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Irrigation water value for potato farmers in the Mooi River Irrigation Scheme of KwaZulu-Natal, South Africa: A residual value approach

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ABSTRACT

Explaining variation of smallholder irrigation water values is a critical element in water allocation and management. However, it has been hampered by data deficiencies at smallholder level. Both primary and secondary data were used to estimate the value of irrigation water for smallholder farmers in the KwaZulu-Natal Province of South Africa. The paper applied the residual value method to estimate water values among smallholder farmers, focusing on the potato crop. The results indicated that, on average, farmers in the Mooi River Irrigation Scheme applied less water (61.4%) to their potato crop when compared to the irrigation crop water requirements, ranging between 14% and 174%. Crops with relatively low gross margins like maize and dry beans yielded lower water values of US\$0.12/m^3 and US \$0.10/m^3 respectively, while tomatoes yielded US \$1.07/m^3. The average water value for potatoes was US\$0.01/m^3, ranging from −US\$1.67/m^3 to US\$1.13/m^3. Location of the irrigated plot along the main canal significantly influenced variability in water value, which accounted for 12.5% of variation. The number of irrigation cycles and education level of the farmer explained 5.8% and 5.9% of variation in water values, respectively. The paper illustrates that where water is provided free of charge to a large group of users, unequal distribution, poor management and inefficient use of water are common. Negative water values also revealed under-performance of smallholder farmers. A paradigm shift toward cost recovery mechanisms to encourage effective irrigation water management and water-use efficiency might need to be considered for smallholder farmers. This can also be coupled by strengthening policies and approaches that encourage user participation in water management.

1. Introduction

Water scarcity for both consumptive and non-consumptive activities is a great threat for economic development in most developing countries (Namara et al., 2010). Consumptive activities occur in agriculture, industry and domestic use, while non-consumptive uses include fishing and tourism. At rural household level, consumptive use of water is the most essential, due to the direct contribution of water to livelihood activities like farming. The challenge in most African countries is water access due to physical scarcity of the resource (Namara et al., 2010). As such, South Africa adopted two strategies to address water scarcity, namely; improving the supply side through dam construction, or by managing the demand side through more efficient use of water (Gillitt et al., 2005). The major concern is the fact that where water is available, lower water productivity is a challenge, and potential gains per drop of water used are not met (Namara et al., 2010).

Smallholder farmers in the Mooi River Irrigation Scheme (MRIS) in the KwaZulu-Natal province of South Africa are confronted with an increasing shortage of irrigation water, which manifests in the form of poor access at scheme level and unequal distribution at individual plot level. The recurrent challenges of accessing irrigation water at farm level among the MRIS farmers has led to high crop failures and increasing underutilization of irrigable land. Irrigation failures at smallholder level expose households to food insecurity (Sinyolo et al., 2014). Where farmers have access to water, volumetric measurement, which would allow efficient management of the resource, is not taking place. Water application to crops is based on traditional irrigation scheduling using techniques like visual assessment of the soil and the “feel” method, and water is applied when the soil is presumed dry. The traditional methods are not very accurate and have been noted to lead to either over-application or under-application of water to the crops, if farmers are not well acquainted with the methods (Svendsen et al., 2009). Furthermore, the non-existence of water markets at smallholder level in South Africa makes it difficult to attach financial and/or economic val-

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ues to irrigation water. This is worsened by poor record-keeping at farm level. Where records exist, they are often very imprecise and incomplete; for example, in some cases farmers can remember the cost of an input per unit but not exactly the quantity applied to the crop in question. That is why weekly input–output data rather than recall data were preferred, which is a unique attribute of this paper.

Agricultural productivity is indicated by value of production of different types of agricultural activities from a given set of inputs including water (Svendsen et al., 2009; Turral et al., 2010). By examining individual factors of production over time, it is possible to measure their overall impact on agricultural output. Although numerous studies examine demand and value of water for domestic and industrial use, research on smallholder agricultural water value in developing countries is hampered by lack of reliable data on water consumption and pricing at farm level (Wang and Lall, 2006). Some studies have, however, attempted to measure the value of irrigation water for various crops in South Africa and different values of water have been obtained (Young, 2005; Lange and Hassan, 2006; Speelman et al., 2008, 2011; Yokwe, 2009). All the studies concur that data deficiencies at smallholder farm level greatly affect the valuation process; hence, the need for continued and improved research on water valuation that can inform irrigation water management practices.

The study draws its theory from neoclassical economics and seeks to estimate irrigation water values and then to identify deficiencies in irrigation water use and management at smallholder level. The study applied the Residual Value Method (RVM) and sought to (1) use secondary data to explain the variation in water values for different crops produced by smallholder farmers in MRIS (2) apply seasonal data, collected weekly over the entire potato crop cycle from crop establishment to harvesting of the crop, to explain the variation in water values at scheme level and (3) explain the factors affecting the variability in water values at scheme level. The study managed to describe water values by using both secondary and primary data, with the latter currently inadequately addressed in the literature (see Speelman et al., 2011). The study analysed how different factors (age as a proxy for farming experience, area planted, location of the farmer's plot within the scheme, frequency of irrigation and number of crops grown) influence variability of water values at smallholder level. It is argued here that the possible over-estimation of water does not affect the distribution of the response variable (water values) as the problem applies to all sampled plots.

An understanding of the variability of water values is an important decision making instrument in scheme rehabilitation exercises as well as for ensuring effective irrigation management in South Africa and other developing countries. Furthermore, an understanding of variations in water values help in: investment decisions in water resources and for cost-benefit analysis of water-based projects, policy decisions on water allocation and re-allocation among users, assessing the socio-economic impacts of water management decisions, designing water pricing policies, and comparing performance of irrigation schemes (Hussain et al., 2007).

The layout of the paper is as follows: the introduction is followed by Section 2, wherein the conceptual framework, analytical tools and the study site are discussed. The results and discussions on water value and the factors influencing variation are presented in Section 3, followed by the conclusions and policy implications of the study in Section 4.

2. Methodology

2.1. Conceptual framework

Valuation of irrigation water can be explained from the neoclassical theory of the firm. Although the behavior of the firm may be characterized in a number of ways, this study focuses on profit maximization. A profit-maximizing firm, operating in a competitive environment, uses an input to the point where marginal revenue gained from an additional unit of a specific input equals the marginal cost of obtaining the input (Gardner and Young, 1983 Young, 2005). By adapting the product exhaustion theorem for residual valuation, economic value of a single unpriced good such as water entails isolating that portion contributed by water to the total value of the product from the contribution of all other inputs that go into the production process (Young, 2005). The theorem postulates that under competitive equilibrium, the total value of the product can be divided into shares, so that each resource is paid according to its value of marginal product and the total value of the product will be exactly exhausted by the distributive shares (Scheierling et al., 2004). In the case of smallholder farmers in South Africa, some markets are either absent or dysfunctional, while others operate at expected levels, hence a need for a case-by-case analysis.

Several water valuation techniques are available depending on the specific use of the water and the purpose for the information. Al-Karablieh et al. (2012) noted three groups of water valuation methods, namely (1) methods that infer water value from information based on water-related markets and benefits where value is derived from rentals and sales of water rights; (2) methods relying on the use of derived demand for water as an intermediate good, where water is assessed from the producers' point of view; and (3) methods that estimate water values from direct consumer demand as in the case of agricultural and industrial use.

Some of the methods that are widely applied in water valuation where water markets are non-existent or dysfunctional include the production function method, RVM, change in net income approach (CNI), conjoint analysis, cost-based approaches, optimization methods using mathematical programming, and the value-added method derived from computational general equilibrium (CGE) models (Young, 2005). The economic valuation of water can also adopt environmental approaches like hedonic pricing and the contingent valuation method (CVM). Some authors also use choice experiments methodology to value irrigation water (Morrison et al., 1999; Barton and Bergland, 2010; Alcon et al., 2014). Each technique has its challenges, with optimization techniques being criticized for over-estimating water values (Young, 2005; Al-Karablieh et al., 2012), while CGE specification requires aggregation which may not be sufficient for local conditions (Al-Karablieh et al., 2012).

The major challenge in deriving economic values of agricultural water in the absence of markets is separating the returns of water from those that should be allocated to other inputs like labor, agrochemicals and land (Hussain et al., 2009). Although the most scientifically accepted methods of water valuation are those based on market behaviour (Hussain et al., 2007; Speelman et al., 2008, 2011), these are not well suited to smallholder farmers in the study area because of non-existence of water markets, where water is provided freely by the government.

Although the RVM can derive meaningful results, Scheierling et al. (2004) and Young (2005) highlighted the possibility of over- or under-estimation of the value of water. Over-estimation occurs when returns that should be allocated to other inputs are allocated to water (Young, 2005). This could also happen when any input (variable or fixed) is left out due to data constraints. Similarly, misallocations of returns from water to non-water inputs result in under-estimation of the value of water (Haab and Mcconnell, 2002; Lange and Hassan, 2006). The RVM is sensitive to variable omissions and use of inaccurate prices (Speelman et al., 2008; Al- Karablieh et al., 2012). The other challenges of RVM can emanate from the specification of the production function, assigning prices to inputs and outputs, measuring and pricing inputs and output and the case of measuring labor and human effort (Hussain et al., 2009).