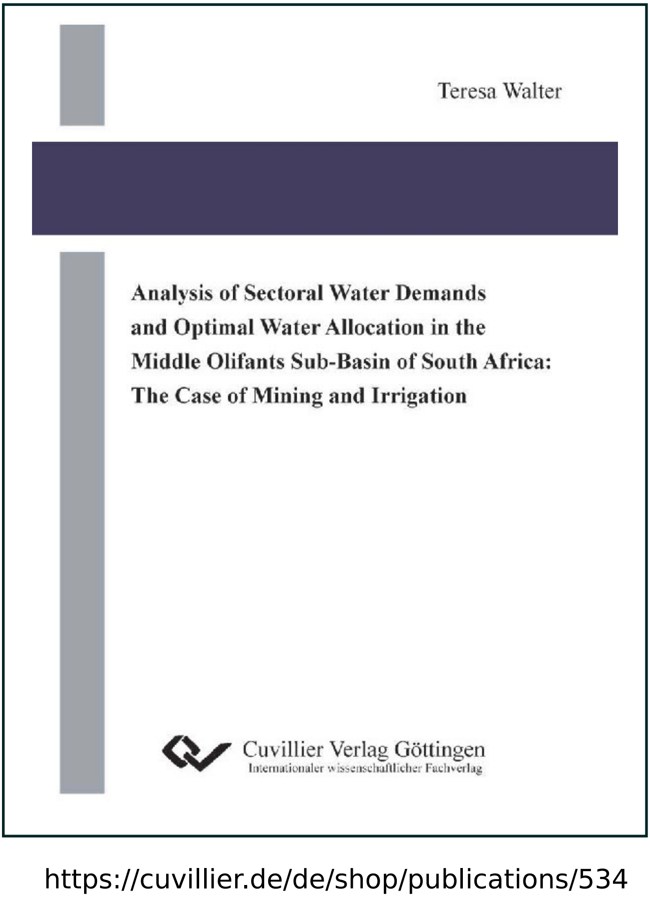
Teresa Walter (Autor)

Analysis of Sectoral Water Demands and Optimal Water Allocation in the Middle Olifants Sub-Basin of South Africa: The Case of Mining and Irrigation



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2. Economic Aspects of Water Resources

Until now economic aspects of water resources have often been neglected in water allocation decisions. Chapter 2.1 discusses the general theory of water allocation whereas chapter 2.2 focuses on underlying valuation concepts. Chapter 2.3 then describes how calculated water values can be used to determine optimal water allocation between different users and chapter 2.4 explains mechanisms to meet an optimal water allocation situation.

2.1. Theory of Water Allocation

In water scarce countries water demand often exceeds the amount of water available in a system in a given year, resulting in an over-appropriation of water rights. This leads to the necessity of governmental intervention in the allocation process if water should be used in a sustainable manner (Platt 2001). Thereby economic theory provides a framework for achieving optimal allocations of water between competing users.

Theoretically in a free competitive market economy, supply, demand and pricing of water resources is self-regulating. This results in the maximisation of economic benefits from the use of water without the necessity for overall planning and management (Spulber and Sabbaghi 1994). The process of exchange establishes a price, which represents the marginal economic value. An economically efficient allocation of water occurs when the marginal value of water is equalised across all uses and respective allocation maximizes social benefits from water use. However, water is rarely supplied by competitive markets and the price of it, if any is charged, usually does not reflect its economic value (Lange and Hassan 2006). Reasons for non-existing and imperfect markets can be found in the nature of water, resulting in inefficient water use. These characteristics include high mobility, stochasticity with regard to timing, location and quality, multiple different and sequential uses as well as conflicting cultural and social values (Saliba and Bush 1987). Additionally, water itself is a public good and is therefore affected by certain public good problems. These include non-excludability[4] and non rivalness[5], which are contributing to mar-

[4] Non-excludability implies that individuals cannot be prevented from using the public good and may benefit from use without compensation, resulting in the free riding problem (Platt 2001).

ket failure (Platt 2001). All these characteristics specific to water, lead to external effects on market resources, imperfect competition, risk and uncertainty as well as imperfect information causing deviations from competitive markets. Hence, politicians and researchers must find ways, how to counteract these deviations to ensure a sustainable and efficient water use. Consequently, economists have focused on allocation issues of water resources between its many competing uses, all of which depend on water for their existence (Groom et al. 2003). Firstly water is a necessity for human existence and basic human needs should be fulfilled. Secondly it is an important input to economic activities and can be seen as both a production and consumption good. And finally water is a public good contributing to recreation and general environmental values as an input to ecosystems and habitats. Consequently balancing these uses must be accomplished in the allocation process and according mechanisms must be established.

Figure 2-1 represents a methodology proposed, in order to evaluate the optimal water allocation within a watershed area, consisting of two important stages. In stage 1 economic valuation techniques (see chapter 2.2) are used to establish the economic value of competing water demands, whereas in stage 2 the optimal water allocation between different users can be determined, taking into account policy implications and their respective impacts.

[5] Non-rival goods may be consumed by one consumer without preventing simultaneous consumption by others.

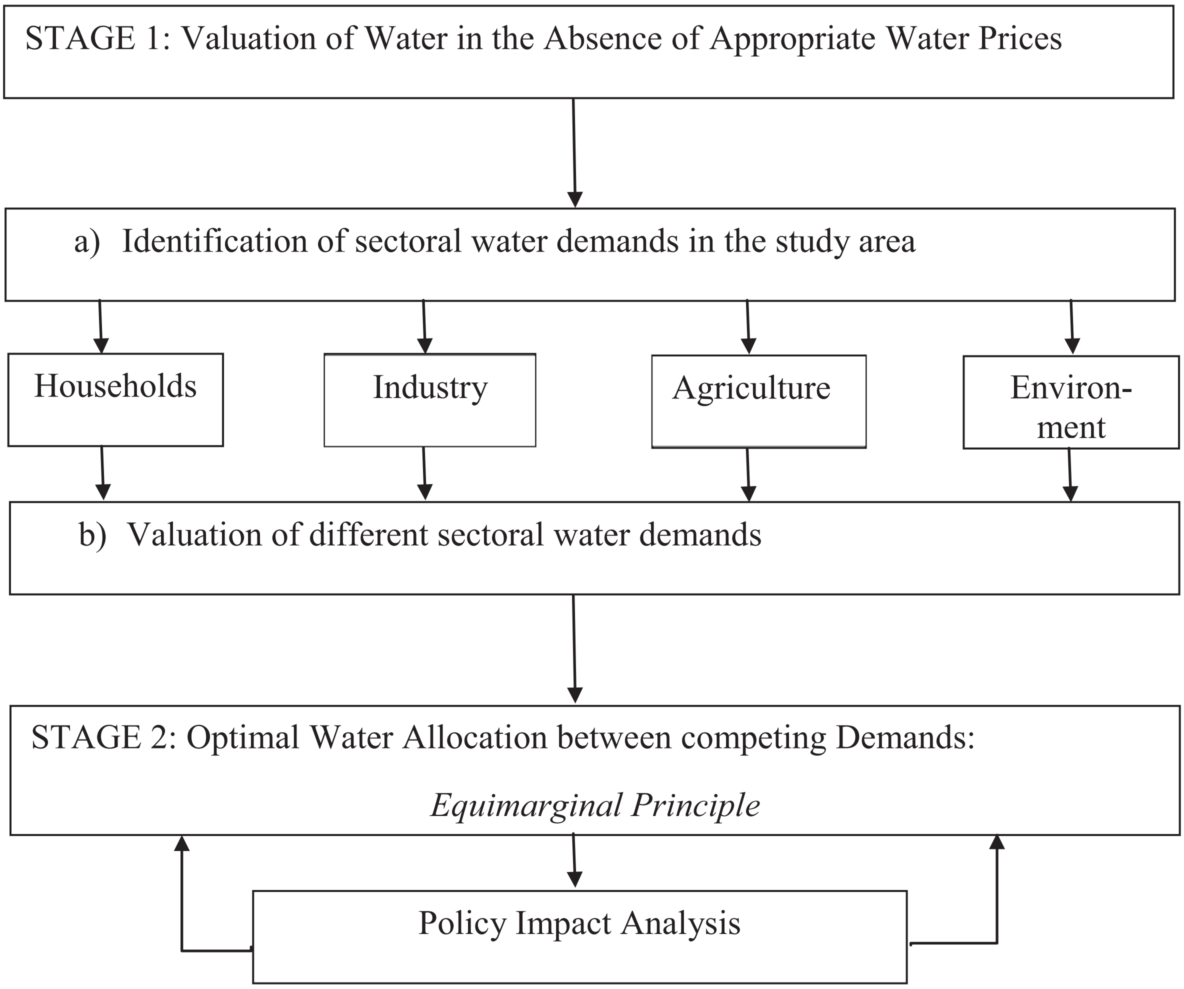

Figure 2-1: Water Allocation Methodology

Source: Groom et al. (2003), modified

After the identification of water demand functions of various users (stage 1), the different demand functions are balanced, based on the economic value in different sectors. The overall objective is to maximize public social welfare under consideration of efficiency, equity and sustainability (Groom et al. 2003). The detailed process of balancing different demand functions will be explained in chapter 2.3 following Grafton et al. (2004).

2.2. The Value of Water Resources

“The economic value of water is defined as the amount that a rational user of a publicly or privately supplied water resource is willing to pay for it” (Ward and Michelsen 2002, 428). The users´ willingness to pay is the maximum amount the users would be willing to pay for that good, which shown by their demand curve, also called marginal benefit or willingness to pay curve. Estimates of the economic value of water in alternative uses are essential for policy decisions concerning water resource development, water use and water allocation, when water supply is scarce relative to its demand. Usually in a functioning market system, economic values of water are defined by its prices and serve as a guidance to allocate water among alternative uses, to maximize total economic benefits (Ward and Michelsen 2002). However, due to imperfect water markets (see chapter 2.1) there are often no prices which can be taken for the identification of water values, and accordingly water allocation decisions are difficult. Hence other methods have to be applied to identify the value of water.

Three different economic concepts of resource values, which are clarified in **Figure 2-2**, can be distinguished; the total, marginal and average value (Lange and Hassan 2006; Ward and Michelsen 2002). The total value is measured by the total willingness to pay for a given level of water used. The marginal value of water on the other hand is relevant for assessing the economic efficiency of the allocation of water among alternative uses (Chowdhury 2005). The average value is equal to the total value divided by the quantity of water supplied.

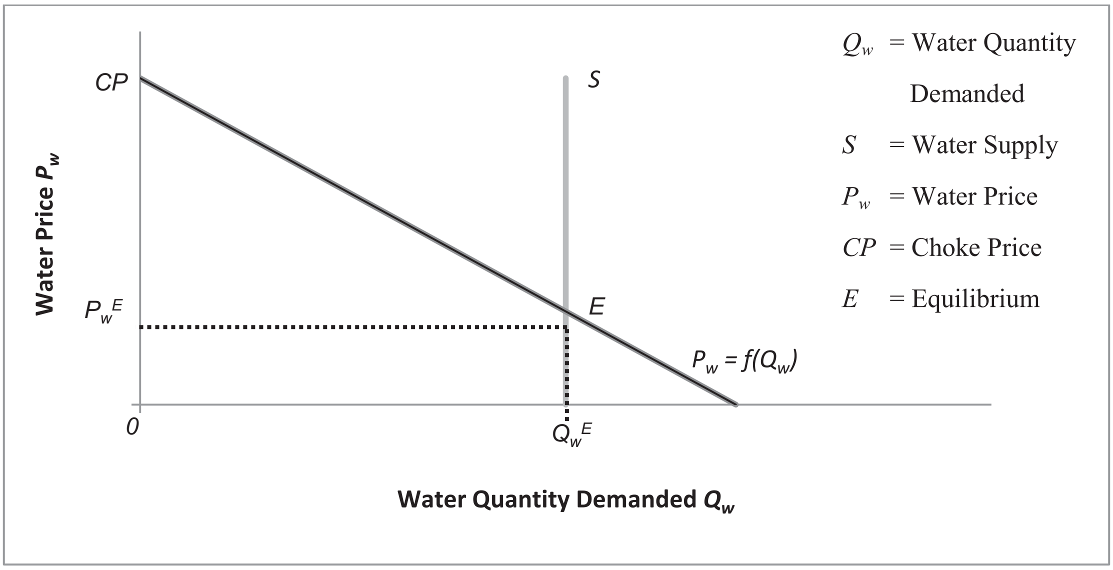

Figure 2-2: Benefit of Water Consumption

Source: own presentation

Assuming a water demand function of the form $Q_w = f(P_w)$ and its inverse[6] $P_w = f(Q_w)$, with Q_w being the quantity and P_w the price of water, each user will choose a quantity of water to withdraw to maximise his/her own benefit. Integration under this curve provides the total benefit associated with any consumption level. At in-elastic supply of water S [7] the total value of water is represented by the area $CP0Q_w^E E$. The average value can be derived by total value divided by water quantity demanded at equilibrium Q_w^E, while the marginal value is calculated as the area $P_w^E 0Q_w^E E$ divided by the water quantity Q_w^E. The result is equal to P_w^E. This is referred to as the marginal concept which is important for measuring the efficiency of the utilization of water, and determining its respective reallocation of use from one sector or area to another where it reaches its greatest efficiency (Nieuwoudt et al. 2004).

If the market is in equilibrium, the optimal price of water is captured by P_w^E at the optimal quantity of water withdrawn represented by Q_w^E. The linear demand curve imposes a “choke price” at CP at which water demanded equals zero. Some functional forms other than linear assume that there will be nonzero demands regardless of the height of the water price. Therefore, to depict reality, where it is not plausible to assume that there will always be a positive amount of water consumed for any arbitrarily large water price, there is likely to be a choke price at some level, which has to be chosen sensibly by the researcher (Griffin 2006).

2.2.1. Approaches for the Economic Valuation of Water Resources

There are several methods for measuring benefits of water uses in the absence of water markets. Revealed preference methods rely on actual expenditure choices for environmentally-related private goods made by consumers from which their preferences can be deduced via statistical analysis or mathematical approaches. Stated preference methods involve asking people directly about the values placed on proposed or hypothetical improvements or reductions in environmental services (Moran and Dann 2008; Young 2005).

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[6] Both forms embed identical information and highly useful information.

[7] Since water supply is fully inelastic in that case, there are no alternating costs of supply, which would have to be deducted from total benefits (TB) of water use. It should be noted that inelastic water supply might lead to an overestimation of TB. However, the lack of time and missing data availability led to the employment of an inelastic supply curve in this analysis. Nevertheless, since the focus of this study lies on the demand side inelastic water supply is a viable assumption.