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RESEARCH ARTICLE

INFLUENCE OF PRODUCTION AND PRICING ON CLEAN WATER ACCESSIBILITY IN RWANDA "*WATER RESOURCE MANAGEMENT OUTLOOK*"

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ABSTRACT

Today the competition for scarce water resources in many places is intense. Managing water as an economic good helps to achieve efficient and equitable use, and ensuring sustainability of water resources. This paper focused on investigating the water production and pricing in Rwanda to improve clean water accessibility. The findings showed that the amount of water produced increased from 38818228 cubic meters in 2012 to 43558705 cubic meters in 2016. The change in number of customers with water connections in the same period has risen from 118393 customers to 175646 customers. The price changes according to the amount of water used in order to influence water accessibility and management. Therefore, pricing water contributes to development of water sector, improving water supply and maintaining water infrastructures countrywide. Strengthening the capacity of existing water treatment plants will lead to ensured production and supply of the required volume of clean water on daily basis.

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INTRODUCTION

Today the competition for scarce water resources in many places is intense. Many river basins do not have enough water to meet all the demands or even enough for their rivers to reach the sea. Further appropriation of water for human use is not possible because limits have been reached and in many cases breached. Basins are effectively "closed," with no possibility of using more water (IWMI, 2007). Domestic water supplies are one of the fundamental requirements for human life. Without water, life cannot be sustained beyond a few days and the lack of access to adequate water supplies leads to the spread of disease. Children bear the greatest health burden associated with poor water and sanitation (WHO, 2002; Howard and Bartram, 2003). According to the UNFPA (2003) report, the central role of water is evident in any systematic appraisal of life sustaining requirements. Even at the most fundamental level of human survival and sustainable development, water not only has life sustaining qualities, but strongly influences economic activity (both production and consumption) and social roles.

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Safe drinking water, good sanitation and hygiene are fundamental to people's health, survival, growth and development. Yet, roughly one-sixth of the world's population lacks access to safe water, and around two-fifths lack adequate sanitation. In terms of human suffering and financial loss the costs are enormous. In developing countries, for example, the costs of disease and productivity losses linked to inadequate clean water and sanitation are equivalent to 2% of gross domestic product (Norström, 2007). According to the research done (GWP and INBO ,2009) report stated that the integrated water resources management approach helps to manage and develop water resources in a sustainable and balanced way, taking account of social, economic and environmental interests. It recognises the many different and competing interest groups, the sectors that use and abuse water, and the needs of the environment. In addition, the report asserted that a range of tools, such as social and environmental assessments, economic instruments, and information and monitoring systems, support this process.

Literature applied: The DNI(2012) defined, *water management:* as used in this report, pricing decisions, allocations of water based upon hydrological modeling, development of water infrastructure (e.g., dams, levies, canals, water treatment facilities), the use of water infrastructure to control water flow, trade of products with high water content,

and effective transboundary water agreements. By taking this (i.e. water management) into account, in Rwanda, RoR/MINIRENA (2013) emphasised that sustainable management of integrated water resources is relevant to achieving Vision 2020 gearing towards a productive and market oriented agriculture. In their report about assessment of water shortages and coping mechanisms of Harare residents (Zimbabwe), Chaminuka and Nyatsanza (2013) put more emphasis that managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources. As soon as water is collected from a source, it has a price as an economic and social good. The human right to access clean water and sanitation at affordable prices must be recognized, but the scarcity of water demands that economic perspectives should not be ignored. In conditions where water is especially limiting, where supply augmentation is not a feasible option, economic tools should play a larger role in determining how limited water resources should be distributed efficiently and equitably.

According to Kjellsson *et al.* (2012) study report, proponents for the privatization of water argue that pricing water will improve overall allocation of water and will encourage conservation. Furthermore, the research stated that pricing water provides an incentive for efficient use and the best allocation for maximum benefit. Despite this, proponents of public provision of water argue for the treatment of water as a human right and fear that treating it as an economic good will leave certain people without vital fresh water resources. Howe, (2005) reported that among the primary roles of water price are: (1) the "economically efficient'' allocation of existing supplies in the short term; (2) the generation of adequate revenues for the operation, maintenance and expansion of the water system; and (3) the 'equitable' treatment of water users. Why is price an 'economically efficient' way of rationing fixed supplies of water among users? The economic efficiency argument for price is that it might be assumed that water users compare their marginal benefits with the marginal costs they face when deciding on changes in water use patterns. According to RoR/MINIRENA (2011) report, water is a strategic natural resource for Rwanda, underpinning the country's socioeconomic development and ecosystems sustenance. The beautiful green hills and moist valleys that produce food all year round and attract international tourists are sustained by water. The report thus, said that the country's water resources management (WRM) capacity is limited in terms of human resources, institutional systems, and infrastructures. Domestic and municipal water use is taken to include clean water supply to households and institutions (schools, health facilities, prisons, public offices) for drinking, cooking, hygiene and other purposes. Clearly, factors such as population growth, demographic changes, economic development and climate change have a critical impact on water resources. In the same way, water resources have a significant impact on production and economic growth, on health and livelihoods, and on national security. As the pressures on water resources grow, it is vital that we manage renewable freshwaters properly. But, managing water is becoming increasingly complex and contentious (GWP and INBO, 2009). According to the CMAP *et al* (2012), anticipated population growth across the communities in our region through mid-century means that water demands and infrastructures 'needs will also evolve, requiring a fresh look at how we approach water especially if we hope to ensure adequate water availability for livable communities and continued economic development going forward. Thus, it is asserted that interest in full-cost pricing as a water management tool is growing across the United States as well as the Great Lakes region. ARDE/KUBAHO (2014) reported that few Rwandans have running water in their homes. Some families can access water through community water points, where they are charged a nominal user fee for the water, according to either container size or monthly consumption. However, many cannot afford clean tap water and collect water from local streams and ponds. Therefore, this is reported to put them at risk of contracting waterborne diseases. In order to make it effective, this research paper focused on investigating the water production and pricing as the management practices influencing clean water accessibility in Rwanda so as to have a wide view on how the water management and supply practices influence the accessibility together with availability of clean water to the community in need. With this perspective a number of objectives to be covered included (1) Assessing the extent of clean water production and supply in Rwanda; (2) Evaluating the pricing mechanisms to influence water accessibility and use in Rwanda; (3) Look at yearly trends in clean water accessibility in Rwanda. This research is a generalized view about clean water demand supply and management countrywide.

METHODOLOGY

Area description: According to MINITERE (2004) Rwanda is a hilly, landlocked and densely populated African country with an area of 26,338 km^2.Geographically, the country is situated in East of Central Africa between the latitude and longitude coordinates respectively $1^0$04'' and $2^0$51''S and between $28^0$53''and $30^0$53''E. The shortest distance to the ocean is 1,200 km long. The Rwandan physical landscape is characterized by a topography which gradually rises from the East to the West. In the East, it has an average altitude of 1,250 m above sea level, which increases in a westwards trend with altitudes ranging between 2000 and 3000 m above sea level. The main features of that predominantly mountainous topography are the volcano range in the north-west culminating at 4507 m above sea level, and the Congo-Nile Ridge stretching from south west to north-west and culminating at 2918 m above sea level. Hydrologically, Rwanda is a landlocked country located within the Great Lakes region of the central eastern part of Africa. The Congo Nile Ridge divides the country's waters into two parts: those flowing to the west into the Congo Basin and those flowing to the east into the Nile Basin. Therefore, Rwanda principally has only two hydrographic basins. The Nile basin (67% of the territory) and the Congo Basin (33% of Rwanda's territory).The water resources management is governed by the existing water and sanitation policy developed in 2004. In 2008, the Law number 62/2008 on the use, conservation, protection and management of water resources was adopted (MINIRENA, 2011).

Research design and data collection: The research consisted of collecting data that would enable the analysis of water production, pricing and related management influences' on clean water accessibility and use in Rwanda. The methods used to collect data include:

- Quantitative data acquisition from WASAC (Water and Sanitation Corporation)

- Direct (face to face) interviews
- Literature and documentation

Direct interview to the staff (WASAC representatives) with open ended questions were used to withdraw the information on the current and ongoing water production and management practices. The big part of data was obtained from WASAC annual reports and related documents on water supply projects with the objectives of having a look at how far clean water is produced and supplied in Rwanda. To help getting the thorough information and useful data, the literature review was done to read through different reports done by different actors in water resources management as well.

Data analysis: Data collected were computerized to make calculations and analysis with Microsoft offices windows offices (excels and words).Water production and water use data were statistically processed. The results were released and presented for further discussions. To help in reporting, percentages and averages were calculated. The results were presented in the tables and others on the charts.

RESULTS AND DISCUSSION

Statistics of customer's

Water and pricing mechanisms: A water rate schedule governs the price that is ultimately charged to individual customers for water services. Water suppliers, typical of public utilities, establish rate schedules not only to ensure efficient use of the resource by consumers, but also to achieve objectives related with equity, environmental efficiency, cost recovery, local acceptability, simplicity and transparency (OECD, 1987, 1999; Hanemann, 1998; Arbués and Villanúa, 2006).The current tariff for water use and related services in Rwanda was designed by WASAC to help in water billing for the efficient control over water usage. Table *2* shows this tariff and the monthly costs schedule for a given customer.

Biswas and Tortajada (2005) reported that in the last decade, institutional changes in the water-use sub-sectors, such as water supply and sanitation, have taken place. The separation of the functions of providing water services, from that of regulating the provision of such services, has been the cornerstone of these changes.

Yearly water production: With reference to the results in (Table 1) and (Table 3), there were increasing rates of customer demand which induced the increase in production. The increase from 118393 customers in the period of 2012-2013 to 175646 customers in the period of 2015-2016 has resulted into an increase in demand which led to the change in water production from 38818228 m^3 to 43558705 m^3 respectively in those periods. Water production, see *table 3*, was increasing on a slow rate. It is clearly observed that an increase, on average, of at least 1% was being added each period. Compared to increase in number of water users where 3% of water connections are added, this production is tending to be low for customers satisfaction. Population growth is a major contributor to water scarcity. Growth in populations means mounting demand and competition for water for domestic, industrial, and municipal uses. Water is also needed for agriculture and industrial use, and for the evacuation of waste materials.

The most water scarce or stressed areas are typically those with few water resources, high population densities, and high population growth rates. Population growth limits the amount of water available per person, drives people into marginal regions which are already water stressed and also into cities (FAO, 2007 and PAI, 2011). The upward trend shows how water production increase every year since the year 2012 to 2016. According to Oyekunle and Akinkunmi (2012) study, drinking water can be produced from any natural sources like ground water, lakes and rivers (surface water) or sea water. Drinking water standard are set by the world health organization/NAFDAC. Drinking water must be free of suspended solids, microorganism and toxic chemicals. MININFRA (2010) report for National Policy and Strategy for Water Supply and Sanitation Services stated that Rwanda has committed itself to reaching very ambitious targets in water supply and sanitation, with the vision to attain 100% service coverage by 2020. The importance of adequate water supply and sanitation services as drivers for social and economic development, poverty reduction and public health is fully acknowledged in Rwanda's flagship policy documents and political goals.

Periodic growth in water user connections: Rengel (2013) reported that almost 97% of the global water resource is saltwater, 2% is snow and ice, and only 1% is available as liquid freshwater. Freshwater is mainly available as groundwater aquifers, whereas less than 2% is in rivers and lakes. Only a fraction of that is accessible for human use: an estimated 9,000 to14,000 km^3 of water is economically available each year. This represents at most 0.001% of the estimated global water resources. The upward trends in water connections for customers show that the number of water users is increasing both on the side of households and other water users. According to MINIRENA(2011) report about National policy for water resources management, water resources of Rwanda face growing challenges arising from pressures of rapidly changing demographic patterns, the demands of intensified socio-economic development, degradation resulting from unsustainable and inappropriate land use practices; and the uncertainties created by climate change, among others. At the same time, the water resources are relied upon to meet many conflicting demands and play its full role in facilitating the achievement of the country's 2020 development vision.

From the results above, the number of water users is increasing at least 3% each period. This is evident from the fact that there is population growth, water demand for growth and economic development. According to PRB (1999) water is a renewable resource, but its rate of renewal depends on the global water cycle, which often cannot keep pace with human demands. Human impact on the flow and storage of fresh water, which makes up only one percent of the world's water resources, has been growing significantly for centuries. Diversions, dams, irrigation works, and reservoirs have all affected the quality and quantity of fresh water available. Population growth is a determining factor in water availability. The country's water infrastructure needs upgrading and its coverage increased. It is estimated that almost half of the water distribution networks suffers from leakage (MoEW 2010 and IFI, 2014). According to the findings, there are sixteen water treatments plants in control of Water and sanitation Authority (WASAC), these water treatment plants contributed to the production of 43558705 m^3 of water over four periods.

Table 1. Total customer connections

Period (Year)	Number of customers
2009-2010	82208
2010-2011	88724
2011-2012	102997
2012-2013	118393
2013-2014	135368
2014-2015	157320
2015-2016	175646

Source: WASAC (2016)

Table 2. Tariff for water use

Customer category	Block of Consumption	Applied tariff in FRW (VAT exclusive)
Public tap	Flat rate per m^3	323
Residential	0-5m^3	340
	6-20m^3	720
	21-50m^3	845
	Above 50m^3	877
Non-residential	0-50m^3	877
	Above 50m^3	895
Industries	Flat rate per m^3	736

Source: WASAC (2019)

Table 3. Changes in water production for over four years since 2012 to 2016

Periods(Years)	Amount of water produced	% water produced
2012-2013	38818228	23.30899
2013-2014	41966741	25.19956
2014-2015	42193934	25.33598
2015-2016	43558705	26.15548

Source: WASAC (2016)

Table 4. Percent increase in customers over four years (2012-2016)

Period (Year)	Percentage(%) of water users
2012-2013	20.17855
2013-2014	23.07172
2014-2015	26.81315
2015-2016	29.93658

Source: Author (2019),

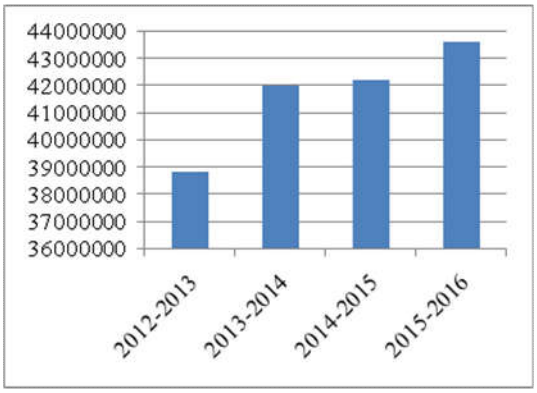

Figure 1. Amount of water treated

The rapid increase in number of connected customers shows that soon the current production will be far surpassed by water users. One can say that there are major water users who consume much water and this is likely to be causing the water shortage to the extent that there is a need for more water production to increase accessibility for all.

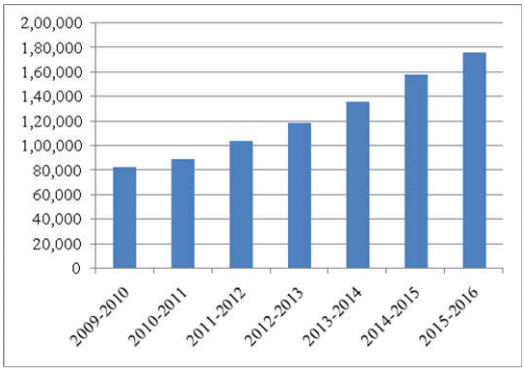

Figure 2. Trends in customer's connections

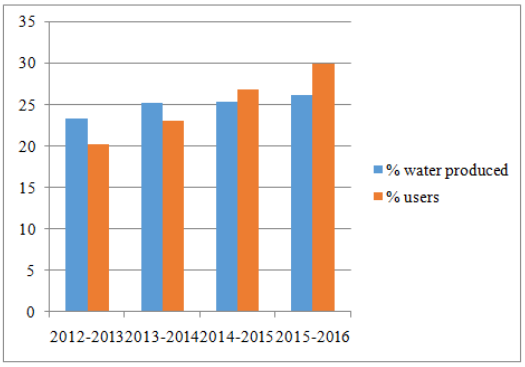

Figure 3. Water production Vs Water users growth

Additionally, Billings and Day, (1989) asserted that long-term residents may have acquired a large stock of water-using appliances and plantings or may have become apathetic toward water conservation. Some of the challenges impairing WASAC to produce and promote accessibility to water for the whole population include:

- Limited fund to implement high impact projects to achieve the 100% access to water supply services
- High cost of electricity which amounts to almost 45% of total OPEX
- High non revenue water
- Aged networks and treatment plants which need rehabilitation.

Economics of water pricing: According to Biswas and Tortajada (2005), there are many kinds of the commodity that we call water, differentiated by location, method of delivery, extent of treatment, reliability and other dimensions of quality. The costs of bringing these supplies to their users differ greatly, so it can be expected the prices charged to the users also differ. The OECD (2009) report highlighted that complex issues pervade political debates about water economics. One is the debate about the public versus private good dimension of different water services and how to deal with the externalities they produce. A second issue is the distinction between water resources and their management *vs.* water services and their provision. A related issue is how to ensure the financing of water resources management and water service provision, and the role of charges on water resources and tariffs for water services as a source of revenue and/or for other policy objectives. Actually, the charges for water use in Rwanda aren't generally reducing water accessibility. In fact, these costs are related to how water is used by different water users. The tariff is flexible and every customer is subjected to paying the costs equaling the amount of cubic meters of water used.

Table 2 shows the relationship between water consumption and prices related to the amount of water used per month. Costs increase appreciably whenever the amount of monthly water used goes up. Based on this evidence, pricing water in Rwanda can help to manage water and ensure efficient water use because water bills, once are higher, it is an inducement to the customers to decrease the rate of wasteful water use and also stimulate the water use efficiency so as to reduce the amount of monthly water bills by trying to look for other water use options such as rainwater harvesting, wastewater treatment, etc. Therefore, Billings and Day (1989) in their research about Demand Management Factors in Residential Water Use in Southern Arizona reported that the actual water bills paid by consumers reflect both rate changes and changes in use (conservation).

Water Supply Projects: According to the IBRD/The World Bank (2014) report, it is clearly stated that virtually every report on water supply conditions speaks about the lack of proper maintenance or the negative effect of "reduced" maintenance efforts, the potential for reducing high electricity costs, and the large volumes of unaccounted-for water. Tariffs never satisfy utility needs and the public always considers them too high (regardless of the level); nonpayment or late payment is the norm for many consumers. Despite this, it was highlighted that governments, the private sector, and water authorities continue to devote substantial resources to develop the water sector. These ongoing efforts are an attempt to guarantee the right to water services that was declared as a human right by the UN in 2009 (IBRD/The World Bank, 2014). Having been determined to ensure an efficient water supply with the objectives of increasing accessibility to water supply in Rwanda, the Water and Sanitation Authority with other partners working in water sector have a number of projects whose objectives are to alleviate water scarcity and increase the capacity of water facilities. Joints projects (i.e. between WASAC together with other partners) are initiated to help moving up accessibility and affordability to water services. Some (not all) of these projects include for example:

- Water Supply system (WSS) Project in Gatsibo District
- African Water Facility supports Rwanda to maximize water and sanitation investments
- Water Supply system (WSS) Projects in Rutsiro District
- The project to rehabilitate and optimize Nzove I and upgrade Nzove II
- Lake Victoria water project
- WASAC Projects on increasing access to clean water to 100%
- Water Supply system (WSS) Project in Nyaruguru District, etc.

Small water utilities are primarily concerned with water for potable use, which is basically for the home. Aside from drinking, other domestic uses include washing, bathing, cooking and cleaning. Other household needs might include tending and watering of home gardens and the upkeep of domestic animals (World Bank, 2012).

Conclusion

The production and supply of water in Rwanda is improving day to day. This evidence was withdrawn from the results of this research as one of the findings.

Although this water sector has started to improve, there still remain a very big concern raised by population growth where there are remarkable cases for pressure on water resources and the issues of sanitations in the areas with higher number of population with less water. Consequently, this limited the efficient accessibility to water and sanitation services because the number of users and economic activities which need water are still expanding. It is evident that every year 3% of new connections need to be added to the existing ones whereas the amount of clean water supplied is about 1% more added to the existing production capacity.

It is better to say that the accessibility to water services is led by the efforts of WASAC and stakeholders in water sector including the government support through joint projects implementation. This has contributed to water production from 38818228 m^3 of water to 43558705 m^3 in 2012 and 2016 respectively. Despite this, the number of customers connected is still low because it is seen that till 2016, the number of customers was 175646 in comparison to the entire population which is far beyond the connected customers (i.e. more than ten millions of people). This is caused by, as stated in WASAC challenges, limited fund to implement high impact projects to achieve the 100% access to water supply services.

Generally, pricing water has many implications in water accessibility and water infrastructures maintenance and management because the revenues from water contribute not only to water sector development but also to the maintenance and rehabilitation of water facilities, water supply systems and networks. It is therefore argued that pricing water is an incentive to people to help in dictating water use efficiency which helps in good water management. Charging prices for water helps to encourage people to play their role in efficient water use, water infrastructure protection and ensure the reduced costs for water infrastructure development and maintenance. Sensitization through different channels, media, Radio, meetings, etc is always a good way implied by WASAC in order to raise awareness among people about the importance of water and sanitation services so that there is sustainability in clean water supply and hygiene promotion.

Recommendation

The production of water and pricing has influence on clean water accessibility in Rwanda. But, as the challenges are still on alarm and prevent the total access to water for all, there are some needs to be taken into account for the management and of the existing water in order to keep on promoting the capacity existing water treatment plants so as to continue improving the water production and supply services.

- Strengthen the capacity of the existing water treatment plants to ensure they treat the sufficient volume of water on day to day basis
- It can be helpful to develop the systems for water user control in order to avoid water misuse and management.
- There is a need for continuous capacity building for the water users to help in harvesting and treating water for their home use rather than relying on tap water only.
- Cooperation among stakeholders to ensure the security (the case of illegal tap connections) and management of water infrastructure to avoid leaking.
- Prices for water should be an economic tool to promote clean water distribution from those revenues since pricing

water has implication in water infrastructures maintenance.

- Promote less water consuming economic activities and encourage businesses to develop water treatment techniques at their disposition to help in water recycling and reuse.

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