Chapter

Incentives for Managing Water Demands: Lessons from the Umgeni River Basin, KwaZulu-Natal, South Africa

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Abstract

This paper examines the incentives for managing water demands from a catchment or basin perspective by focusing on defined property rights dimensions. Using property rights theory, the paper has investigated the existence of relationships between attributes of property rights and intentions of water users to conserve water. A case study was used to test whether property rights can be used as incentives in the management of water demands. The results from the analyses that were conducted using IBM SPSS indicated that property rights would be very significant in curtailing water demands in a catchment by acting as incentives in water resource utilisation, specifically by motivating water user users to conserve water. This is an important finding because it would thus help water resource managers to use a properly defined property rights system (better duration and secure tenure) to enable water users curtail the ever-increasing water demands in the river basins.

Keywords: property rights, water demand management, water licences, water conservation, water scarcity

1. Introduction

At a global level, water has been declared to be a social and an economic good by *fiat* by the definition of water in The United Nations Conference on Environment and Development Agenda 21 "*as an integral part of the ecosystem, a natural resource and a social and economic good…*" [1] (Chapter 18) and by the fourth Dublin Statement Principle "*Water has an economic value and should be recognized as an economic good, taking into account affordability and equity criteria*" [2] since 1992. As seen in [3] it also satisfies *de facto* the Robbins conditions of the definition of economy as "*the science which studies human behavior as a relationship between ends and scarce means which have alternative uses*" [4] since scarcity is accepted by OECD in [5] pp. 18,129 and finiteness by the first Dublin Statement Principle "*Water is a finite, vulnerable and essential resource which should be managed in an integrated manner*" [2].

Booker and his colleagues further assert this by stating that water is used in the production of virtually all economic goods and services; and above all, plays a vital role in the provision of basic ecosystem services for human beings and organisms [6]. The importance of water in the economy can also be seen via the Water-Energy-Food (WEF) Nexus as seen in general in [7] and for South Africa in particular in [8–10]. In addition to this, other scientists have recognised the influence that water has on development [11]. For example, it has been claimed by the World Water Assessment Programme [12] that proper management of water resources brings the prospects of poverty reduction and economic growth to developing economies. Brown and Lall [13] further add that the production of food and most infrastructural development initiatives across the world have been affected by the amount of rainfall received and its variability. Rainfall variability plays an important role seen in general in [14], for South Africa in [15–17] and for KwaZulu-Natal Province in particular [18] while extreme rainfall is seen in general in [14] and for South Africa in [19–21]. This is particularly true in Sub-Saharan Africa where infrastructure development in the water sector still lags behind, and storage of the available water is a challenge such that farmers are not able to continue food production without depending entirely on rainfall [22]. As a consequence, it has been argued by Ward [23] that the need to satisfy the growing human demands for water while protecting the aquatic ecosystems on whose products and services economies and life itself depend has emerged to be a significant challenge for 21st Century water policy especially as the demand for freshwater sources continue to increase worldwide.

It is further noted that literature is awash with evidence on the relationship between resource use and incentives to manage the resource. Musole [24] has argued in his paper that resource users tend to increase resource use efficiency when they have stake in the resource. In addition, some scholars [25–27] posit that by properly defining the rights of use of the water resource, there are high chances that a water user will invest in the improvement of the resource and hence ensure its efficient use. However, despite the growing body of knowledge on property rights and natural resource use [28–30], little research has been conducted to examine how the property rights definition would help in managing the increasing water demands at the scale of a river basin. While numerous studies have been conducted to examine the role that property rights play in creating incentives for investment in land use rights and conservation of fish and forestry resources [31–37], there is scarce literature to indicate the existence of similar research in water demand management. In addition to that, while research efforts have advanced in water demand management, most of this research places its focus on residential or domestic water demands and economic instruments like pricing. Efforts to study the response of water users to property rights institutions in water resource utilisation have been insignificant.

The purpose of this paper is therefore to explore how a property rights system can enhance incentives towards managing water demands by luring users to conserve water on their properties. The argument is that property rights can serve as both incentives and disincentives towards the actions of water users and those actions may either reduce or increase water demands. We learn from Bruns and Meinzein-Dick [38] that property rights can secure access to water for existing users and offer equitable ways to meet additional water needs/demand, including urban expansion, economic growth and environmental protection. However, in order to advance the understated aim, an understanding of water availability and scarcity, demand management and property rights theory is required.

The paper is organised as follows; following hereafter is the background to debates on water availability and scarcity bringing out the rationale for improved water management efforts. After this section, the paper gives a brief overview of the current understanding in demand management efforts in the water sector. A discussion of the property rights theory and its applicability in water resources management has been presented next. This section is followed by a methods section which precedes the results and discussion section. The paper finally closes with some significant conclusions that have been generated from the results of the study.

2. Water availability and scarcity

There are various definitions for water availability divided into blue and green parts e.g., "*blue water availability is defined as total natural runoff net of 20% assigned to environmental flow requirements*" [39], "*Green water availability is defined as total rainfall infiltration in agricultural land minus runoff from this area multiplied by a reduction factor for minimum evaporation losses in agriculture of 0.85*" [ibid]. The same authors argue that water accessibility is even more important as water sources are often far from their point of use due to issues of spatial population or/and productive land distribution and industry. For instance, it is reported that the Amazon river has a 95% flow inaccessibility [40] while only less than 50% of the Congo River's flow can be assessed by the population due to infrastructure challenges despite being one of the largest rivers in Africa [41].

As seen in [42] water scarcity is divided into physical scarcity and economic scarcity. Physical scarcity occurs when, due to the global interconnectedness of the hydro-climatic system [43], water fails to satisfy consumption demand as well environmental flows [44]. Economic scarcity occurs when failure to satisfy the aforementioned demands is attributed to the socio-economic system's failure in water utilisation [ibid] either due to inadequacies in storage, timely distribution and access (infrastructure development) [45] or as seen in [46] in case human/ institutional actions or lack of capital place limits to water access.

An apt definition of water scarcity, among many seen in the relevant literature, is the one employed by the EU "*water demand exceeds the water resources exploitable under sustainable conditions*" [47]. According to Shiklomanov [48], 75% of the earth's surface is covered with water, but only 3 per cent of the earth's water is available as freshwater for human use with the other fraction locked up in oceans and hence salty. The quantity of usable water available is further constrained by a number of factors exacerbated by continued economic growth, population growth, climate change and rapid urbanisation that have increased pressure on the resource [49].

Figure 1 shows water withdrawals across the globe as projected from 1995 to 2025 [50]. It is interesting to note from the figure that water withdrawals continue to rise especially in Africa, China and South Asia and South East Asia. Alcamo, and his colleagues [ibid] report that water withdrawals are prone to grow in these regions due to rapid population and economic growth. For instance, Hoekstra, Mekonnen [51] allege that the increased need for food to feed the growing population will lead to more water withdrawals in the agriculture sector which is the driving force behind economic development in these regions. At the same time, the rate of urbanisation especially in the developing world has led to increased domestic water demand, a situation described by Serageldin [52] as worrisome due to multifaceted implications this has on the social well-being of urban populations. Consequently,

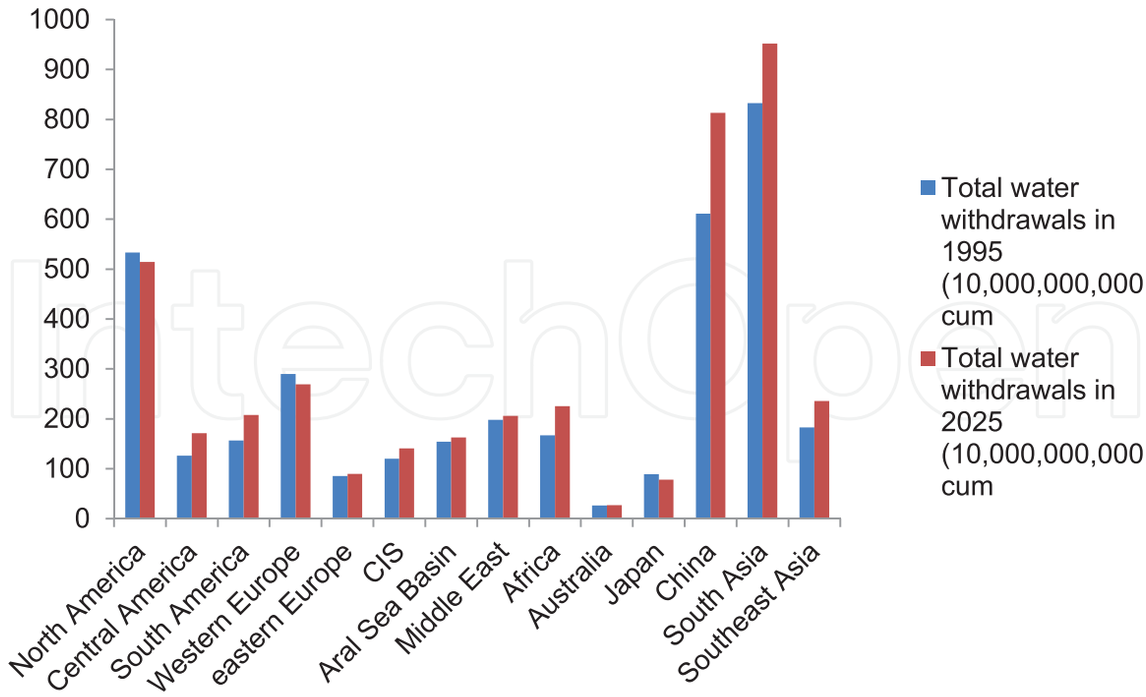

Figure 1.
Graph showing Water Withdrawals projected from 1995 to 2025 [50].

the increase in population coupled with increased water withdrawals has seen approximately 2.1 billion people living in severely water stress basins [50] with Dzikus [53] warning that a total of 1.1 billion people in African countries will be greatly affected by the dwindling water availability if the status quo is maintained.

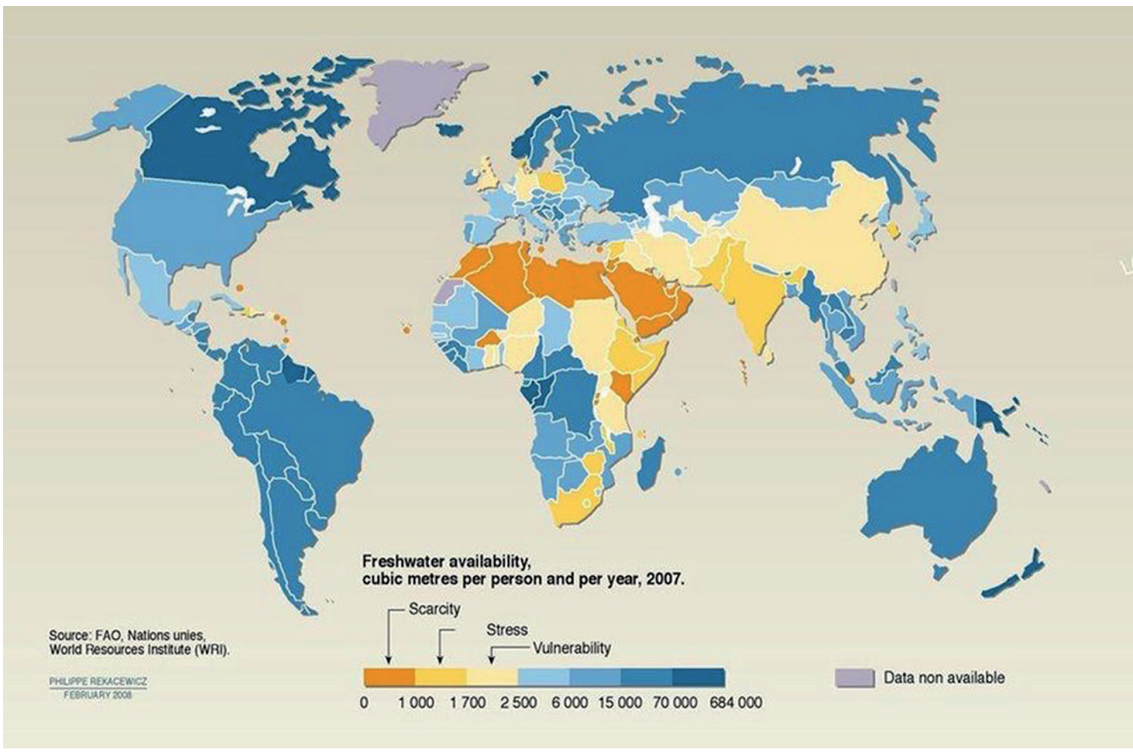

Figure 2.
Map showing freshwater availability across the globe.

The question that remains is whether the available water will be able to meet the growing demands if the situation remains the same [51], and this has led to some authors claiming of an impending global water crisis. However, Lall and Heikkila [54] has acknowledged in their report that the existence or emergence of a global water crisis still remains a topic of controversy among scientists, with some scholars claiming that it is being overstated while raising are questions regarding available data [55]. This not-withstanding, Brown and Lall [13] argues that it is the ability of states to manage their available water resources that affect economic development and social well-being of the society.

Figure 2 is the map showing the availability of freshwater across the globe. While **Figure 1** indicates that global water withdrawals continue to rise in developing countries, it can be observed from **Figure 2** that most African countries including South Africa are heading towards stress levels with some countries especially in North Africa in critical situations of water scarcity.

All this points to the fact that increased water management efforts are imperative and more proactive measures should be sought [56]. However, it has to be admitted that managing the scarce water resources for increasing demands in an equitable and sustainable manner is one of the greatest challenges facing the world in the 21st Century [57, 58].

3. Managing water demands

While the conventional approach to deal with increasing water demands has been to increase supply through infrastructure development for dams and new water supply schemes (29), this has become pecuniary expensive alternative over time as water resources have been affected by multifaceted challenges which include climate change, demographic changes and pollution. It must be highlighted that while managing water demands has been exhorted as probably a more beneficial alternative to supply side management, some authors have found otherwise [56]. For the water users, it has been contended that effective water demand management would enable equity among them and aide in financial savings that would emanate from water use bills [59]. In addition, water supply and management institutions would be saved from making huge infrastructure investments like dam constructions, new water schemes and inter-basin transfers. On the other hand, studies conducted in Iran found that while the adoption of trickle irrigation methods led to improved water use efficiency, there was a significant reduction of the downstream return flows leading to less water available for ecological purposes and those users reliant on these flows [56]. It has been argued by Molle that while there are indeed significant savings by various commercial farmers by employing improving methods of water application and changes in the crop husbandry practices in order to save water, the reality has been that water users tend to utilise every drop of their allocated water by even expanding their current farm coverage [ibid]. This notwithstanding, water demand management strategies should be designed in such a way that they are not a means to themselves but rather with downstream measures to ensure there are water savings that can be reallocated to other users in cases of closed basins as well as environmental uses.

There are thus various types of instruments that have been used to curtail water demands across the globe. These include legal instruments (institutions), economic/financial/market-based instruments, technical instruments and social-political

arrangements [59–61]. For the purposes of this study, this discussion will focus on property rights as a form of institutions that can be used to manage water demands.

3.1 Property rights theory

There has been a lot of disagreements on how to define the concept of property rights among scholars in literature [24]. The differences are prominent among legal, economic and social scholars. For example, Furutbotn and Pejovich [62] as cited by Musole [24] defined property rights from a legal perspective as the claims, entitlements and related obligations among people regarding the use and disposition of a scarce resource. However, Barzel [63] later in 1989 cited by Musole [24] contested from an economic view that a person's property rights consists of the rights or the power to consume, obtain income from and alienate the property to another person. On the other hand, Wiebe and Meinzen-Dick [64] in their study on property rights as policy tools in resource use defined property rights as formal and informal institutions and arrangements that govern access to resources, as well as the resulting claims that individuals hold on those resources and on the benefits they generate. Irrespective of the fact that these scholars come from different backgrounds, however, these definitions share some common features. More generally, they all point to the fact that property rights determine what can be done with a resource, by whom, at what time and in what manner, and a permit or a licence system is used for administering or allocating the resource to the user. For the purposes of the current study, the definition proposed by Wiebe and Meinzen-Dick [64] was adopted due to its applicability in the context of water resources management [65]. It must be pointed out that as some authors argue, property rights affect economic outcome in various ways e.g., the resource use pattern, the goods and services produced quantity and mixture as well as the resulting income and wealth distribution but they do not determine it as it can affect in its turn the structure of property rights themselves [66].

3.2 The attributes of property rights

According to Scott and Coustalin [65], rights to natural resources such as water have prescribed attributes such as duration, exclusivity, quality of title, flexibility and transferability that make the property rights structure effective or otherwise. In addition to these, other scholars point out that a successful property rights system needs to have enforcement mechanisms [24, 67, 68]. The way these attributes have been defined represents the quality of the property right system and to an extent may lead to the success or failure of the system in sustainable management of the natural resources. Some authors have argued that a property rights system would be ill-defined if these attributes are not considered in the design of the system leading to the increase in transaction costs and uncertainty among resource users [62, 63, 69–71]. The discussion in this study has, however, been limited to duration, flexibility, enforcement and transferability of the property rights; while the discussion of enforcement has been combined with exclusivity because they quite often share similar traits.

3.2.1 Duration

Duration of a property right is defined by Crase and Dollery [72] as a representation of the period or length of the right possessed by an individual. The length of property rights is an important element in determining water use. As pointed out by

several scholars [27, 67, 73], property rights of long duration encourage water users to invest in water saving technologies as well as infrastructure improvements on the resource. This would enhance efficient use of the water resource thereby leading to sustainable utilisation as well as curbing the insurgent demands of water in water stressed river basins.

3.2.2 Exclusivity and enforcement

Exclusivity is the description of the extent to which other resource users can be prevented from accessing the resource and enjoying the benefits of the resource [72]. Most scholars agree that this attribute is an important dimension that determines the success or failure of most property right regimes [27]. According to Musole [24], the right of the resource users to the resource would be deemed exclusive if there are adequate enforcement mechanisms in place. This suggests that the enforceability of the property right is an important prescription that needs to be considered if property rights regimes are to be successful. Understanding the enforceability of the property rights structure would help in understanding the behaviour of water users in the way they use the resource.

Several authors assert to the need for exclusive property rights by stating that they tend to internalise resource depletion [24, 74, 75]. Furthermore, well enforced property rights have been upheld by Kemper and Olson [76] in that they lead to emergence of water markets in water scarce areas. This means that water would be allocated to its highest values within the water scarce river basins. In addition, Rosegrant and Binswanger [77] bring about another significant contribution of exclusive property rights systems particularly in water demand management which was also later echoed by Bruns and Meinzen-Dick [38]. They claim that having an enforceable property right could motivate long-term investments in water saving technologies (an important element in demand management) among water users, cause users to consider the opportunity costs of water and to use it efficiently, and gain additional income from the sale of water and internalise externalities.

3.2.3 Flexibility

Crase and Dollery [72] defines flexibility of property rights as the extent to which the right permits an alteration to the pattern of use without forfeiting the right. Flexibility of the right has some intriguing consequences on the sustainability of water resource utilisation. It has been argued that placing exclusive flexibility on property rights especially in water resources implies that a right-holder can alter the pattern of water usage without regard to the impacts on other users. In view of this, therefore, many scholars recommend that flexibility need to be attenuated to limit the extent to which right-holders can modify usage [64, 68, 78, 79].

3.2.4 Transferability

The transferability of property rights has been defined by Veettil, Speelman [80] as the ability of the resource user to transfer the individual property right to another user either temporarily or permanently in line with the specified rules of the governing body. Authors such as Crase and Dollery [74] consider property rights especially in water resources that are not transferable as ill-defined property rights. This is in agreement with several other scholars who argue that transferability of property right enables

resource users to get incentives to invest in the resource and hence improve resource use efficiency [27, 38, 75]. Further than that, transferable property rights in water have been deemed important in the emergence of water markets whereby underutilised and low productive resources can be allocated to higher productive uses [80, 81].

4. Methods

The data used in this study was collected in the Umgeni River Catchment in the year 2013 as part of a larger research program. It focused on water users in the basin who are individual farmers (commercial and small scale), industrial companies and forestry companies in the study area such that the unit of analysis was the individual and corporate water user. According to the National Water Act of 1998, all users of water in a specified area including individuals (farmers, smallholders, landowners or lessees), communities, companies or businesses, water users associations and water service providers are regarded as 'water users' [82] and are required by law to obtain a licence to use the water. The Umgeni River catchment has the population of about 1.6 Million with total urban population at 74% and 26% rural population [83]. This population encompasses a total of 368,250 households. According to the Department of Water Affairs (DWA), the area has higher per capita income as compared to other areas within the province reaching as high as R15,100 while the average lies around R11,000.

A probability sampling technique was utilised in order to determine the respondents that made up the required sample from the population of registered water users in the river catchment. This was deemed appropriate because this would validate the generalisation that can be made from the sample about the population [84] and every member of population had equal possibility of being part of the sample. The sampling technique used here enabled the study to imply the results that emanated from the sampled water users to the rest of the users within the Umgeni River Catchment area.

Questionnaires were distributed to a random sample of 351 out of 818 users that was drawn from an extensive database of registered water users in the study area referred to as the Quaternary catchment U provided by the Department of Water Affairs (DWA). Out of this sample, 146 water users returned the questionnaires. This sample size was calculated using the online sample size calculator [85] at 95% Confidence Level and 6% margin of error or Confidence Interval. The Online Sample Calculator is a tool used for determining sample size in survey research developed by the Creative Research System group of America. The tool uses the target population, Confidence Interval and Confidence Level to determine appropriate sample size for survey research.

The collected data was analysed using Statistical Package for Social Scientists (SPSS) version 20. Four hypotheses were developed to facilitate the investigation of relationships between property rights attributes and intentions by water users to conserve water.

5. Results and discussion

It has been argued in paper that the attributes of property rights affect the incentives for utilising and sustaining water resource base over a period of time. As demands for water continue to increase across the globe particularly due to social

and economic dynamics like population growth (and urbanisation) and of course compromised resource quality, it is increasingly becoming important that water users reduce the amount of water they use by practising water conservation on their properties. One of the ongoing challenges is, however, finding the best approach to encourage water users conserve water and curtail the increasing demands. As was reported previously, a number of studies have been conducted aimed at expanding our knowledge on incentives that can enhance water conservation behaviour among water users. The evidence in this paper agrees with Becker and Gibson [86] who argues that formulating and defining property rights to natural resources is one of the fundamental requirements that is necessary for ensuring that resource users have the incentives to conserve the resources and avoid degradation.

5.1 Duration of property rights and water conservation

The importance of the duration of property rights is highlighted by the fact that water users know the period by which they would continue to benefit from the resource using their right. In accordance with the property rights institutions theory, this would have an impact on the behavioural actions among water users in the catchment [74, 87]. The results from the analysis using SPSS Kruskal Wallis Test are presented in **Table 1** showing the relationship between intention to water conserve water and the duration or tenure of their property right.

From the results of the study, it has been evident that there is a significant direct relationship between duration of the right and water conservation intentions among water users. This result denotes that the duration of the property right can be an incentive to enhance conservation of water among water users in the Umgeni River Basin. Nonetheless, this finding does not in itself clarify the extent to which duration would influence the intentions to conserve water as the results indicated a difference in the influence between five to 10 and 21 to 30 durations and 21 to 30 and 31 to 40 year duration (See **Table 2**).

By looking at the mean scores, the results revealed that water users were more motivated to conserve water with the lower durations and this motivation continued to drop as the duration increased. This finding would suggest that shorter water durations are key if water users are to be more conservative in water use, and this would help in reducing water demands in water stressed basins. According to Adhikari [88], resource users with shorter property rights durations attach more importance to optimising their benefits from the resource within the given period. The implication of this proposition would be two-fold. On the one hand, resource users would expropriate more resources from the source as they have no concerns for

Test Statistics[a,b]	
Test Statistics	**Intention to conserve water**
Chi-Square	19.518
Df	5
Asymp. Sig.	.002

[a] *Kruskal Wallis Test.*
[b] *Grouping Variable: What is the length of your water licence?*

Table 1.
The relationship between intention to water conserve water and the duration or tenure of their property right.

Dependent variable	Length of property right	N	Mean rank
Intention to conserve water	5 years	14	92.64
	6 to 10 years	15	90.47
	11 to 20 years	10	76.95
	21 to 30 years	23	49.61
	31 to 40 years	23	86.22
	Greater than 40 years	47	62.55
	do not know	14	88.82
	Total	**146**	

Table 2.
Intention to conserve water vs length of property right.

longer term availability of the resource thereby leading to degradation of the resource and increased conflicts among water users due to increased demands. The resource users may, nevertheless, be conservative with the available resource supply if they have a shorter duration so as to maximise their benefits from the supply. However, other studies indicate that the ability to conserve and sustainably use the resource with respect to the duration of the property rights depends more on the certainty of whether they can easily renew their licence after the expiry of the current allocation [27, 89]. Further than that, although Nikouei, Zibaei [90] argues that resource users are believed to be conservative if they are certain that they will continue benefiting from the resource, Hasan [36] reports in her study that some resource users will reduce their commitment to preserve the integrity of the resource in the long run.

5.2 Flexibility of property rights and water conservation

There is huge evidence in literature that resource degradation and sustainable management is dependent upon the efficient institutional arrangements [71, 91]. It was argued in the preceding sections that placing flexibility on property rights can

Variables	Test statistics	Intention to conserve water	Overall flexibility of property right
Intention to conserve water	Correlation Coefficient	1.000	**.190****
	Sig. (2-tailed)	.	.022
	N	146	146
Overall flexibility of property right	Correlation Coefficient	**.190****	1.000
	Sig. (2-tailed)	.022	.
	N	146	146

***Correlation is significant at the 0.05 level (2-tailed). Bold shows statistically significant results.*

Table 3.
Flexibility of property right vs water conservation.

have both positive and negative impacts on the resource. The results from the correlation analysis between flexibility and intention to conserve water are presented in **Table 3**.

The results of this research indicated that the flexibility of the property rights correlated significantly with water conservation intentions among water users implying that low flexibility may lead to low conservation intentions while higher flexibility may lead to higher conservation intentions. However, the results revealed that the relationship was very weak (as observed from a correlation coefficient of 0.19). Since the flexibility of one's property right would affect the behaviour of another resource user within the resource regime [72], Corral-Verdugo, Frias-Amenta [92] suggest that the intentions of resource users to conserve water would be affected by the actions of those other users in the catchment. Corral-Verdugo and his colleagues argue that water users that are affected by other rights holders who change the pattern of water use are more likely going to be demotivated to conserve water on their property. In addition, these authors claim that flexible property rights would also reduce the likelihood of collective action towards conservation and sustainable utilisation of the resource. From this observation, it can be suggested that there is need to ensure that property rights should exhibit some form of flexibility in order to motivate water users conserve water while at the same time protecting the interests of neighbouring water users.

5.3 Enforceability of property rights and water conservation

Well defined property rights entails having a good compliance monitoring and enforcement mechanisms either done by the community of resource users themselves or indeed by the state [93]. Ostrom and several other colleagues argue that the behaviour of actors lean to a large extent onto the enforceability of the institutions within the context [78, 87, 94, 95]. An analysis on the relationship between enforceability and intentions of water users to conserve water using SPSS Spearman's Rho Correlations has been presented in **Table 4**.

In this study, it has been established that there is a positive correlation between enforcement of property rights and conservation of water by resource users. This result implies that any increases in enforcement of the property rights by the water management agency would result in increased water conservation efforts by water users. Although the current study finds a moderately strong correlation, there is agreement

Variables	Statistics	Intention to conserve water	Overall enforcement of property right
Intention to conserve water	Correlation Coefficient	1.000	.517**
	Sig. (2-tailed)	.	.000
	N	146	146
Overall Enforcement of property right	Correlation Coefficient	**.517****	1.000
	Sig. (2-tailed)	.000	.
	N	146	146

***Correlation is significant at the 0.01 level (2-tailed). Bold shows statistically significant results.*

Table 4.
Enforceability of property rights and water conservation.

with the findings from a study conducted by Yang, Zhang [96] in China. Yang and his colleagues reported that irrigation farmers were more motivated to conserve water by having enforceable water rights than changing the pricing incentives. From this finding, it can be concluded that the enforceability of the property right can be used as incentives towards the conservation of water by water users on either their farm or other properties. By having a well enforced property right system in place, water users would be able reduce water consumptions by adhering to their set water abstraction limits thereby reducing water demands. In so doing, water management agencies would be in a position to contain the surging water demands in stressed river basins.

5.4 Transferability of property rights and water conservation

Transferability of the property rights has received greater attention in property right literature especially by scholars looking water markets. Proponents of transferable property rights argue that transferable property rights are very important in water resource management because they aide in water being allocated to its highest value and efficiently utilised. In very water stressed basins, water can be transferred from one sector to another and from one user to another as long as the property rights institutions allow transferability of rights. In the light of escalating water demands, transferring the property rights from low value uses to high value uses may help manage the demands at basin level. An analysis on the relationship between transferability and intentions of water users to conserve water using SPSS Spearman's Rho Correlations has been presented in **Table 5**.

The results from this study suggest a significant relationship between transferability of the right and intentions of water users to conserve water although the correlation effect is not strong enough. This finding may imply that water users find the transferability of their right as incentives towards conservation of water but not to a larger extent. As discussed earlier in the beginning of the paper, even though transferability of property rights has some significant benefits in water allocation, some authors critiqued the concept of transferability.

Scholars such as Anderson have argued "*since rights cannot be perfectly enforced, ownership will always be probabilistic; but when the probability of capturing benefits from a use is low, it is less likely that the owner will devote the resource to that use*" [97].

Variables	Statistics	Intentions to conserve water	Transferability of property right
Intentions to Conserve Water	Correlation Coefficient	1.000	.580*
	Sig. (2-tailed)	.	.030
	N	146	146
Transferability of Property right	Correlation Coefficient	.580*	1.000
	Sig. (2-tailed)	.030	.
	N	146	146

**Correlation is significant at the 0.05 level (2-tailed).*

Table 5.
Transferability of property rights and water conservation.

In Pakistan a survey of watercourses (1990) showed the existence of 70% active trading between farmers [98] while market type trading of water rights is seen to result in social benefits via improvement of water resource allocation efficiency. Allocative efficiency maximisation which leads to net economic returns maximisation is rarely attained in practice as there are supply and demand imbalances [99]. Water intersectoral reallocation, as long as economic efficiency is attained via transfer to a use of higher value, is a positive process as seen in [100]. However, in this case, a framework of intersectoral trading is created where a competitive situation arises [101] unless the transfer is facilitated by central economic policy *fiat* as is the case in Jordan's shift from agricultural to industrial use [102]. Transferable property rights may lead to overutilization and/or overexploitation of the resource as seen in [103]. For instance, when water has been allocated to the highest efficiency sectoral value uses, like from agriculture production to industrial uses, there are high chances that the new right holders will aim to optimise production per unit water allocation within the particular industrial process employed which differs from agricultural use. The resulting consequence can be increased degradation of the water resource thereby creating water stress in the river basin.

6. Conclusions and implications for water demand management research

In the preamble of this paper, it was indicated that most demand management literature and research focus on the use of economic and market-based incentives to curtail water demands. Indeed, there is a lot of scholarly work that supports that water demand can better be managed by economic incentives like pricing [59, 76, 104–106]. However, there is also growing concerns on the applicability of these instruments in a river basin context [56, 80, 107] as most of this research is conducted with a primary focus on either residential water demands or irrigation water demands.

While there is acknowledgement of property rights institutions as an instrument that can be used to manage water demands [56, 59, 60, 108], it was observed that little research work was done to understand the potential and applicability of property rights in this respect. This research, therefore, aimed at examining the role of property rights in managing this water demand as an alternative incentive to the economic instruments. The main argument was that property rights institutions guide the behaviour of resource users towards resource utilisation [24, 64, 89, 95]. By utilising the property rights theory [29], a proposition was made that the attributes of property rights would act as incentives and influence the patterns of behaviour of water resource users resulting in either reduction or increase in water use. The interaction between these property rights attributes and water users would result in a well-managed water demand scenario or another tragedy of the water resources commons.

Using evidence obtained in this study, property rights would be very significant in curtailing water demands in a catchment by acting as incentives in water resource utilisation, specifically by motivating water user users to conserve water. This finding presents a new dimension in water demand management research. Although these results are mostly inconclusive as regards the amount water savings property rights would have, efforts would be done to delve into understanding more on the incentive structure of property rights as regards water resource utilisation across the sectors in a catchment. By focusing on catchment wide water users, research would be able to incorporate dynamics that affect water user behaviour often ignored in studies focusing on residential water demand management.

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References

[1] United Nations. Protecting the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management, and Use of Water Resources. In Agenda 21. New York, NY: United Nations Publication. 1992; Chapter 18

[2] ICWE. The Dublin statement on water and sustainable development. In: International Conference on Water and the Environment. Dublin, Ireland: ICWE; 1992

[3] Zisopoulou K, Zisopoulos D, Panagoulia D. Water economics: An In-depth analysis of the connection of blue Water with some primary level aspects of economic theory I. Watermark. 2022;**14**(1):103

[4] Robbins LRB. The Nature and Significance of Economic Science. London: Macmillan; 1932

[5] Herrington P. Pricing of water services. Organisation for Economic Co-operation and Development. Ottawa: Renouf; 1987

[6] Booker JF, Howitt RE, Michelsen AM, Young RA. Economics and the modeling of water resources and policies. Natural Resource Modeling. 2012;**25**(1):168-218

[7] Zisopoulou K, Karalis S, Koulouri M-E, Pouliasis G, Korres E, Karousis A, et al. Recasting of the WEF Nexus as an actor with a new economic platform and management model. Energy Policy. 2018;**119**:123-139

[8] Conway D, Van Garderen EA, Deryng D, Dorling S, Krueger T, Landman W, et al. Climate and southern Africa's water–energy–food nexus. Nature Climate Change. 2015;**5**(9):837-846

[9] Mabhaudhi T, Simpson G, Badenhorst J, Mohammed M, Motongera T, Senzanje A, et al. Assessing the State of the Water-energy-food (WEF) Nexus in South Africa. Vol. 76. Pretoria, South Africa: Water Research Commission (WRC); 2018

[10] Naidoo D, Nhamo L, Mpandeli S, Sobratee N, Senzanje A, Liphadzi S, et al. Operationalising the water-energy-food nexus through the theory of change. Renewable and Sustainable Energy Reviews. 2021;**149**:111416

[11] Lenton R, Muller M. Integrated Water Resources Management in Practice: Better Water Management for Development. Routledge, London; 2012

[12] World Water Assessment Programme (United Nations). Water: A shared responsibility. UNESCO, Paris; 2006

[13] Brown C, Lall U. Water and economic development: The role of variability and a framework for resilience. In Natural resources forum. Oxford, UK: Blackwell Publishing Ltd. 2006;**30**(4):306-317

[14] Panagoulia D, Vlahogianni EI. Nonlinear dynamics and recurrence analysis of extreme precipitation for observed and general circulation model generated climates. Hydrological Processes. 2014;**28**(4):2281-2292

[15] Mason SJ, Jury M. Climatic variability and change over southern Africa: A reflection on underlying processes. Progress in Physical Geography. 1997;**21**(1):23-50

[16] Fauchereau N, Trzaska S, Rouault M, Richard Y. Rainfall variability and changes in southern Africa during the 20th century in the global

warming context. Natural Hazards. 2003;**29**(2):139-154

[17] Reason CJ, Landman W, Tadross M, Tennant W, Kgatuke M. Seasonal to Decadal Predictability and Prediction of Southern African Climate. UCT, Cape Town. 2004; pp. 1-44

[18] Ndlovu M, Clulow AD, Savage MJ, Nhamo L, Magidi J, Mabhaudhi T. An assessment of the impacts of climate variability and change in Kwa Zulu-Natal Province, South Africa. Atmosphere. 2021;**12**(4):427

[19] De Waal JH, Chapman A, Kemp J. Extreme 1-day rainfall distributions: Analysing change in the Western cape. South African Journal of Science. 2017;**113**(7-8):1-8

[20] Landman WA, Botes S, Goddard L, Shongwe M. Assessing the predictability of extreme rainfall seasons over southern Africa. Geophysical Research Letters. 2005;**32**(23)

[21] Sikhwari T, Nethengwe N, Sigauke C, Chikoore H. Modelling of extremely high rainfall in Limpopo Province of South Africa. Climate. 2022;**10**(3):33

[22] Serdeczny O, Adams S, Baarsch F, Coumou D, Robinson A, Hare W, et al. Climate change impacts in sub-Saharan Africa: From physical changes to their social repercussions. Regional Environmental Change. 2017;**17**(6):1585-1600

[23] Ward FA. Decision support for water policy: A review of economic concepts and tools. Water Policy. 2007;**9**(1):1-31

[24] Musole M. Property rights, transaction costs and institutional change: Conceptual framework and literature review. Progress in Planning. 2009;**71**(2):43-85

[25] Ahmad M. Water pricing and markets in the near east: Policy issues and options. Water Policy. 2000;**2**(3):229-242

[26] Ray D. Introduction to development theory. Journal of Economic Theory. 2007;**137**(1):1-10

[27] Speelman S, Farolfi S, Frija A, Van Huylenbroeck G. Valuing improvements in the water rights system in South Africa: A contingent ranking approach 1. JAWRA Journal of the American Water Resources Association. 2010;**46**(6):1133-1144

[28] Meinzen-Dick R, Nkonya L. Understanding legal pluralism in water rights: Lessons from Africa and Asia. In African Water Laws Workshop: Plural Legislative Frameworks for Rural Water Management in Africa. IWMI. 2005; H038746

[29] Ostrom E. Doing Institutional Analysis Digging Deeper than Markets and Hierarchies. Boston, MA. Springer; 2005. pp. 819-848

[30] Schlager E, Ostrom E. Property-rights regimes and natural resources: A conceptual analysis. Land Economics. 1992:249-262

[31] Agrawal A, Ostrom E. Collective action, property rights, and decentralization in resource use in India and Nepal. Politics and Society. 2001;**29**(4):485-514

[32] Begossi A. Property rights for fisheries at different scales: Applications for conservation in Brazil. Fisheries Research. 1998;**34**(3):269-278

[33] Costello CJ, Kaffine D. Natural resource use with limited-tenure property rights. Journal of Environmental Economics and Management. 2008;**55**(1):20-36

[34] Guerin, K. Property rights and environmental policy: A New Zealand perspective. No. 03/02. New Zealand Treasury Working Paper; 2003

[35] Haddad BM. Property rights, ecosystem management, and John Locke's labor theory of ownership. Ecological Economics. 2003;**46**(1):19-31

[36] Hasan L. Property Regimes in Resource Conservation-A Framework for Analysis. Germany: University Library of Munich; 2000

[37] Heltberg R. Property rights and natural resource management in developing countries. Journal of Economic Surveys. 2002;**16**(2): 189-214

[38] Bruns BR, Meinzen-Dick R. Frameworks for water rights: an overview of institutional options. Water rights reform: Lessons for institutional design. IFPRI; Washington. 2005:3-25

[39] Zisopoulou K, Panagoulia D. An in-depth analysis of physical blue and green water scarcity in agriculture in terms of causes and events and perceived amenability to economic interpretation. Watermark. 2021;**13**(12):1693

[40] Latrubesse EM. Patterns of anabranching channels: The ultimate end-member adjustment of mega rivers. Geomorphology. 2008;**101**(1-2):130-145

[41] Chishugi DU, Sonwa DJ, Kahindo J-M, Itunda D, Chishugi JB, Félix FL, et al. How climate change and land use/land cover change affect domestic water vulnerability in Yangambi watersheds (DR Congo). Landscape. 2021;**10**(2):165

[42] Seckler DW. World Water Demand and Supply, 1990 to 2025: Scenarios and Issues. IWMI; Colombo, Sri Lanka. 1998

[43] Alcamo JM, Vörösmarty CJ, Naiman RJ, Lettenmaier DP, Pahl-Wostl C. A grand challenge for freshwater research: Understanding the global water system. Environmental Research Letters. 2008;**3**(1):010202

[44] Ahopelto L, Veijalainen N, Guillaume JH, Keskinen M, Marttunen M, Varis O. Can there be water scarcity with abundance of water? Analyzing water stress during a severe drought in Finland. Sustainability. 2019;**11**(6):1548

[45] Nairizi S. Drought and Water Scarcity. International Commission on Irrigation and Drainage: New Delhi, India; 2017

[46] Molden D. Water for Food Water for Life: A Comprehensive Assessment of Water Management in Agriculture. Routledge, London; 2013

[47] European Commission. Communication from the Commission to the European Parliament and the Council. Brussels: European Commission; 2007

[48] Shiklomanov IA. Summary of the monograph "world water resources at the beginning of the 21st century" prepared in the framework of IHP. UNESCO. 1999;**12**(11):2010

[49] Rosegrant MW, Cai X, Cline SA. Global Water Outlook to 2025: Averting an Impending Crisis. IWMI; Colombo, Sri Lanka. 2002: No. 572-2016-39087

[50] Alcamo J, Döll P, Henrichs T, Kaspar F, Lehner B, Rösch T, et al. Global estimates of water withdrawals and availability under current and future "business-as-usual" conditions. Hydrological Sciences Journal. 2003;**48**(3):339-348

[51] Hoekstra AY, Mekonnen MM, Chapagain AK, Mathews RE, Richter BD. Global monthly water scarcity: Blue water footprints versus blue water availability. Plo S one. 2012;**7**(2):e32688

[52] Serageldin I. Water resources management: A new policy for a sustainable future. Water International. 1995;**20**(1):15-21

[53] Dzikus A. Managing water for African Cities: An introduction to urban water demand. In: Regional Conference on the Reform of the Water Supply and Sanitation Sector in Africa–Enhancing Public-Private Partnership in the Context of the Africa Vision for Water (2025). Uganda: Kampala; 2001

[54] Lall U, Heikkila T, Brown C, Siegfried T. Water in the 21st century: Defining the elements of global crises and potential solutions. Journal of International Affairs. 2008:1-17

[55] Dantas IRM, Delzeit R, Klepper G. Economic research on the global allocation of scarce Water resources needs better data. Water Economics and Policy. 2021;**7**(03):2150013

[56] Molle F, Turral H. Demand management in a basin perspective: is the potential for water saving overestimated?. In International Water Management Institute Conference . IWMI; Colombo, Sri Lanka. 2004: No. h034365

[57] Hoekstra AY. Sustainable, efficient, and equitable water use: The three pillars under wise freshwater allocation. Wiley Interdisciplinary Reviews Water. 2014;**1**(1):31-40

[58] Mekonnen MM, Pahlow M, Aldaya MM, Zarate E, Hoekstra AY. Sustainability, efficiency and equitability of water consumption and pollution in Latin America and the Caribbean. Sustainability. 2015;**7**(2):2086-2112

[59] Tate DM. Water Demand Management in Canada: Inland Waters Directorate. Water Planning and Management Branch; Quebec. 1990

[60] Mohamed AS. Water Demand Management: Approach, Experience and Application to Egypt. Delft: Technische University; 2001

[61] Savenije HH, Van Der Zaag P. Water as an economic good and demand management paradigms with pitfalls. Water International. 2002;**27**(1):98-104

[62] Furubotn EG, Pejovich S. Property rights and economic theory: A survey of recent literature. Journal of Economic Literature. 1972;**10**(4):1137-1162

[63] Barzel Y. Economic Analysis of Property Rights. Cambridge: Cambridge University Press; 1989

[64] Wiebe KD, Meinzen-Dick R. Property rights as policy tools for sustainable development. Land Use Policy. 1998;**15**(3):203-215

[65] Scott A, Coustalin G. The evolution of water rights. Natural Resources Journal. 1995;**35**:821

[66] Ditwiler CD. Water problems and property rights—An economic perspective. Natural Resources Journal. 1975;**15**(4):663-680

[67] Narain V. Institutions, Technology and Water Control: Water Users Associations and Irrigation Management Reform in Two Large-Scale Systems in. India: Wageningen University and Research; 2003

[68] Speelman S, Frija A, Buysse J, Van Huylenbroeck G. The importance of

irrigation water rights: Lessons from South Africa and Tunisia. Water Policy. 2011;**13**(5):663-676

[69] Bajt A. The property rights school: Is economic ownership the missing link? International Review of Law and Economics. 1993;**13**(1):85-97

[70] Bell D. The structure of rights in the context of private property. The Journal of socio-economics. 1995;**24**(4):607-622

[71] Fitzpatrick D. Evolution and chaos in property right systems: The third world tragedy of contested access. Yale LJ. 2005;**115**:996

[72] Crase L, Dollery B. Water rights: A comparison of the impacts of urban and irrigation reforms in Australia. The Australian Journal of Agricultural and Resource Economics. 2006;**50**(3):451-462

[73] Hodgson S. Modern Water Rights: Theory and Practice. Food & Agriculture Org; Rome. 2006

[74] Mwangi E, Meinzen-Dick RS. Understanding Property Rights in Land and Natural Resource Management. Institutional Economics Perspectives on African Agricultural Development; 2009. pp. 295-318

[75] Narain V. Water Rights System as a Demand Management Option: Potentials, Constraints and Prospects. Strategic Analyses of the National River Linking Project (NRLP) of India: Series 3. IWMI; Colombo, Sri Lanka. 2009:127-146

[76] Kemper KE, Olson D. Water pricing: the dynamics of institutional change in Mexico and Ceará, Brazil. In: The Political Economy of Water Pricing Reforms. 2000. pp. 339-357

[77] Rosegrant MW, Binswanger HP. Markets in tradable water rights: Potential for efficiency gains in developing country water resource allocation. World Development. 1994;**22**(11):1613-1625

[78] Orindi V, Huggins C. The Dynamic Relationship between Property Rights, Water Resource Management and Poverty in the Lake Victoria Basin. IWMI; Colombo, Sri Lanka. 2005: H038769

[79] White SE, Kromm DE. Appropriation and water rights issues in the high plains Ogallala region. The Social Science Journal. 1996;**33**(4):437-450

[80] Veettil PC, Speelman S, Frija A, Buysse J, Van Huylenbroeck G. Complementarity between water pricing, water rights and local water governance: A Bayesian analysis of choice behaviour of farmers in the Krishna river basin, India. Ecological Economics. 2011;**70**(10):1756-1766

[81] Tietenberg T. Tradable permits in principle and practice. Moving to Markets in Environmental Regulation. In: Moving to Markets in Environmental Regulation. Oxford: Oxford University Press Online; 2006

[82] Republic of South Africa. National Water Act No 36, Government Gazette. Cape Town. 1998; p 19182

[83] DWAF. Mvoti to Mzimkulu Water Management Area Situational Assessment. Kwa Zulu Natal Regional Office; Durban. 2001

[84] Bryman A. Social Research Methods. Oxford, UK: Oxford University Press; 2016

[85] American Marketing Association. Creative Research Systems, the Survey System-sample Size Calculator. 2007.

[86] Becker CD, Gibson C. The Lack of Institutional Supply: Why a Strong Local

Community in Western Ecuador Fails to Protect its Forest. FAO; Rome. 1998. pp. 111-133

[87] North DC. Institutions and the Performance of Economies over Time. Berlin: Springer; 2008. pp. 21-30

[88] Adhikari B. Literature review on the economics of common property resources. Report prepared for NRSP. 2001

[89] Snell M, Bell KP, Leahy J. Local institutions and Natural Resource Management. In 2010 Annual Meeting, July 25-27, 2010, Denver, Colorado. Agricultural and Applied Economics Association 2010 (No. 61880)

[90] Nikouei A, Zibaei M, Ward FA. Incentives to adopt irrigation water saving measures for wetlands preservation: An integrated basin scale analysis. Journal of Hydrology. 2012;**464**:216-232

[91] Gerber J-D, Knoepfel P, Nahrath S, Varone F. Institutional resource regimes: Towards sustainability through the combination of property-rights theory and policy analysis. Ecological Economics. 2009;**68**(3):798-809

[92] Corral-Verdugo V, Frias-Armenta M, Pérez-Urias F, Orduña-Cabrera V, Espinoza-Gallego N. Residential water consumption, motivation for conserving water and the continuing tragedy of the commons. Environmental Management. 2002;**30**(4):527-535

[93] Thobani M. Formal water markets: Why, when, and how to introduce tradable water rights. The World Bank Research Observer. 1997;**12**(2):161-179

[94] Brown KM. New challenges for old commons: The role of historical common land in contemporary rural spaces. Scottish Geographical Journal. 2006;**122**(2):109-129

[95] Ostrom E. Background on the institutional analysis and development framework. Policy Studies Journal. 2011;**39**(1):7-27

[96] Yang H, Zhang X, Zehnder AJ. Water scarcity, pricing mechanism and institutional reform in northern China irrigated agriculture. Agricultural Water Management. 2003;**61**(2):143-161

[97] Anderson TL. The new resource economics: Old ideas and new applications. American Journal of Agricultural Economics. 1982;**64**(5):928-934

[98] Thobani M. Tradable property rights to Water: How to improve water use and resolve water conflicts. The World Bank. 1995

[99] Vaux HJ. Economic factors shaping western water allocation. American Journal of Agricultural Economics. 1986;**68**(5):1135-1142

[100] Howe CW, Schurmeier DR, Shaw WD Jr. Innovative approaches to water allocation: The potential for water markets. Water Resources Research. 1986;**22**(4):439-445

[101] Farolfi S, Perret SR. Inter-Sectoral Competition for Water Allocation in Rural South Africa: Analysing a Case Study through a Standard Environmental Economics Approach. University of Pretoria; Pretoria, South Africa. 2002: No. 1737-2016-140373

[102] Carpio CE, Ramirez OA, Boonsaeng T. Potential for tradable water allocation and rights in Jordan. Land Economics. 2011;**87**(4):595-609

[103] Ajuzie EI, Altobello MA. Property rights and pollution: Their implications

for Long Island sound and the oyster industry. Applied Economic Perspectives and Policy. 1997;**19**(2):242-251

[104] Mwendera E, Hazelton D, Nkhuwa D, Robinson P, Tjijenda K, Chavula G. Overcoming constraints to the implementation of water demand management in southern Africa. Physics and Chemistry of the Earth. 2003;**28**(20-27):761-778

[105] Olmstead SM, Hanemann WM, Stavins RN. Water demand under alternative price structures. Journal of Environmental Economics and Management. 2007;**54**(2):181-198

[106] Winpenny J. Demand Management for Efficient and Equitable Use. Water: Economics, Management and Demand. E & FN Spon, Chapman Hall; London. 1997. pp. 296-303

[107] Mohamed A. Water demand management in Egypt: Policy objectives and strategy measures. Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere. 2000;**25**(3):243-249

[108] Brooks B. Water demand management: Conceptual framework and pollicy implemation. In: Management of Water Demand in Africa and the Middle East: Current Practices and Future Need IDRC. 1997:1-10