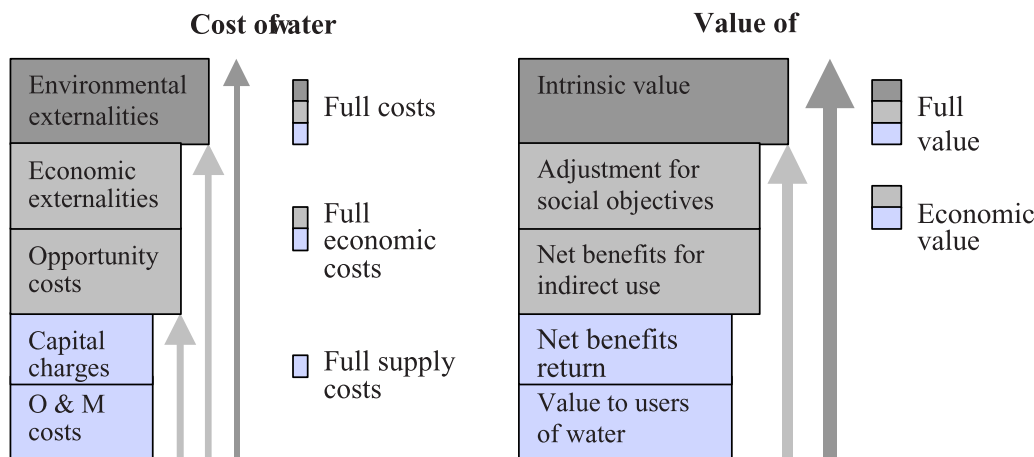
[13] The principle behind current water pricing policy in South Africa is that payment for water should be at a level reflecting its scarcity except for water required to meet basic human needs and the ecological reserve. Currently, 25 L of water per day per person is assumed to meet basic human needs, while ecological reserve requirements differ per water management area. The water pricing policy is structured into three tiers [Council for Scientific and Industrial Research (CSIR), 2001]: (1) first tier, raw water tariffs administered by DWAF for the sale of water to Water Boards; (2) second tier, water boards set the wholesale price of water to bulk water users such as municipalities and industries such as Eskom and Sasol; (3) third tier, municipalities determine the price of water to charge end users such as households and industries.

[14] A rise in raw water tariffs will automatically lead to an increase in the price in the second and third tiers. According to the Water Act, all water users should be registered and pay for the water. Water use in South Africa is classified into three kinds: schedule 1 authorization, which grants lawful access for reasonable domestic use (small gardening and livestock watering without paying water tariffs or charges); general authorization, by which water use is authorized for a group of water users as long as certain minimum requirements are met; and water use license where individual water users should apply to DWAF for a license to use water and where water should preferably be allocated to those users generating the highest social, economic, or environmental value and equity.

[15] Water pricing can be based on a number of pricing strategies that include full supply cost, full economic cost and full cost of water (Figure 3). The South African government is introducing a water resource management charge to recover some of the costs for water management and to reflect water scarcity in the country. This means that the government is moving toward full economic costs of water by taking into account the supply cost and the economic opportunity cost of water.

### 3. Double Dividend: A Literature Review

[16] According to the double dividend theory, the revenues of environmental taxes can be used to lower other (distortionary) taxes, and therefore lower the economic cost of the environmental tax. The positive effects of lowering other taxes could even outweigh the negative effects of a rise in environmental taxes. This is when the double dividend occurs: both the environment (first dividend) and the economy (second dividend) will be in better shape than before the environmental tax reform. Policy makers who want to use environmental taxes to curb pollution but find it hard to sell a drop in GDP or employment would of course welcome this. It also explains why the double dividend theory has become a popular research theme.



**Figure 3.** Underlying principles for the cost and value of water. From King [2004], adapted from Rogers *et al.* [2001].

[17] In the early phases of the double dividend theory, bold statements were made about the general validity or invalidity of the theory. These statements were, respectively, based on partial models of the economy and simple one-factor general equilibrium models that assumed competitive markets [see, e.g., Pearce, 1991; Bovenberg and De Mooij, 1994]. Later analysis focused on multiple production factor models and allowed for a distorted labor market. This analysis led to more nuanced statements about the possibility of a double dividend and will be discussed in the next two sections.

### 3.1. Multiple Production Factors

[18] One-factor models claim it is impossible to attain a double dividend because the environmental tax would be more distortionary (just looking from an economic viewpoint and abstaining from environmental benefits) than the factor tax it replaced [Bovenberg and De Mooij, 1994; Goulder *et al.*, 1997]. Adding another production factor (usually capital; the one-factor models use only labor) to the modeled economy introduced the possibility of inefficiencies in the tax system. From a tax efficiency point of view, taxes on the two production factors should have the same marginal efficiency costs or marginal excess burden (MEB), that is the loss of overall production efficiency due to taxation. The MEB of a labor tax depends on its level and on the (compensated) wage elasticity of labor supply: the larger this elasticity, the greater the distortion. For a capital tax in a closed economy it is again its level and the intertemporal elasticity of substitution in consumption: the larger the elasticity, the larger the distortion along the intertemporal dimension (the margin of choice between consuming today and consuming in future). If the MEBs are not the same, reducing this difference reduces the distortions in the economy caused by taxation.

[19] In the double dividend literature this inefficiency is “used” to create possible economic gains from the introduction of an environmental tax. This happens if the environmental tax shifts the tax burden from the overtaxed factor (with the higher MEB) to the undertaxed factor (with the lower MEB). As stated by Goulder [1994], the gain is larger if (1) the difference in MEBs is larger; (2) the burden of the environmental tax falls mainly on the undertaxed

factor; and (3) the recycling of revenues mainly reduces the burden of the overtaxed factor.

[20] Substitution elasticities between labor, capital and water (the scarce resource) are also important. With capital fixed, this factor should be a poor substitute for water, while labor should be a good substitute. With an elastic capital supply, it is the other way around [De Mooij and Bovenberg, 1998].

[21] This efficiency gain has to be large enough to overcome the negative effects that are inherent to an environmental tax (its narrowness, and the extra distortionary costs that arise from taxing inputs or goods instead of taxing production factors directly). The broader the tax base the lower the distortion. Environmental taxes, however, are relatively narrow by nature and on purpose because they are meant to change specific behavior [Goulder, 1994]. In the theoretical tax literature, taxes on intermediate inputs generally have larger welfare costs than do equal revenue taxes on primary factors because they distort both the intermediate input choice and factor markets, instead of just distorting factor markets [Goulder, 1995, p. 288]. The effects of tax shifting have also been studied with empirical general equilibrium models. Goulder [1995], Bovenberg and Goulder [1997], and Jorgenson and Wilcoxon [1993] all study the results of a revenue neutral environmental tax reform for the United States with an intertemporal general equilibrium analysis. Goulder [1995] and Bovenberg and Goulder [1997] fail to find a double dividend. In all their scenarios the environmental tax is more distortionary than the taxes it replaces and the economic costs of the tax reform are therefore always positive. The main reason for this is the relative narrowness of the environmental tax. Jorgenson and Wilcoxon [1993] do find a double dividend under certain conditions. Irrespective of the end result, the costs or benefits of the tax reform varied with the scenario chosen, and they moved in line with Goulder’s [1994] expectations: the lower the costs, the larger the difference in MEB, and the more the tax burden was shifted from the overtaxed to the undertaxed factor.

### 3.2. Noncompetitive Markets: Involuntary Unemployment

[22] The second main improvement to the double dividend analysis was the inclusion of involuntary unemploy-

ment. In the literature, involuntary unemployment has been incorporated in the analysis in several different ways, but usually some model of wage bargaining between firms and workers is used. *Bovenberg and Van der Ploeg* [1998], for instance, use a search model of the labor market with individual worker-firm bargaining. In another paper, *Strand* [1998] assumes a monopoly union that unilaterally determines the wage, after which a fixed number of firms determine employment. In the work by *Koskela et al.* [1998] a monopolistic firm determines employment, this time after bargaining over wages with a small trade union.

[23] In these papers, a double dividend depends on the effect of the green tax reform on the bargaining positions of firms and workers. For employment (not necessarily welfare) to increase, producer wages have to decrease, and this happens if workers' bargaining position deteriorates or that of the firm(s) improve. This is the case if workers' outside options (e.g., income under unemployment or in the informal sector) worsens, or if the firm's labor demand becomes more elastic with respect to wages. Another way to reduce wages is to shift the tax burden to the unemployed as is done in the paper by *Bovenberg and Van der Ploeg* [1998].

### 3.3. Distributional Effects

[24] Besides raising revenue, the most important function of taxation is the (re)distribution of income between members of society. This distribution is also the main reason why tax systems deviate from optimality (in the absence of externalities it would be optimal to have a lump sum tax). Unfortunately, the way an environmental tax reform affects distribution is not studied in much detail in the double dividend literature. The scarce information we do have points in the direction of a small negative distributional effect, but this, of course, depends on the specific form of the tax return [see, e.g., *Ekins and Barker*, 2001; *Bach et al.*, 2002]. However, this would again diminish the increased efficiency of the tax system and could, depending on the measures taken, forestall a double dividend. Shifting the tax burden to the unemployed or those working in the informal sector, as is done by *Bovenberg and Van der Ploeg* [1998] to increase employment, will obviously have negative income effects on the lowest income groups.

[25] Concluding, a double dividend is possible but is by no means certain or automatic. The initial situation regarding existing taxes and distortions in the labor market, together with the specific form of the tax reform, will determine the ultimate outcome. In policy terms, a double dividend can be achieved if the tax reform is smart. Tax reforms that ignore preexisting distortions but are designed on alternative criteria (e.g., political considerations) would probably not result in a double dividend. By extrapolation, a third dividend (poverty reduction in our case) would place even greater demands on policy design.

## 4. Model, Data, and Scenarios

### 4.1. Previous Studies

[26] A computable general equilibrium model is arguably the best tool available to study the effects of changes in taxes on consumption, growth, and income distribution on a macro level. Computable general equilibrium (CGE) models are based on the national accounts. As water is

typically not included in the national accounts in a meaningful way, water is often excluded from CGE models as well. There are a few exceptions, however. *Decaluwé et al.* [1999] analyze the effect of water pricing policies on demand and supply of water in Morocco. *Gomez et al.* [2004] compare water markets to desalinization for the Balearic Isles. For the Arkansas River Basin, *Goodman* [2000] shows that temporary water transfers are less costly than building new dams. *Seung et al.* [2000] look at water reallocation in Nevada. *Diao and Roe* [2003] study the effect of trade liberalization on water policy in Morocco. *Horridge et al.* [2005] study the effect of drought on the Australian economy. *Berrittella et al.* [2005a, 2005b] use a global CGE with water in, studying the effects of water shortages and water pricing. All of these studies look at water consumption (our first dividend) and economic growth (our second dividend), but none of these studies look explicitly at poverty (our third dividend) or at South Africa.

### 4.2. Model and Data

[27] The model used here is called UPGEM, which stands for the University of Pretoria computable general equilibrium (CGE) model of South Africa. It is very similar to the familiar ORANI-G model of the Australian economy, which is well documented, with the full equation system presented and explained by M. Horridge (ORANI-G: A generic single-country computable general equilibrium model, lecture notes for the Practical GE Modeling Course, 17–21 June 2002, hereinafter referred to as Horridge, lecture notes, 2002). The reader may visit <http://www.monash.edu.au/policy/orani.htm> for a summary of all the country models that have been built in the Orani style, and may download a Word document with the said complete description of the Orani model. UPGEM was developed from the same set of equations. Here we present a diagrammatic overview of the structure of the model.

[28] The model has a theoretical structure that is typical of most static CGE models, and consists of equations describing, producers' demands for produced inputs and primary factors; producers' supplies of commodities; demands for inputs to capital formation; household demands; export demands; government demands; the relationship of basic values to production costs and to purchasers' prices; market-clearing conditions for commodities and primary factors; and numerous macroeconomic variables and price indices.

[29] Conventional neoclassical assumptions drive all private agents' behavior in the model. Producers minimize cost while consumers maximize utility, resulting in the demand and supply equations of the model. The agents are assumed to be price takers, with producers operating in competitive markets, which prevent the earning of pure profits.

[30] In general, the static model with its overall Leontief production structure does not allow for substitution on the production side, but substitution is assumed in consumption. It has CES substructures for (1) the choice between labor, capital and land, (2) the choice between the different labor types in the model, and (3) the choice between imported and domestic inputs into the production process (see Figure 4). In the short-run simulations reported here, we do not allow for substitution in production between

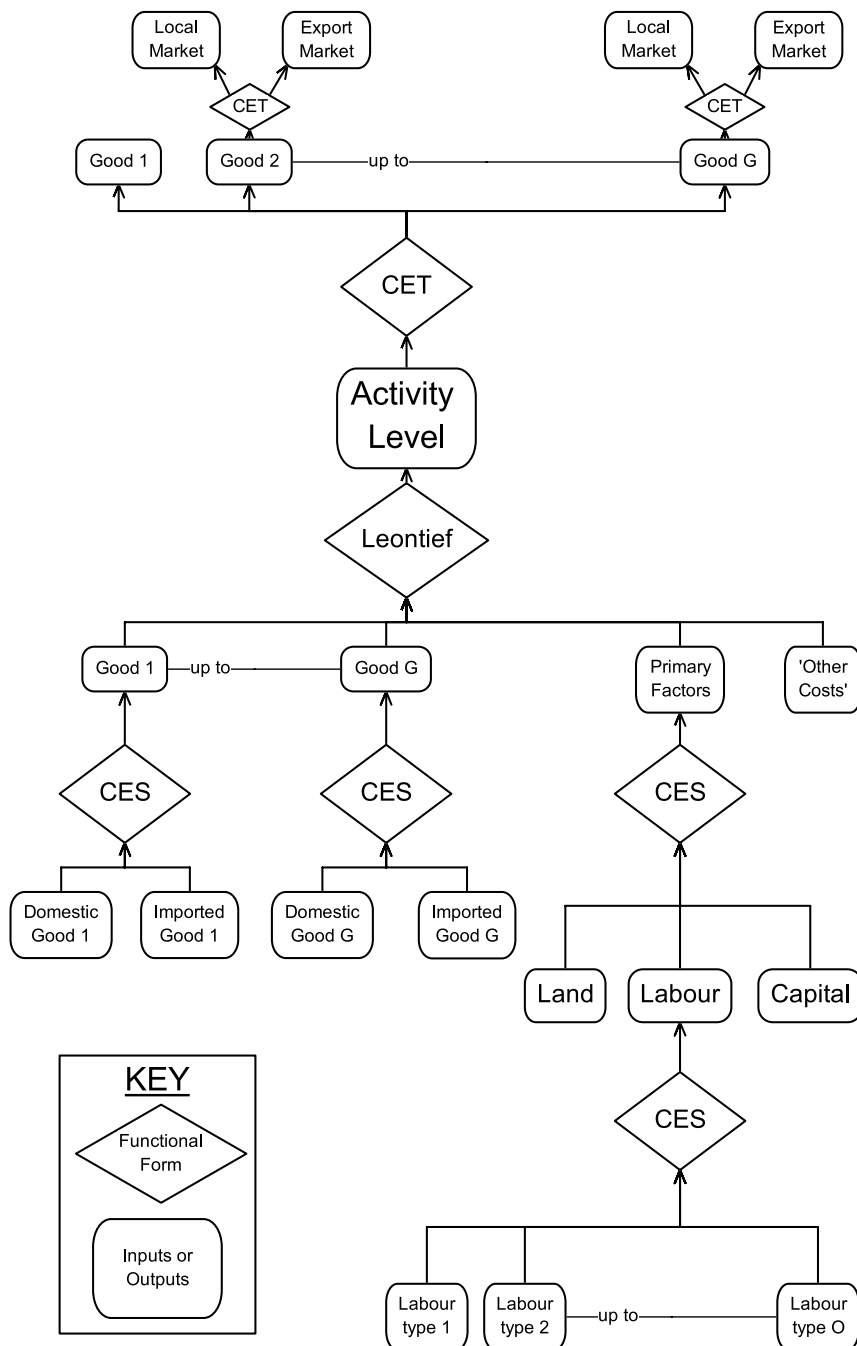


Figure 4. Structure of production. Data from M. Horridge (lecture notes, 2002).

water and other inputs. Consequently, water is modeled as a required input per unit of output and conservation options are not considered. Household demand is modeled as a linear expenditure system that differentiates between necessities and luxury goods, while households’ choices between imported and domestic goods are modeled using the CES structure.

[31] Figure 4 shows that commodity composites, a primary factor composite and ‘other costs’ are combined using a Leontief production function. Consequently, they are all demanded in direct proportion to total production (“activity level”). Each commodity composite is a CES function of a domestic good and the imported equivalent. The primary

factor composite is a CES aggregate of land, capital and composite labor. Composite labor is a CES aggregate of occupational labor types. Although all industries share this common production structure, input proportions and behavioral parameters may vary between industries (Horridge, lecture notes, 2002). The elasticities used for the CES functions in the model have been taken from *de Wet* [2003], and are summarized in Table 2.

[32] The model is based on the official 1998 social accounting matrix (SAM) of South Africa, published by *Statistics South Africa* [2001]. As is common with in CGE analysis, our model exactly reproduces the data. This is clever calibration, not validation. Relevant model validation

**Table 2.** Values for Key Elasticities Used in the CGE Model<sup>a</sup>

	Value
Export demand elasticities	-5
CES between imported and domestic goods	0.5-1.5
CES between capital, labor and land	0.5-1.0
CES between labor skill groups	0.5

<sup>a</sup>Source: model database.

is unfortunately impossible, as water charges have yet to be implemented. This SAM divides households into 12 income and 4 ethnic groups (official names are Asian, black, colored, and white) and distinguishes 27 sectors. We split the energy and water intensive sectors further to arrive at a total of 39 sectors. (Triple dividends for energy taxes are discussed in a related paper [*van Heerden et al.*, 2006].) The official SAM has only one sector for all agriculture, and we split it into seven subsectors to be able to determine exactly which water policies would render the best results. The seven are irrigated and dry field crops, irrigated and dry horticultural crops, livestock, forestry, and other agriculture. Similarly, on the energy side, subsectors such as crude petroleum and gas, petroleum products, and iron and steel, are all included with other sectors in the official SAM, and was separated out for the scenarios that we wanted to test. The weights used for the said splits come from the Coningarth supply and use tables in South Africa (Coningarth Consulting, 2001), which have 41 production sectors. The RAS technique (the standard work on RAS is by *Bacharach* [1970]) was used to balance the extended SAM.

[33] The model's closure rules reflect a short-run time horizon. The capital stock in each sector is assumed fixed, while the rate of return on capital is allowed to change. The South African labor market is characterized by large unemployment of unskilled labor, and a shortage of skilled labor. The model differentiates between 11 different labor groups that are classified as either skilled or unskilled. Skilled labor is treated as human capital in inelastic short-term supply. The supply of unskilled labor is assumed to be perfectly elastic at fixed posttax real wages (i.e., nominal posttax wages deflated by the economy-wide CPI). The distinction between skilled and unskilled labor supply reflects the South African labor market realistically and allows for investigating the effect of certain policies on employment of unskilled labor. The supply of land is also assumed to be inelastic [*Van Heerden et al.*, 2006].

[34] With reference to the macroeconomic variables, it is assumed that aggregate investment, government consumption and inventories are exogenous, while consumption and the trade balance are endogenous. Consumption is a function of posttax wage income by household and race group, while imports and exports have CES demand functions of relative prices. This specification allows us insight into the effect of the suggested policies on South Africa's consumption and competitiveness. All technological change variables and all tax rates are exogenous in the closure. Finally, the nominal exchange rate is set to be the numeraire in each of the simulations.

[35] The water supply and use accounts produced by the CSIR [2001] were used to create a vector of "taxable water" for each industry in the SAM, as well as a vector of "extra water charges" that may be charged on volumes of water

used. The former is a vector of water volumes that include all taxable water, namely water extracted from underground or rivers, or water received from the formal water sector. Variables are also defined for taxable water used, and extra water charges, to be able to calculate changes in total revenue raised and changes in water demand.

[36] The core water equation added to the UPGEM model is equation (2). It is derived from the identity that total revenue raised (R) is equal to the rate per volume (T) times the volume of water (X):

$$R = T \cdot X \quad (1)$$

UPGEM's equations are all written in percentage or absolute change form, and not in absolute levels. The model is therefore linearized and easily solved. From (1) the change in revenue (dR) is approximately equal to the tax rate (T) times the change in the base (dX) plus the base (X) times the change in the rate (dT):

$$dR = T \cdot dX + X \cdot dT = T \cdot X \cdot x/100 + X \cdot dT = R \cdot x/100 + X \cdot dT \quad (2)$$

with x the percentage change in X. If x is the percentage change in X, then we know  $x = 100 \cdot dX/X$ , so that  $dX = x \cdot X/100$ . Equation (2) is used in the model to calculate the absolute changes in revenue received from charges on water consumption by all industries. The changes in revenue received from charges on water consumption by all industries. The changes in the tax rates are exogenous, and shocked according to various scenarios outlined below. All the other variables are entered into, or calculated by the model. Note that variable x is the percentage change in water consumption by industries, and it is an endogenous variable, that is, calculated by the model. We expect that an additional charge on water will lead to a decrease in water consumption. Total revenue from the extra water charges is added to total government revenue.

#### 4.3. Scenarios

[37] The following scenarios were tested using the UPGEM model to try and adhere to the suggestions proposed by water authorities and experts: (1) a surcharge of 10c per m<sup>3</sup> water used by forestry, (2) a surcharge of 10c per m<sup>3</sup> water used by irrigated agriculture, and (3) a surcharge of 10c per m<sup>3</sup> water used by all mining industries.

[38] On the recycling side, three simulations were performed: (1) a decrease in the overall level of direct taxation on capital and labor, (2) a decrease in the overall level of sales tax on household consumption, and (3) a decrease in the sales tax rate on food to households.

[39] No unambiguous improvement in consumption levels of all race groups in the poorest three household groups was found by any one of the scenarios, so that we had to refine the scenarios further. Irrigated agriculture was split into field crops and horticulture, and the results reported separately. Mining was also split into three components (gold, coal, and other mining), and results are reported separately as well.

[40] This results in eight scenarios of water charges, and three scenarios of revenue recycling. Rather than simulating  $8 \times 3 = 24$  scenarios, we use the additive property of a CGE under small shocks. To this end, we normalized the water

**Table 3.** Marginal Change in Water Consumption due to Tax Change and an Indication of Scenarios That Result in a Water Dividend<sup>a</sup>

	Marginal Change in Water Consumption	Recycling Scheme		
		Direct Tax Break	Indirect Tax Break	Food Tax Break
Water tax		0.0007	0.0009	0.0009
Tax on forestry water	-0.316	+	+	+
Tax on mining water	-0.026	+	+	+
Gold mining	-0.028	+	+	+
Coal mining	-0.026	+	+	+
Other mining	-0.025	+	+	+
Tax on irrigated agriculture	-0.055	+	+	+
Field crops	-0.066	+	+	+
Horticulture	-0.033	+	+	+

<sup>a</sup>The numbers represent the percent change in water use per 10 million Rand tax revenue. In the recycling scheme columns a water tax is levied; the numbers are the reduction in water use. In the rows, the tax is recycled; the numbers are the increase in water. If the sum of the two effects is negative, water use falls, and a plus sign is given.

consumption, economic growth and income distribution effects of the water charge scenarios by the respective revenues, and did the same thing for the revenue scenarios. The impact of water charge plus recycling is closely approximated by the sum of the impact of water charge and the impact of revenue recycling.

## 5. Simulation Results

### 5.1. Environmental Effects

[41] The first of the three dividends is the environmental dividend reaped. Here it is a reduction in water use. Table 3 shows that all the simulations do yield the first dividend, whether the revenue collected is recycled through a direct or indirect tax break. An additional charge on water consumption always leads to a decrease in water demand. All that is needed for the environmental dividend to occur is that the increase in water consumption that results from a direct or indirect tax break (the row numbers in Table 3) is less than the decrease due to the water charge (the column numbers in Table 3). The model results as shown in Table 3 indicate that this is the case.

[42] The water charge increases the price of water and directly affects the amount of water consumed. The model predicts that the water charge will lead to a decline in water consumption in the forestry and irrigated agriculture sector by 32% and 6% per billion Rand tax revenue received, respectively. Water consumption by the mining sector would decrease by only 3% per billion Rand tax revenue received.

[43] A tax break affects all commodities, not only water. Consumers will use the extra income to demand more of all commodities, including water. However, water is a necessity, and the demand for it will increase very little, as the results in Table 3 show. The decrease in water consumption as a result of water charge is greater than an increase in water consumption because of tax breaks, thereby yielding the environmental dividend.

### 5.2. Economic Effects

[44] The second dividend is the effect on the total economy, and is determined using the concept of marginal excess burden. The marginal excess burden (MEB) is defined as the change in real GDP divided by the change in real government revenue. Note that UPGEM has a simple representation of the labor market. The closure rule has an

infinite supply of unskilled labor. Any increase in real GDP coincides with a decrease in unemployment. One may interpret this as a separate dividend, but as it is beyond our model, we prefer not to.

[45] The MEB's for all eight water charge policy measures as well as the three recycling measures are given in Table 4. A double dividend is indicated by a plus sign in Table 4, that is, when the increase in real GDP per unit of real government revenue lost as a result of a tax break (recycling policy) is larger than the decrease in real GDP per unit of real government revenue collected from a new water charge.

[46] A charge on water consumed by the mining industry would lead to a decrease in real GDP by 55 cents per Rand of real government revenue collected from the tax. Recycling via a direct or indirect tax break or a tax break on food would lead to a GDP increase by 59, 72 and 70 cents per Rand of real government revenue forsaken by government respectively. This gives a net gain to the economy. However, if only gold mining were water taxed, it would not render a double dividend. Neither would coal mining with the direct tax break as method of recycling. Other mining industries give quite a different result from coal and gold mining in that GDP only decreases by 25 cents per Rand extra water charged. An additional charge on water consumption by irrigated agriculture renders double dividends, whether the tax is levied on field crops only, or horticultural crops, or on both. The damage done in terms of MEB is smaller with field crops than with horticulture. However, none of the three recycling schemes is able to undo the damage of additional water charges on forestry.

[47] The percentage change in total employment per unit of real government revenue collected was also calculated, and the pluses and minuses follow exactly the same pattern as in Table 4. That is, employment and GDP per unit of real government revenue are closely related to each other. The explanation is simply that the total production function in the model has Leontief and CES characteristics in terms of intermediate and primary inputs, so that GDP and employment will always move in the same direction as a result of an exogenous shock.

### 5.3 Effect on Poverty

[48] The criterion used to measure an improvement in poverty levels is the percentage change in total real con-

**Table 4.** Marginal Excess Burdens of Different Tax Instruments and an Indication of Scenarios That Result in a GDP Dividend<sup>a</sup>

	Marginal Excess Burden	Recycling Scheme		
		Direct Tax Break	Indirect Tax Break	Food Tax Break
Water tax		0.586	0.722	0.703
Tax on forestry water	-0.825	-	-	-
Tax on mining water	-0.547	+	+	+
Gold mining	-0.964	-	-	-
Coal mining	-0.658	-	+	+
Other mining	-0.249	+	+	+
Tax on irrigated agriculture	-0.372	+	+	+
Field crops	-0.338	+	+	+
Horticulture	-0.442	+	+	+

<sup>a</sup>The numbers represent the percent change in gross domestic product per 10 million Rand tax revenue. In the recycling scheme columns a water tax is levied; the numbers are the reduction in GDP. In the rows, the tax is recycled; the numbers are the increase in GDP. If the sum of the two effects is positive, GDP increases, and a plus sign is given.

sumption of the three poorest household groups in the economy, by race. The model has eleven household groups and four race groups. It calculates consumption for each group by commodity, as well as total consumption. Table 5 gives the results for real consumption by the poorest household group. Note that the results for the poorest three groups are similar, so that Table 5 is representative of all three.

[49] Some policy combinations render a net improvement for one race group while they have detrimental effects on another. A tax on water consumption by mining industries other than gold and coal is the only water charge that could be recycled in a way that would benefit all four race groups within the poorest groups of households. However, all the water taxes except one would render the poverty dividend if they were combined with a tax break on food.

[50] For irrigated agriculture, it helps to differentiate between water charge on field crops and on horticultural crops. We found that a tax on irrigated horticultural crops has a more severe influence on the consumption of the poorest groups, in that at least one group is made worse off with this tax, while with irrigated field crops at most one group is made worse off.

## 6. Discussion of Results

[51] Extra water charges on forestry are detrimental to three of the four race groups in the poorest household group,

including Africans who comprise close to 90% of this group. The eight key commodities that Africans spend the most of their income on are (in order of importance) food, petroleum, real estate, textiles, electricity, transport services, other manufacturing and agricultural goods.

[52] The direct impact of extra water charges on forestry is an increase in the costs and prices in, firstly, the forestry industry and, secondly, in the wood, paper and pulp industries, which are part of “other manufacturing”. The agricultural sector is the largest intermediate supplier to the food industry. Food is an important commodity to all households-rich and poor. Other manufacturing is also high on poor consumers’ priority list; these two channels are significant in the detrimental effect on the poor.

[53] Extra water charges on mining do not have a direct effect on households in the same way as water taxes on forestry and irrigated agriculture. Households do buy some coal, but no gold or other mining goods, so that there are no direct effects on households from the latter two industries. They influence consumers through the downstream effects on industries who buy the outputs of the mining industries.

[54] The effect from the mining industry as a whole comes mostly from more expensive coal, through two obvious channels. African households do burn coal and they use electricity, for which coal is the most important input. The gold mining industry has indirect effects only: it sells gold to other manufacturing, which is a key commo-

**Table 5.** Marginal Change in Poverty and an Indication of Scenarios That Result in a Poverty Dividend<sup>a</sup>

	Marginal Change in Poverty	Recycling Scheme		
		Direct Tax Break	Indirect Tax Break	Food Tax Break
Water tax		0.104	0.133	0.403
Tax on forestry water	-0.291	-	-	+
Tax on mining water	-0.285	-	-	+
Gold mining	-0.568	-	-	-
Coal mining	-0.268	-	-	+
Other mining	-0.092	+	+	+
Tax on irrigated agriculture	-0.196	-	-	+
Field crops	-0.175	-	-	+
Horticulture	-0.239	-	-	+

<sup>a</sup>The numbers represent the percent change in real consumption of the poorest household group per billion Rand tax revenue. In the recycling scheme columns a water tax is levied; the numbers are the reduction in consumption. In the rows, the tax is recycled; the numbers are the increase in consumption. If the sum of the two effects is positive, poverty decreases, and a plus sign is given.

**Table 6.** Summary of Dividends (Water Use, GDP and Employment, and Poverty)<sup>a</sup>

Water Tax	Recycling Scheme		
	Direct Tax Break	Indirect Tax Break	Food Tax Break
Tax on forestry water	+ - -	+ - -	+ - +
Tax on mining water	+ + -	+ + -	+ + +
Gold mining	+ - -	+ - -	+ - -
Coal mining	+ - -	+ + -	+ + +
Other mining	+ + +	+ + +	+ + +
Tax on irrigated agriculture	+ + -	+ + -	+ + +
Field crops	+ + -	+ + -	+ + +
Horticulture	+ + -	+ + -	+ + +

<sup>a</sup>The results follow from Tables 2–4; the first sign is for water use, the second for GDP, and the third for poverty; note that if GDP goes up (down), so does employment.

dity for households. Three of its most important suppliers of intermediate goods are petroleum, electricity and other manufacturing, all three key commodities for the poor.

[55] The results that appear in Table 5 also take into consideration recycling, and the effects described above should be compared to the increases in consumption of various commodities due to recycling. In general the recycling benefits all industries, while the environmental taxes harm a few industries severely and affecting others marginally. The recycling of revenue allows consumers to have more of all commodities, and hence also more of all their key commodities of which they consume the most. The default net outcome of the combined policy options (water charges and recycling) should therefore be beneficial to the consumers, unless the environmental effects are focused on a few key commodities, and outweigh the recycling effects. The extra water charges on “other mining” are a case in point. There is no direct negative effect on consumers since they do not buy “other mining” commodities. The most important indirect effects are on petroleum, basic iron and steel and construction, of which only the first is important on the consumers’ list. Hence the results demonstrate positive net effects on consumption by the poor for all three recycling schemes.

[56] Extra water charges on irrigated agriculture directly increase the cost of field and horticultural production. Field and horticultural products comprise a large proportion of agricultural commodities, and an increase in their prices directly affects the prices of industries buying them as intermediate inputs. The four largest demanders of agricultural goods are food, other manufacturing, petroleum and textiles, all important to poor households. The only recycling scheme that is able to offset the decrease in consumption due to water charges on agriculture, is a decrease in the food tax rate. Food is the most important consumer good for poor households, and it is to be expected that cheaper food would dominate the tax on an industry only indirectly linked to poor households.

[57] The good news with a water charge policy that involves irrigated field crops is that Africans are made better off, despite the way of recycling used. They comprise more than 89% of total consumption in their six most important commodities, and a very high proportion of all

commodities consumed by the poorest groups. The colored group consume less than 10% of all commodities in the poorest group and is the only group to be harmed by a tax on irrigated field crops.

[58] All the simulation results are summarized in Table 6. The first plus in each cell shows the first dividend (water use), which is positive in all cases. The second plus or minus shows whether a double dividend on GDP and employment has been achieved with the combination of policies, while the third plus or minus shows a triple dividend on poverty reduction. There are quite a number of policy combinations that render double dividends, but we are interested in achieving poverty reduction simultaneously with environmental management. With both a direct tax break and a general decrease in the sales tax rate for households, the only triple dividends are obtained through a water charge on “other mining.” However, six of the eight environmental tax policy measures render triple dividends with a decrease in the tax rate on food to households.

## 7. Conclusion

[59] The large water users are irrigated agriculture and it is (politically) important that a tax on water used by irrigated agriculture would render the desired triple dividends for all four race groups, if the revenue were properly recycled. A tax of irrigated agriculture does render double dividends with all three recycling schemes (direct taxes, indirect taxes, food taxes), and a triple dividend with one of the three (food taxes). An additional water charge on the mining sector, particularly on coal and other mining, stands a high chance of yielding dividends in terms of less water used, positive impacts on poverty reduction amongst the poor and positive impacts on the economy. Again, a reduction in indirect taxes, particularly on food, is more effective than a reduction of direct taxation. A more detailed analysis with more specific charges needs to be carried out to further substantiate this conclusion.

[60] We show that there can be a triple dividend of water policy, simultaneously reducing water scarcity, improving economic growth/reducing unemployment, and reducing poverty. Smart policy design could improve all three pillars of sustainability, viz. the environment (planet), the economy (profit), and society (people). Methodologically, this study goes beyond water in South Africa. Water is but one environmental problem, and South Africa is among many countries in which environment, economic and social problems coincide. The methods used in this paper could be used in other contexts and other places to study policy interventions for sustainable development.

[61] Replication of this study for other places and contexts would also shed light on the robustness of the results presented here. *Van Heerden et al.* [2006] reach similar conclusions for energy use, but the model, parameters, and data are almost identical. The literature review and the simulations clearly show that double and triple dividends can had under particular conditions only. This implies that a different model may find double and triple dividends for a different set of tax reforms than we do. Further empirical research is therefore needed. This paper only establishes that, in principle, it is possible to reduce water consumption, stimulate economic growth, and alleviate poverty, all at the same time.

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