2.4 Economic analysis of water policy reforms in South Africa: The case of the Olifants river basin

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The Center for Development Research, ZEF, is an international university-affiliated institute conducting interdisciplinary research on development related-issues all over the world. The project Integrated Water Resources Management: Middle Olifants South Africa (MOSA) was hosted by the Economic and Technological Change Department. The project team was constituted by Prof. Dr Joachim von Braun, Dr Djiby Racine Thiam, Ms Georgina Wambui and Ms Phillipa Kanyoka. Throughout this project ZEF has established a very good partnership with the University of Pretoria – South Africa, to facilitate data collection, fieldwork and the implementation of the results. The Center for Environmental Economics and Policy in Africa (CEEPA), with Prof. Rashid Hassan, was the main partner of ZEF.

2.4.1 Introduction

Water scarcity is a major constraint to socio-economic development in South Africa. South Africa is rated among the 30 most water-stressed countries in the world. Many of its regions continue to face persistent water shortages as well as an increasing competition between water users, a growing population and varying climatic changes (Rosegrant & Binswanger 1994; Earle, Goldin & Kgomotso 2005; Tsegai et al. 2009; Mwendera et al. 2003; Mallory 2011). Specifically, the Olifants river basin ranks as the country’s third most water stressed basin as well as one of the most polluted (Kloos 2010; Walter 2010; Van Veelen 2011). The Olifants basin is one of the 19 Water Management Areas (WMAs) and it faces a serious water scarcity, with water deficits occurring in most years. The scarcity of water has led to intense competition for the resource among uses and between upstream and downstream uses and has had an impact on household food production and food security of poor rural households who rely on agriculture for their livelihoods.

Table 2.4-1 illustrates water use by sector for the year 2011 while Table 2.4-2 shows the water balance for the Olifants catchment in the year 2010. Table 2.4-2 indicates a small surplus with the exclusion of the reserve requirement, which if included, would bring it down to a deficit because the water requirements would be higher than the available water resources. Projection from this indicates that by the year 2035, the basin will be experiencing a negative water balance (Mallory 2011).

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Table 2.4-1: Sectoral water requirements[1] in the Olifants basin in million m^3/annum

Sub-catchment	Power generation	Indus-trial	Urban	Rural	Mining	Irrigation	Total
Upper	228	9	93	4	26	249	609
Middle	0	0	56	22	28	81	187
Lower	0	0	29	3	32	156	220
Total	228	9	178	29	86	486	1016

Source: (Mallory 2011)

Table 2.4-2: Water balance for the Olifants basin in the year 2010: Million m^3/annum

Sub catchment	Water requirement	Water resource	Losses	Water balance
Upper	609	630	0	21
Middle	187	185	(19)	(21)
Lower	220	248	(5)	23
Total	1016	1063	(24)	23

Source: (Mallory 2011)

Such projection trends emphasise the need for better water management. The country has therefore intensified efforts to come up with and implement more efficient water management practices to meet growing demand from competing users and uses. The country's National Water Act (NWA), one of the most comprehensive ones in the world, recognises water as both a human right and an economic good. It stipulates IWRM-principles, implementation of which is expected to meet the Water Act goals of efficiency, equity, social development and sustainability. The NWA stipulates water policies such as: water tariffs, compulsory licensing, water trade, establishment of water user associations (WUAs) and effluent discharge permits that improve water quality standards. In South Africa water tariffs (pricing) are subsidised and fixed at low levels. Therefore pricing does not reflect cost of water supply and scarcity in water resources. To reduce costs associated with water supply, municipal infrastructure grants as well as various other temporary conditional capital grants[2] are provided by the state. Compulsory licensing is a policy which aims at promoting re-allocation of water

1 Water requirements are summed up over all user sectors (urban, rural, industrial, mining, irrigation and power generation) while the water resource is the yield from major dams and diffuse resources such as farm dams, run off river abstraction and ground water.

2 The Consolidated Municipal Infrastructure Programme.

resources in water stressed[3] catchments. Beyond areas already under water stress, compulsory licensing is also applied to areas where water stress is expected and water quality is damaged by pollution. The water market is a mechanism used in promoting a voluntary transfer of water-use rights for financial compensation (Saleth and Dinar 2008; Easter et al. 1998; Howitt 1998; Hassan and Thiam 2015; Rosegrant and Binswanger 1994). In the agricultural sector, water markets assume that farms holding licenses that are not used after a completion of irrigation schedules (surplus license holders) sell such licenses to the ones that still need additional water (deficit license holders) to complement their irrigation schedules (Thiam et al. 2015). Water user associations (WUAs) are new forms of institutional arrangements set up by the former Department of Water Affairs of the Republic of South Africa to enhance decentralisation and involvement of local stakeholders into the water management process. Finally, effluent discharge permits are a policy undertaken to reduce water pollution, mainly generated by mining industries and large-scale commercial farmers.

However, implementation of the above envisaged policies continues to face challenges such as the lack of relevant supporting institutional frameworks. Consequently, water allocation challenges such as poor water quality, poor services in water supply, water restrictions in dry periods, administrative delays, water distribution and storage difficulties still prevail. Therefore, research that guides the water policy reform in South Africa is imperative. The current BMBF funded project contributes towards this by informing policy in the water sector and equipping decision makers with evidence-based research by examining the effects, impacts and transaction costs of selected water policies in South Africa. Additionally this project evaluates the extent to which water policy reforms might improve water use efficiency and water quality deterioration.

2.4.2 Transaction costs in water policy reforms

Implementation of water policy reforms requires a good understanding of the transaction costs that surround and influence water users' behaviours. Transaction costs have been widely identified as the biggest hindrances to policy implementation and compliance as they constitute a large component of total policy costs (Coggan, Whitten & Bennett 2010). For instance, studies carried out in the US show that transaction costs represent a substantial part of total costs incurred in designing a policy objective, with a magnitude ranging from 8 % of the water purchase cost to 38 % of the agricultural assistance programme (Howitt 1994; McCann et al. 2005). In Latin America, a study carried out in Chile shows that transaction costs associated with water trade represent between 7 % and 23 % of the total price (Hearn and Eater 1995). Therefore policymakers should take into account the nature and level of transaction costs in designing policy recommendations, since this influences the extent to which water users (farmers, mines and households) react with regard to the designed policy. Most of the studies on transaction cost analysis have evaluated the role transaction costs play in influencing allocation of resources, without saying much about the extent to which they affect policy implementation outcomes. For instance, Coase (1960) and Williamson

3 It is important to highlight that water scarcity (stress) is different from vulnerability in water access. Different indicators (indexes) are provided for a determination of water scarcity (i.e.: Falkenmark indicator, Basic Human Water Requirement, Social Water Stress index etc.). Brown (2011) provides the panorama of indicators measuring both water stress and water access vulnerability.

(1979) have eloquently elaborated the importance of transaction costs to shape competition between agents and therefore protect investors against risks and uncertainty that arise from market allocation. Very few studies have investigated the impacts of transaction costs on the success or failures of public policy implementation and compliance. This limitation is mainly due to the difficulty to measure and monitor transaction costs, especially in countries where the existing institutional arrangements difficultly secure property rights allocated to stakeholders.

This section shows the extent to which transaction costs influence successes (failures) of water policy reforms in South Africa. Based on survey data collected in the Olifants river basin, we identify the main transaction costs associated with water policy reforms. Transaction costs are differentiated between water users and managers in order to take into account of heterogeneity in farm sizes and locations and features of policymakers. Water users, in this study, are represented by farmers, since they consume more than 80 % of the total available water in the Olifants river basin. Managers refer to policymakers from the Department of Water and Sanitation (DWS) who are in charge of designing and enforcing implementation of water policy reforms in the country. The data collected from the field allow us to evaluate the extent to which farm and management features influence evolution of transaction costs. The typologies of transaction costs considered for this study are support and administration, monitoring, contracting and enforcement costs.

The study follows a typology and chronology provided in McCann and Easter (2004) and McCann et al. (2005) to measure the associated transaction costs of selected water policies. Measurement is carried out under three different policy phases: early implementation, full implementation and established programme. Early implementation refers to a situation in which water policy rules are designed and adopted by public services, public agents are hired for administration and notices and hearings are conducted. During "early implementation" the policy is at the beginning of its life cycle and the largest part of associated transaction costs is represented in administrative and support costs. "Full implementation" refers to a situation where policies come into full effect, meaning that the policy is now completely implemented and water users have changed their behaviours to adopt and comply with the terms of the policy. Finally, "establishment programme" corresponds to situations where the policy has reached the end of its life cycle and therefore it is entirely integrated as a full part of the water decision making investment.

Figure 2.4-1 shows the interplay of transaction costs along the entire process of the policy life cycle; from policy design to implementation and compliance. Water policy reforms in South Africa follow different steps ranging from policy design to enforcement, contracting, monitoring, implementation and compliance. The degree to which farmers adopt and comply with the policy not only depends on the characteristics (flexibility, transferability) of the policy itself but also on the socio-economic and technological features of the farming systems. For instance, farmers with lower education or income are less likely to identify the transaction costs surrounding their farming activities. At the same time poor farmers usually face more constraints in accessing the market, because of high transaction costs and weak infrastructures, as outlined in the national agricultural programme of the country. Therefore, beyond their effects on policy outcomes, transaction costs also affect farms' characteristics. This, in turn, affects the compliance of farmers and their associated social welfare. Moreover, it is important to highlight that alternative regulatory actions taken in different sectors (agriculture, health, etc.) may influence the water sector, which influence water-related transaction costs. For instance, previous studies have shown that previous regulations introduced in the South African agriculture through prices (subsidies and taxes) and non-price (quotas) measures have affected the transaction costs faced by small-scale farmers (Thiam, Hassan & Zilberman, forthcoming).

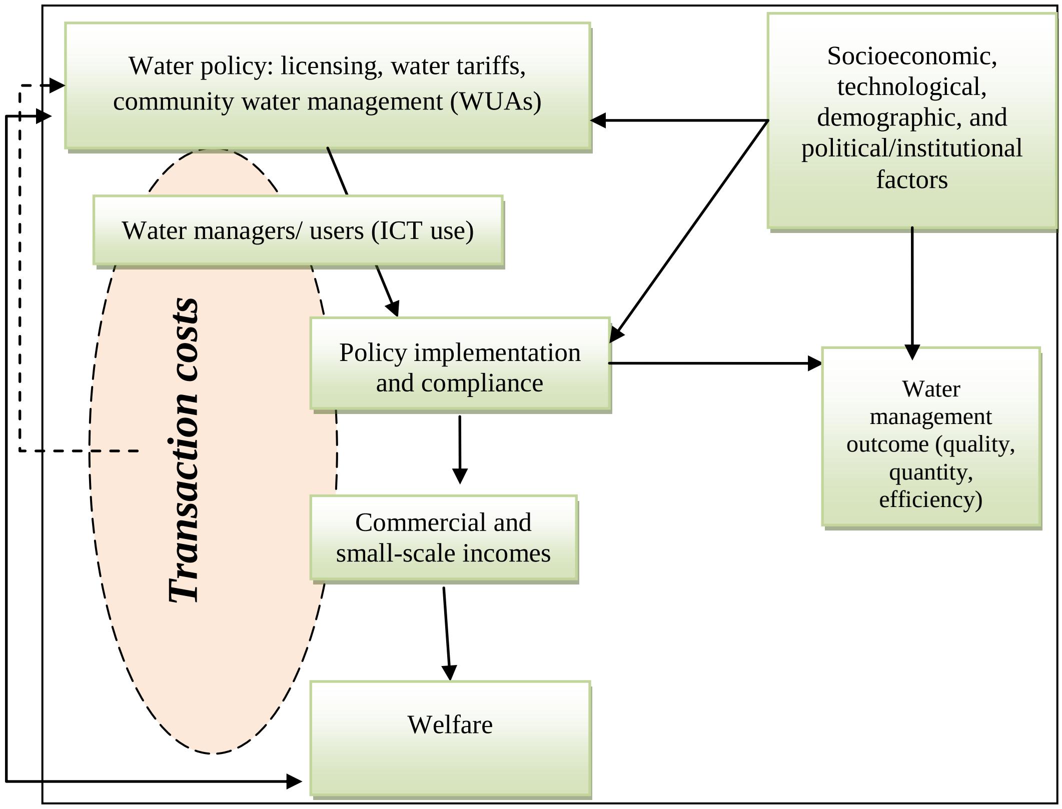

Figure 2.4-1: Conceptualisation of transaction costs
(Compiled by the authors)

Figure 2.4-2 indicates the percentages of contracting costs between the four policies (water tariffs, compulsory licensing, effluent permits and WUAs) as incurred by irrigation farmers. Water tariffs are reported as having the highest of all transaction costs at 47 %, probably because this is one of the most widely adopted policies across the Olifants river basin. Transaction costs incurred for the effluent discharge payment policy are second highest at 25 %. Compulsory licensing transaction costs are third in magnitude at 19 %. This could be because this policy is not so widespread in terms of user compliance and the fact that its payment is made once per annum. Compulsory licensing also continues to be a new idea for many water users. Formation of water use groups, herein referred to as WUAs, is last at 9 % of the reported transaction costs. We attribute this to the already established WUAs which have been in operation for many years starting as far back as the 1930s, especially for commercial farmers. This implies that their systems are already in place and not much of operational transaction costs are incurred. Similar suggestions are reported in Falconer et al. (2001). As for the small scale water users, they are organised into small informal groups and report minor transaction costs as well. As water tariffs have the highest reported transaction costs, we highlight the specific transaction cost elements (travel, telephone, additional information costs, finance and decision costs) and their magnitudes in Figure 2.4-3. We find that all of these elements are high during the early implementation phase of the water tariffs and decline over time. However, costs incurred to arrange for finance remain constant over the three time periods, most likely because water payment remains constant throughout.

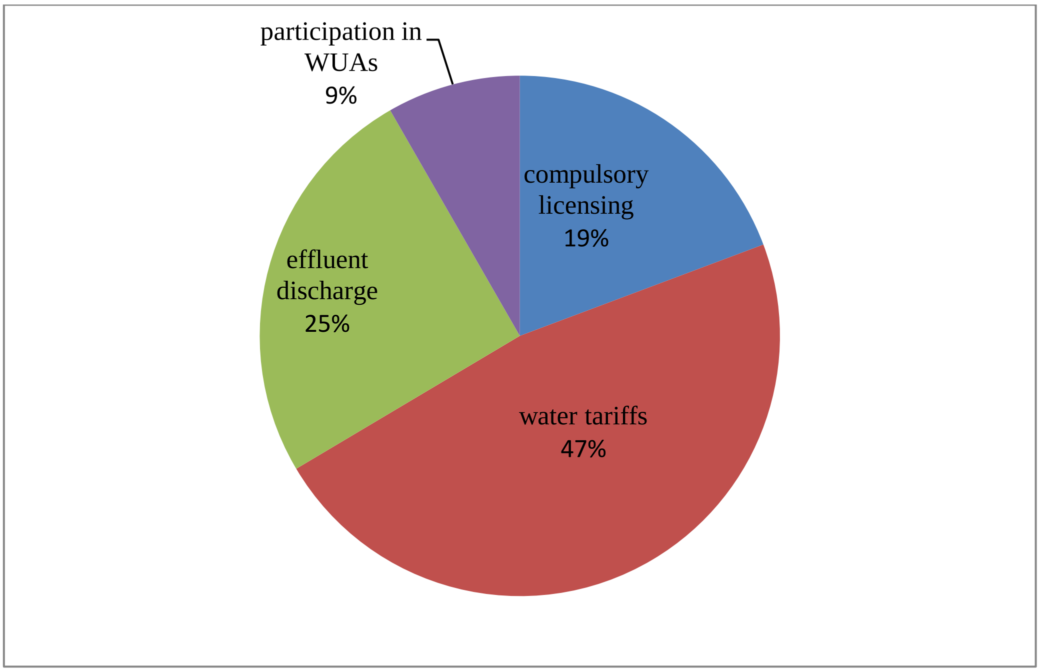

Figure 2.4-2: Contracting costs across four policies
Source: Authors' compilation

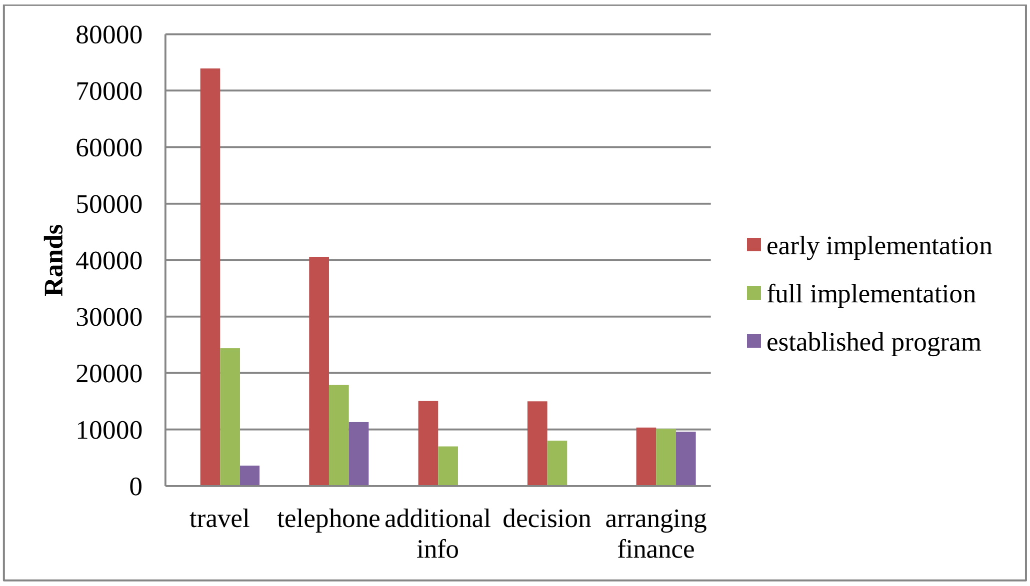

Figure 2.4-3: Water Tariff contracting cost components over time
Source: Authors' compilation

2.4.3 Water policy reforms and water use efficiency

This section examines the extent to which water policy reforms combined with farm and country characteristics influence water use efficiency (WUE) of irrigation farmers in the Olifants basin. Two main approaches are used in literature used for measuring technical efficiency. These are the parametric approach also known as the stochastic frontier analysis and the non-parametric approach also referred to as DEA (Speelman et al. 2008; Frija et al. 2009;Wang 2010). The parametric approach estimates a parametric production function (or its dual cost or profit function), representing the best available technology. It provides a convenient framework for hypothesis testing and the construction of confidence intervals. The non-parametric DEA on the other hand uses linear programming methods to construct a linear envelopment frontier over the data points. The DEA is considered to have several advantages over the parametric approach because firstly, it does not need to assume a functional form such as a translog production function for the frontier technology (Speelman et al. 2008). Secondly, the constructed surface over the data allows comparing one production method with the others by applying a performance index.

This study examines the effect of the different water policy reforms (WUAs, compulsory licensing and water pricing) on irrigation water use in the Olifants basin.

Tobit regression methods are used for the analysis. The Tobit model represents an alternative to OLS for situations in which the dependent variable is bounded from below or above (or both) either by being censored, or by corner solutions (Frija et al. 2009). It was suitable for this case, because the efficiency parameters vary between zero and one, thus termed as being censored. The theoretical Tobit model takes the form:

$$y_i^* = x_i'\beta + \varepsilon_i, \quad i = 1,2,\ldots\ldots,N, \tag{1}$$

$$y_i = y_i^* \quad if\ y_i^* > 0$$

$$y_i = 0 \quad if\ y_i^* \leq 0,$$

Where, y_i^* is the latent variable for the i^{th} farm, x is the vector of independent variables hypothesised to affect efficiency. ($\beta = \beta_0, \beta_1 \ldots \beta_n$) are the unknown parameter vectors related with the independent variables for the i^{th} farm. ε_i is the error term, assumed to be normally distributed and independent of x_i $(0,\sigma^2)$ with zero mean and constant variance.

$$y_i^* = \beta_0 + \sum_{n=1}^{n} \beta_n x_i + \varepsilon_i \tag{2}$$

Where,

$0 < y_i^* < 1,$

0 if y_i^* <0 and 1 if $y_i^* > 1$

y_i^* is the DEA sub-vector efficiency index for water used as a dependent variable. x_i is a vector of independent variables related to attributes of the farmers.

Results indicate that among the three policy variables of interest, water pricing techniques and involvement in WUAs were significant in explaining irrigation water use. Farmers involved in WUAs are more likely to use less water for irrigation compared to non-WUA-members. This finding was in line with previous studies, which argue that collective management of natural resources leads to better management outcomes (White & Runge 1995; Balooni et al. 2008; Gorton et al. 2009; van Ast & Boot 2003**;** Bekkari 2008). This is an important finding for the South African water reform process, because the law on formation of WUAs is already under review even before its full implementation and effects are realised.

The results further show that farmers, who use more water, have a higher willingness to pay for an additional price charge. Such farmers have an inelastic water demand function due to the high impacts of water use on irrigation activities. This is contrary to the expectation that an increase in water price leads farmers to reduce their irrigation water consumption as suggested by Speelman et al. (2008). Following Frija et al. (2011) and Speelman et al. (2009), we attribute this to very low water tariffs that do not comprise a significant percentage of farmer production costs. Water prices affect consumption behaviours starting at certain thresholds. When prices are already too low, the opportunity costs of water consumption remains low, therefore farmers do not find incentives to change their water consumption. Our results further validate the focus group discussions held with large-scale farmers who claimed that the current water tariffs were negligible and failed to count as part of farm production costs.

2.4.4 Water policy reforms and water quality

This section evaluates the extent to which water policy reforms introduced in the country have contributed to improving water quality. Water quality is defined as the chemical, physical, biological, radiological and aesthetic characteristics of water (UNESCO/WHO/UNEP 1996).

Accordingly, the Department of Water Affairs and forestry (DWAF) of South Africa has categorised the fitness-for-use of water for various uses using six parameters, which give the discrete values that describe a specific effect due to a given set of conditions. These are:

1) Electrical conductivity (EC): This indicates salinisation of water resources and serves as a proxy for total dissolved solids (dissolved inorganic salts). Salinisation affects domestic and irrigation water use. Aquatic life is only affected in extreme high levels
2) Orthophosphate (PO_4-P): Phosphate indicates the nutrient levels in water resources (eutrophication). Phosphate has no direct effect on water use but indicates contamination from activities in a catchment such as fertiliser use and wastewater discharge.
3) Sulphate (SO_4 2): Sulphate is a naturally occurring substance found in mineral salts in the soil, decaying plant and animal matter. It is generally not toxic but affects human consumption at very high levels.
4) Chloride (Cl): It shows the nature of salinity i.e. salty taste and corrosiveness. Mainly affects aquatic life and irrigation
5) Ammonia (NH_3-N): indicates presence of ammonia, which is highly toxic to aquatic life even in low concentrations. It has no effect on human life and irrigation in the state it occurs in rivers and dams
6) pH (pH value): This is a measure of the acid-base equilibrium of various dissolved compounds and indicates the acidity/alkalinity of water. Water pH only affects water use at the extreme levels.

We use the Multinomial Logit Model (MNL) for this section because it allows estimating choice probabilities for many categories. The dependent variable (water quality) is a multivariate variable with four possible categories (Ideal, acceptable, tolerable and unacceptable). Ideal – the water has no polluting effects on the user, acceptable – slight to moderate pollution problems exist, tolerable-moderate to severe problems encountered and unacceptable – highly unusable water due to its highly polluted nature. The multinomial logit model assumes all errors of the alternatives to be independent (independence of irrelevant alternatives-IIA). This ensures the parameter estimates of the MNL model remain unbiased and consistent .i.e. P_j/P_k is independent of the remaining probabilities. Equation (3) represents the estimated functional form.

$$P\left(y = {}^{j}/_{x}\right) = \exp\,(x\beta_j)\;/\;[1 + \sum_{h=1}^{j} \exp(x\beta_h), \qquad j = 1,2,\dots,J] \tag{3}$$

Where y denotes a random variable taking on the values {1, 2, …, J} for a positive integer J; and x denote a set of conditioning variables. x is a 1xK vector with first element unity and β_j is a K×1 vector with j = 1,2, …, J. In this study, y denotes water quality (category) status while x signifies hypothesised factors influencing farm water quality. Equation (3) shows the effect of changes in an element of x (holding other factors constant), on the response probabilities $P(y = j/x)$, j = 1, 2, …, J.

The results show the factors that explain:

- Ideal water quality

  For the ideal water quality category, the number of farming years and farming of cereals distinctly explain water quality. More farming years negatively affected good water quality while growing of cereal crops also negatively related to good water quality.

- Tolerable water quality

  Farmer location, occupation, cereal and perennial crop farming significantly influence tolerable water quality. Results indicate that irrigators from the middle and lower Olifants are less likely to use water of tolerable quality compared to their upper Olifants counterparts.

- Bad water quality

  The results indicate that farmers compliant to compulsory licensing, those involved in WUAs/informal water use groups and the leaders in these groups were less likely to use very bad quality water.

2.4.5 Conclusion and policy implications

This study identified and quantified the ex post transaction costs related to the water policy process in the Olifants basin of South Africa. The study focussed on irrigation water users' and public agents' transaction costs. The results indicated that considerable transaction costs were incurred by the two groups of stakeholders. Transaction costs formed between 13 to 29 % of the total water policy budget. The public agents' transaction costs remained higher than that of water users. This could be explained by the high support and administration costs which varied only slightly over the three time phases of policy implementation. Transaction costs were high for the widely implemented policies but they fairly decreased over the course of policy implementation. The transaction costs incurred by irrigation water users mainly consisted of travel, telephone, additional information costs, finance and decision costs. Very high start-up transaction costs were associated with the implementation of water trade; a policy that is currently not in operation in the Olifants. High start-up transaction costs were also associated with the effluent discharge system; a policy which is also yet to kick off. We conclude that different levels of transaction costs for the different water policies existed and could be contributing factors to inefficient policy implementation and compliance. We argue that knowledge of the relevant and existing transaction costs prior to policy implementation ensures optimality in the choices made. Moreover, it helps to make comparisons between policy alternatives and nurture effective design and implementation ex ante. It further permits evaluation of existing policies ex post for improvement purposes and assessment of their budgetary impact to establish their sustainability and efficiency.

Secondly, the study used regression methods to examine the effects of water policies and other socio economic factors, on water quality and water use efficiency in irrigation farming in the Olifants basin. Water use efficiency was assessed using DEA methods and the results indicated that irrigation farmers in the Olifants were water use inefficient; the average water use efficiency was only 31 % suggesting major room for improvement and water re allocation. Various demographic, socio economic and institutional factors influenced water use efficiency and quality. The Tobit results showed that compulsory licensing, schooling years, technical assistance and crop choice influenced water use efficiency. The MNL results on the other hand indicated that compulsory licensing, involvement in WUA and water costs among other factors negatively influenced the use of bad quality water. Use of ideal water quality was explained by farming experience and cereal farming while tolerable water quality was significantly explained by farmer location, main occupation and crop choice. We conclude that the array of factors influencing the various aspects of irrigation water use should guide policy towards better water management; this is especially so for the examined water policy reform factors of compulsory licensing, WUAs and water pricing. For example, the highly significant positive effect of compulsory licensing on water use efficiency highlights the importance of water rights and lays emphasis on water reforms. The water rights ensure that farmers have entitlement to the water they use and promote water use efficiency. Current water prices on the other hand do not seem to encourage water saving as farmers comfortably pay the corresponding costs for higher quantities of water used. We recommend a review of the current tariffs and strict implementation of the same. Other factors, such as technical assistance, point to the needed improvement in extension service and alternatives of information dissemination. Schooling points to the importance of capacity building though it is a difficult target for policy in the short run. In the short term, farmers can best learn from the practices of their efficient counterparts, possibly through extension tools such as farmer field days.

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