IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Human Journals
Research Article
March 2018 Vol.:9, Issue:1

Water Demand Management as a Solution to Water Resources Challenges in Rwanda

IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

BIZUHORAHO Theobald [1,*], ICYIMPAYE Gisele [1], NADIA Badr El-Sayed[1, 2]

[1]*Pan African University-Institute of water and Energy Sciences (Including Climate Change), Algeria. c/o Abou Bekr Belkaid University of Tlemcen B.P.119, Pôle Chetouane 13000 Tlemcen Algeria.*

[2]*Department of Environmental Sciences, Faculty of Science, Alexandria University, Moharrem Bek, Alexandria 21511, Egypt.*

Submission: 21 February 2018
Accepted: 28 February 2018
Published: 31 March 2018

HUMAN JOURNALS
www.ijsrm.humanjournals.com

Keywords: Water Demand Management; Population; Water resources; SWOT analysis tool; Rwanda.

ABSTRACT

The population of Rwanda is increasing rapidly, as well; socio-economic life is improving. Hence, water demand for satisfying their needs in agriculture sector, municipal sector, industrial sector and other sectors is increasing. This high water demand together with manmade activities causing numerous water resources challenges in different catchments. For sustainable water resources protection and exploitation, there is a need of feasible and appropriate water demand management measures. The general aims of this paper is to demonstrate how water demand management can be a solution to water resources challenges in Rwanda. With emphasizing on current water use and illustrating water demand based on the different level 1 catchment; describing the water resources challenges and identifying the measures taken by Government of Rwanda. The desk review was conducted to achieve the specific objectives of this paper. The results showed that there is a high increase of water use and demand hence the decided actions, laws, policies for efficient use of water; need a clear role of people participation in water demand management strategic measures. Using SWOT analysis tool of Water demand management measures, we proposed the defensive measures, offensive measures, and reactive measures for achieving better and sustainable water demand management.

1. INTRODUCTION

The population of Rwanda is increasing, as well as water demand. National Institute of Statistics of Rwanda (NISR),2012, reported that the population of Rwanda is expected to increase from 10.5 million in 2012 to 16.9 million in 2032 with the population density of 645 inhabitant per km2. As Rwanda is committed to ensure the availability and sustainable management of water and sanitation for all by 2030, as the Sustainable Development Goals state especially in its Goals 6 (Ministry of Infrastructure, 2016), it is mandatory to optimize Water Demand Management activities by solving the water resources challenges. Water Demand is defined as total water volume mobilized to meet the different uses excluding the green and virtual water; this includes the water lost during the distribution and use (Global Water Partnership, 2012). Water demand also includes all total water withdrawal and non-conventional water. Moreover, Water Demand Management is considered as the implementation of the policies and/or measures, which tend to control or affect the amount of water usage and lead to improve efficiency in production, transmission, distribution and use of Water (GWP, 2012).

All-over the world the three sectors namely Agriculture, Industrial and Municipal are the largest water demand sectors for fulfilling the basic needs of 7 billion of world inhabitants. According to Food and Agriculture Organisation (2016), global population increased 4.4 times over the last century while water withdrawal increased 7.3 times. As consequence, the global water withdrawal increased 1.7 times faster than world population. Currently, global water withdrawal ratio estimates 69% for agricultural sector, 19% for industrial sector and 12% of municipal sector. Particularly, In Africa over 80% of water withdrawal used in agriculture, 5% in industrial activities and 3% water withdrawal used in municipal sector (FAO, 2016). Generally, in Rwanda, as one of the East African Countries, in year 2000, around 68% of water withdrawal utilized in agriculture sector, 24% of water withdrawal used in municipal activities and 8% of water withdrawal used in industrial activities (United Nations Environment Program, 2010). This high water demand is putting pressure on water resources due to socioeconomic improvement of the population hence challenge water resources. One of the solutions for the water resources challenges is Water Demand Management in all sectors, for compromising the needs for the future generation. For better and sustainable Water Demand Management in Rwanda, different programs (EDPRS 2,

Vision 2020), Institutions framework, Legal, policies and Stakeholders, are all committed to manage water demand in order to solve water resources challenges.

1.1. Aim of study

As the population of Rwanda is increasing at rate of 2.37% (NISR, 2012), their socio economic development is being improved, which requires high water demand to satisfy their needs. In year 2012 water used was 238,280,000 m^3 (RNRA, 2014) while after two years (2016) water used was doubled to 499,468,512m^3 (Munyaneza, *et al.* 2017). This increase of water use and water demand is observed differently depending on human activities located in catchment levels. High water use and demand coupled with human activities are bringing the different challenges to water resources, which affect water demand for both current and future generation. In order to achieve the willingness of Government of Rwanda, of ensuring the availability of water and sanitation for all by 2030, there is a need of reinforced policies, laws and collaboration of Government institutions with stakeholders aiming at boosting the efficient water demand management to secure water for present and future population and reduce water resources challenges.

The main aim of this paper is to demonstrate how water demand management can be a solution to water resources challenges by benefiting the available strengthen and opportunities to overcome the weakness and threats to Water demand management in Rwanda by:

a. Assessing current water use and future water demand in level 1 catchment.

b. Describing frequent water resources challenges in Rwanda.

c. Identifying different water demand management measures taken by the Government in collaboration with different stakeholders.

1.2. Study Area

Rwanda is a landlocked country located in the Great Lakes region of the central eastern part of Africa. The rainfall is unevenly distributed in time and space across the country. The eastern plateau and low lands of the west party of country has rainfall distribution from 700 mm to 1400mm. Meanwhile, central party of country has rainfall distribution from 1200 mm to 1400 mm and the high altitude region has 1300 mm to 2000 mm. In terms of uneven

distribution following the time, the country has two rainy seasons and two dry seasons each year (MINIRENA, 2011). Average annual precipitation is 1200 mm, that plays significant role in recharging both surface and groundwater resources and contribute to the agricultural sectors as the 90% of Rwandan agriculture is rain-fed (MINIRENA, 2011). The long rainy season in Rwanda starts from February and ends in May with a heavy rain constituting about 48% of complete annual precipitation. However, the dry season starts from June to mid of August.

Rwandan water resources have two hydrological basin separated by Congo Nile ridge moving from North to South. Nile basin locates in the east party, occupies 67% of national territory, and drains 90% of country water in which its main rivers are Nyabarongo and Akanyaru, with their tributaries flowing to Akagera River, ends up in Lake Victoria (Figure 1). While Congo basin locates in the western party, represents 33% of Rwandan territory, and drains 10% of Country water flowing to Lake Kivu, through Rusizi River ends up to Lake Tanganyika (REMA, 2015). Around 8% of country surface area (26338km^2) is occupied by surface water resources including 101 lakes, 861 rivers and a network of disconnected wetland and other shared water resources with the neighboring countries (MINIRENA, 2011). Lakes Kivu, Bulera, Muhazi, Cyohoha, Ruhondo, Mirayi, Kilimbi and Sake form the major Lake and Akagera, Akanyaru, Nyabarongo Mukugwa, Muvumba, Kagitumba and Ruvubu for Nile Basin and Koko, Rubyiro, Ruhwa, Rusizi for Congo basin form major rivers (REMA, 2009).

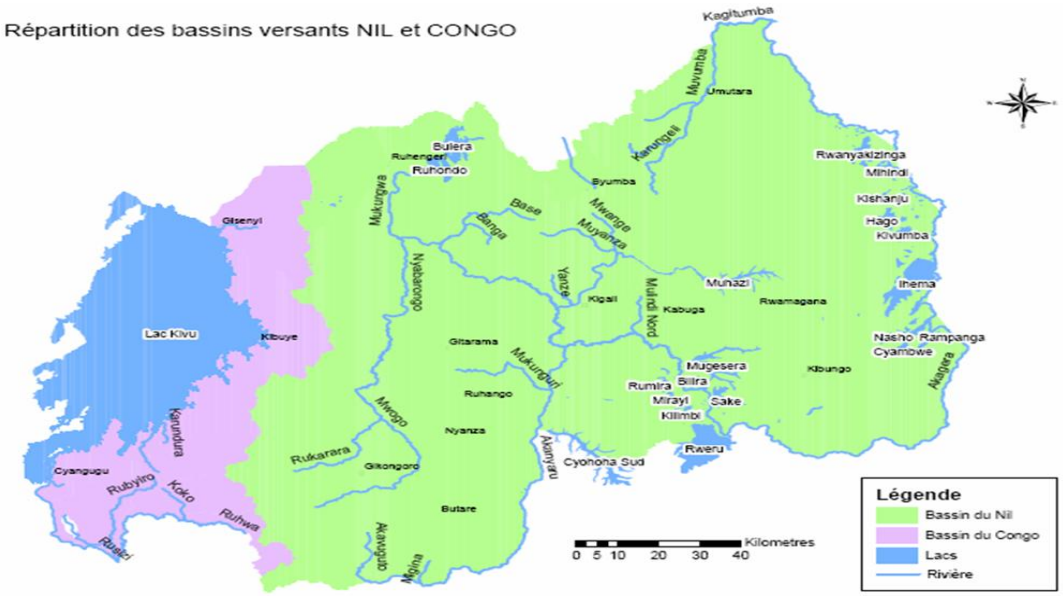

Figure 1: Main Rivers networks in Rwanda

Source: RNRA, 2015

Information on groundwater and aquifers of Rwanda is still incomplete but the estimated available underground renewable water resources is 66 m3/s and 22,000 known springs are recognized to contribute to output of 9 m3/s (REMA, 2009, 2015). Groundwater provide 86% of safe drinking water in rural areas as in the Eastern and South party of the country. Most people depend on borehole and by year 2009, 400 boreholes and wells were recognized in the country (MINIRENA, 2011). In addition, the water balance of Rwanda is affected by different problem in which high population growth and its reliance of subsistence agricultural practices, Urbanization and industrialization, intensification of agriculture continue to increase demand of water. Studies has projected that by the year of 2020, water consumption will massively increase due to infrastructure development and improved distribution to domestic, industrial and agricultural sectors (Warnest *et al.*, 2011).

2. METHODOLOGY

The methods used to conduct this paper is based on desk research of secondary data collected from qualitative data and quantitative data of government institutions and individual research published. Secondary data were used through desk reviews to know water use and water demand figures in level1 catchments and to describe water resources challenges hence to identify water demand management measures for overcoming water resources challenges to secure the present and future water demand. The secondary data for this research review was drown form Government institutions report in charge water resources management, individual research, and other institutions in charge of planning. The document reviewed were: National policy for water resources management, 2011; Water resources management sub-sector strategic plan 2011-2015; Consultancy services for Development of Rwandan National water resources master plan, 2014; Rwandan Water laws 2008; Ministerial law 2017, establishing Rwanda Water and Forestry Authority; Baseline study on water users and water uses in Level 2 catchments in Rwanda; Fourth population and housing census, 2012. Then the SWOT analysis tool was used to evaluate water demand management, as a way of proposing the solutions to the policymakers for solving the existed water resources challenges due to high water demand.

3. RESULTS AND DISCUSSION

3.1. Current Water Use in level 1 catchment

The Ministry of Natural Resources identified three most water users sectors in Rwanda namely: Agricultural, domestic and industry, in addition, there is fisheries, energy production, infrastructure, recreational and ecosystem maintenance. The calculation of water use and water demand is basing on the catchments levels. Rwandan water resources comprise 9 level 1catchments and 20 level2 catchments (Munyaneza, *et al.*2017). Catchments division is based on their Basin, surface water and groundwater hydrology (RNRA, 2014). In year, 2000 Agriculture activities consumed 68% of water used, 24% for domestic and 8 % for industrial activities (FAO, 2016). Meanwhile, total water withdrawn in year 2012 was 238,280,000 m3 (RNRA, 2014), while in the year 2016 total water used was 499,468,512m3 (Munyaneza, *et al.*2017).

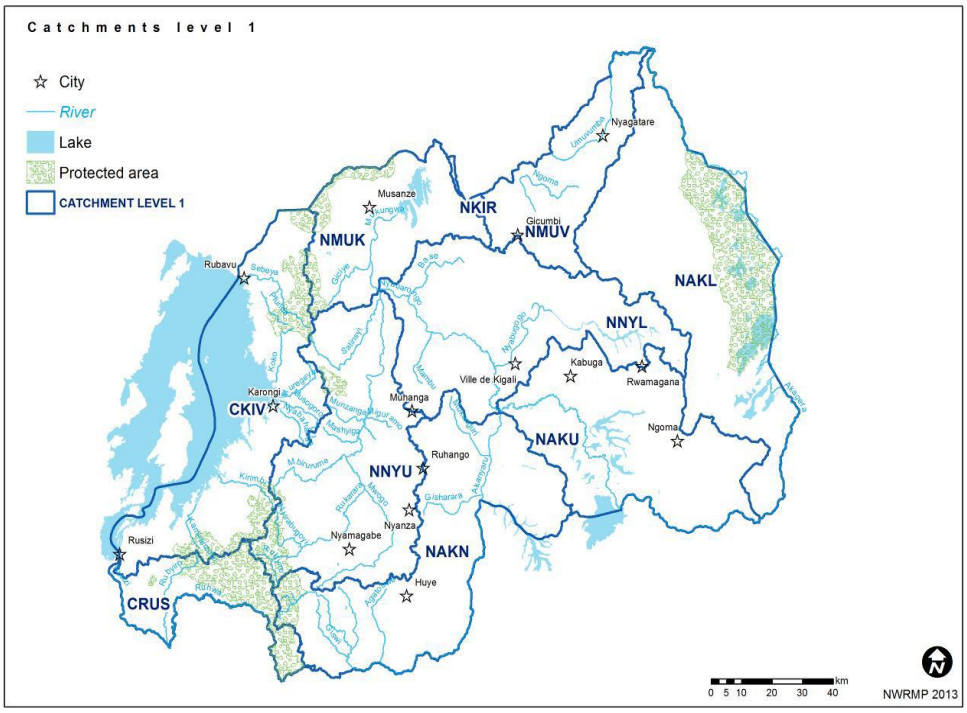

Figure 2: Level 1 Catchments division in Rwanda

Source: RNRA, 2014

The Fig. 2 shows, the level 1 catchments division. Both Lake Kivu catchment (CKIV), with an area 2,695km^2 and Rusizi catchment (CRUS) with an area 2,011km^2 are located in Congo Basin. While in Nile Basin there are: Upper Nyabarongo catchment (NNYU) with area

3,348km^2, Mukungwa Catchment (NMUK) has area 1,949km^2, Lower Nyabarongo catchment (NNYL) with the total area 3,305km^2, Akanyaru catchment(NAKN) with 5,328km^2, Akagera Upper catchment(NAKU) with area 3,053km^2, Lower Akagera(NAKL) is covering 4,288km^2 finally Muvumba catchment(NMUV) with 1,565km^2 (RNRA,2014). The study conducted in 2012 by RNRA, provided the data of water used in the different level 1 catchments, as graph 1 shows.

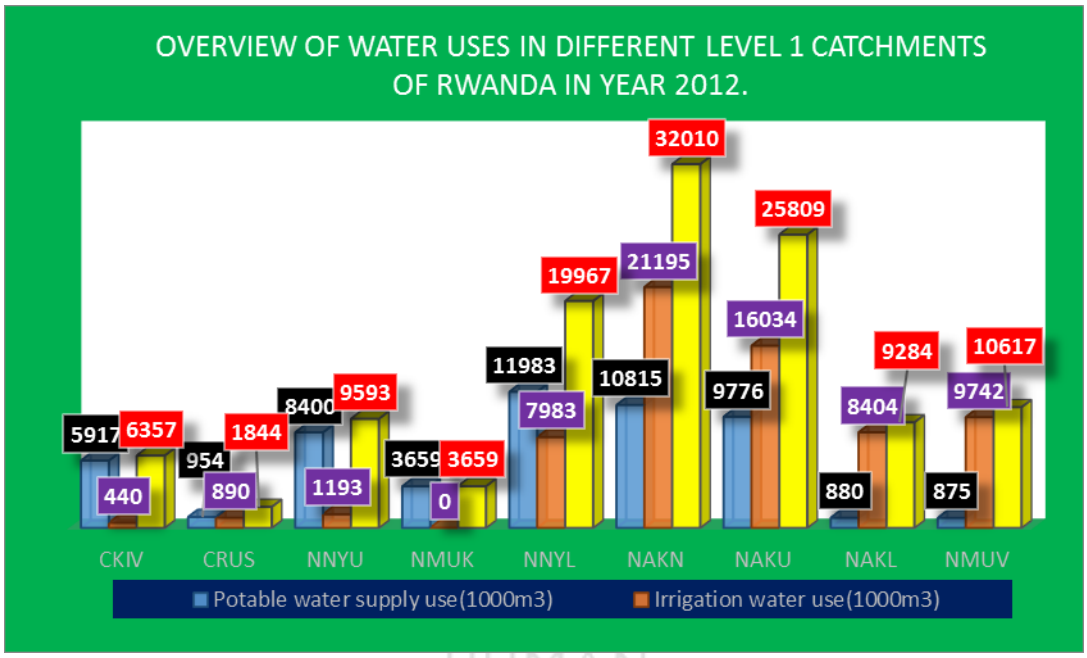

Figure 3: Overview of water use in the different catchments of Rwanda

Fig. 3 shows water used in the different level 1catchments per year 2012, where the most water users catchments are Akanyaru Catchment, followed by Akagera upper catchment then Nyabarongo Lower catchment, the least is Rusizi catchment. This is due to that, in Akanyaru catchment there is a big swamp areas and marshland developed that are using irrigation like Rwasave swamp and hillside irrigation on the radical terraces in Rwabicuma sector, Akanyaru catchment also comprises Amayaga region which is food silo of Rwanda. In addition, Akanyaru catchment has a huge number population density of 481.5inhabitant/km^2 (NISR, 2012). For Akagera Upper catchment, which is located in Eastern province with low rainfall and extended period of sunshine with fertile land and a big number of Cattles (Cows), this region has the different irrigation projects that are expected to be implemented on 589,000hectares during the EDPR2 phase (MINAGRI, 2014). Meanwhile high water consummation in Nyabarongo Lower catchment is due to that Kigali, the capital city of the Rwanda with population of 1,318,000 (NISR, 2012), is located in Nyabarongo lower

catchment. This population of Kigali for their daily life, they need potable water for drinking, washing water, flushing the toilettes, car washing, recreational water etc., this raise the quantity of water use in the Nyabarongo lower catchment. In addition, Kigali is one the fast growing and clean city in Africa; it is required to use much water for the cleanliness of the houses; hotels activities; watering the beautiful garden located in Kigali city, also most of the industries are located in Kigali that increase the water use in Nyabarongo Lower catchment.

3.2. Water Demand Projection in Rwanda

Water demand in Rwanda was estimated for the population of Rwanda for period of years 2012, 2020, 2030 and 2040, to satisfy their socioeconomic activities (RNRA, 2014). Water demand for urban water supply will vary from 60 litre/person/day in 2012 to 70 litre/person/day in year 2020; 80 litre/person/day in 2030 and 100 litre/person/day in 2040. On the other hand the rural water supply will vary from 40 litre/person/day in the year 2012; 60 litre/person/day in year 2020; 80 litre/person/day in 2030 and 100 litre/person/day in year 2040. While Water Demand for consumptive industrial activities will vary from 2 litres/capita/day in year 2012 to 5 litre/capita/day in 2020, 10 litre/capita/day in year 2030 and 20 litre/capita/day in the year 2040. In addition, to that, water demand for the coffee washing stations will be high in Kivu catchment with 375000m3/annum, followed by Nyabarongo, lower catchment, which will use 20100m3/annum of water for washing the coffee. Meanwhile, water demand for mining activities in the years 2012, 2020, 2030 and 2040 will be 1 litre/capita/day, 3 litres/capita/day, 5 litres/capita/day and 10 litres/capita/day, respectively. This water demand for mining activities may even be higher because most of the mining activities are still using the surface water resources and it is not monitored. In addition, the water demand for livestock in the different catchments of Rwanda will be 50 litre/head/day for the improved cow milk, while 8 litres/head/day needed for sheep and goats each one and for Swine will need 15 litre/head/day. Water demand for livestock may even increase more because the cattle are increasing day to day due to the different projects like Girinka (One cow per family) program, which increase the number of Rwandans who have cows, eventually they will need water (EDPR2013-2018). As the report of MINAGRI, 2011, the water demand for fisheries is 1000 m3/day/pond, with the water demand of 7 mm/day needed for evaporation and seepage in the year while around 1000 mm of the rainfall with an annual demand of 1500 mm/year in the fisheries activities. For rain fed agriculture, water demand is vital part of natural hydrological cycle and does not considered as consumptive

water demand in this period of 2012-2040. For irrigation water demand, the marshland development additional to water used in undeveloped marshland is 2,000 m3/ha/year. The irrigation, which use surface or groundwater resources, will vary from 6,000 m3/ha/year in western areas with the rainfall of 1200 mm/year while in eastern party, with estimated insufficient rainfall of 800 mm/year, the irrigation will use 8000 m3/ha/year. The water demand for the recreational activities, navigation, ecotourism and protected areas activities are assumed Zero during this period of 2012-2040 (RNRA, 2014).

3.3. Water use and withdrawal categories in Rwanda

In Rwanda, water use and withdrawal is still increasing day to day due to the increase of population and their social economic development of the people. The water resources management subsector strategic plan, categorises major water users into Agriculture sector, Domestic sector, and industrial sector, in addition, there are fisheries, energy, infrastructure recreation and ecosystem maintenance, which are minor water users c (MINRENA, 2015). The data provided by Baseline study on water users and water uses in level 2 catchments in Rwanda report, showed that water use is increasing day to day. In year 2016, the total water withdrawal, was 499,468,512 m3, with 7.3 water withdrawal-availability ratio (Munyaneza, *et al*, 2017), comparing total water withdrawal 238,280,000 m3 in year 2012 (RNRA, 2012).

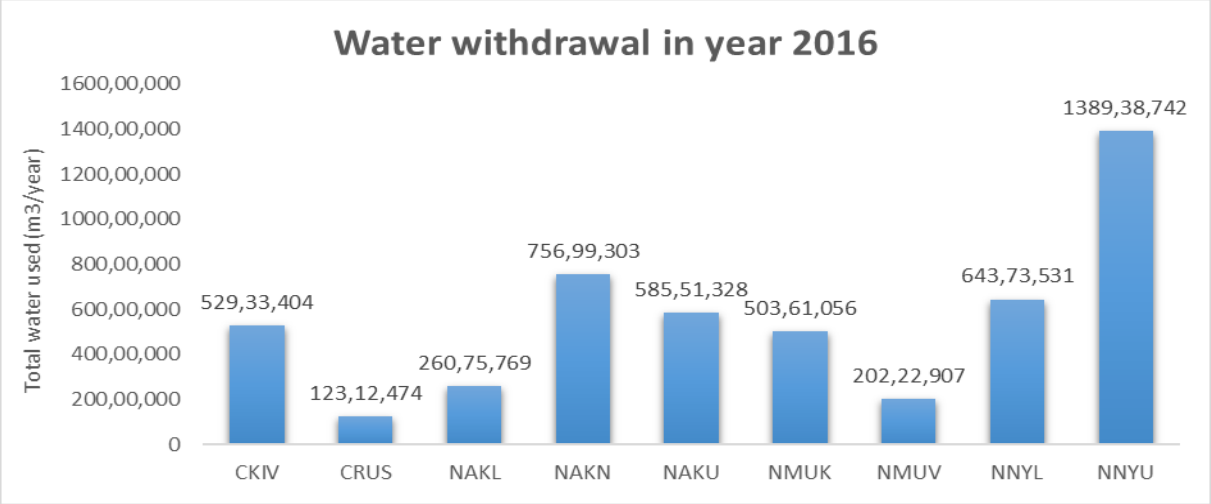

Figure 4: Level 1 catchments total water withdrawal in year 2016

Higher water total withdrawal in year 2016 was remarquably found in Nyabarongo Upper level 1 catchment (Fig.4), with water withdrawal-availability ratio 10.78 (Munyaneza *et al.* 2017). This is due to the hydropower plants constructed in the catchments, especially

Nyabarongo I hydropower plant located in Mushishiro sector, constructed on Nyabarongo River, which is largest hydropower, using 54.7m3/s, with power capacity generation of 28 MW (GoR, 2017). Akanyaru catchment had high water withdrawal-availability ratio 11.62 in year 2016 (Munyaneza et al, 2017), due to the irrigation schemes developed in this catchment.

In year 2016, generally higher water user sector was irrigation sector, with 222,328,965m3/year, which covers 44.5% of water abstracted in 2016. Hydropower production is second water user sector with total water abstracted of 157,982,746 m3/year, which is 31% of all water used in Rwanda. Water treatment plant used 54,076,940 m3/year; in addition, the spring sector used 39,118,224 m3/year, while Coffee Washing Stations used 1,948,637 m3/year. Manufacturing and industries used 7,279,233 m3/year, which is 1.4% of all water used in year 2016. On the other hand, the boreholes used 5,657,800 m3/year, whereas mining sector used 1,046,788 m3/year, which is 0.2%. The least water user sector is water ponds (Aquaculture), which is consuming 29,180 m3/year covering 0.006% of water, abstracted in Rwanda (Munyaneza, *et al*.2017).

3.4. Water resources challenges in Rwanda

Water resources are vital party to support the life and socio economic activities development. Nowadays, Rwandan water resources are facing the challenges due to population growth, pollution, urbanization, mining activities and climate change that degrade the quantity and quality of water resources.

Population growth: Rwandan population is increasing each year, which make pressure on the available water resources in terms of quantity and quality, this increase water demand that is not proportional to the population hence increase the use of unsafe water like lakes and rivers. Meanwhile, the projected population of Rwanda (Table 1) shows that Rwandan population will continue to increase on high rate this will have an impact on water demand (Droogers *et al.*, 2017).

Table 1: Projected increase of Rwandan Population

Year	High Population	Medium Population	Low Population
2023	13,688,000	13,547,000	13,135,000
2030	16,151,000	15,711,000	14,897,000
2050	23,393,000	21,923,00	19,960,000

Source: World Meter, 2017.

Water resources pollution: Water resources pollution is also one of the challenges of Rwandan water resources and it has a link with population growth, urbanization, socio-economic development. The research conducted from 2012 to 2013 in Nyabarongo lower catchment, which comprise Nyabugogo sub-catchment located Kigali city, showed how Nyabugogo River was polluted by manmade activities from Kigali city (Naphi, *et al*.2010). Therefore, Nyabarongo River flows into Akagera River finally to Lake Victoria. Consequently, Nyabugogo River constitutes a source of pollutants to the trans-boundary water resources. In Kivu catchment, high loads of sediments and high bacteria counts (RNRA, 2014) also affect River Sebeya. Most of the sediments flow into this river are from the Agriculture sediment and erosion from the highland of GISHWATI mountains.

Mining activities: Mining activities is a source of water resources pollution. In Rwanda, mining is still young industry, which is contributing to the economic development of the Country by providing foreign exchange and employment opportunities (Cole *et al.* June 2011). However, they cause deterioration of water quality due to the potential of heavy metals such lead, zinc, cadmium, copper that accumulate in the soil and enter the floodplains used for agricultures and irrigation activities hence pollute water resources due to inadequate exploitation and exploration techniques (REMA, 2015).

Urbanization: Urbanization has an effect on water resources, as the urbanization accompanied by improvement of lifestyles, increase of water demand for housing, recreational activities and sanitation services, all of this increase water demand and ends up by making pressure on water resources (MINIRENA, 2011). In Rwanda, the rate of urbanization is expected to increase from 16.5% in 2012 to 30% in 2032, this means that 1.7 million of population in 2012 to 4.9 million of population in 2032 will be in Urban area while the rural population will be from 8.7 million in 2012 to 11.4 million in 2032(NISR, 2012).

Water Aid reported that the, people living in urban slums are supposed to buy water from Non State Provider (NSP) which make them buy it, at high cost compared to the one fixed by the state Utility. In Sub Sahara Africa, between 30% -60% of urban population are served by NSP, as they do not connect to public water supply. In addition, urbanization involves the development of impermeable surface, which increases the runoff volume going to water bodies, and ends up by floods when the river capacity is exceeding and reduce the infiltration

capacity of catchment, therefore, reduce groundwater level and disturb stream outflow during dry season (Gatwaza *et al.*, 2016).

Climate change Impacts : Climate change is a global issue on water resources, it has direct and indirect impacts such as: flooding, drought, sea-level rise in estuaries, poor water quality for both surface and groundwater, drying up of rivers, rainfall and water vapour pattern distortions, snow and land ice mal-distribution(Urama *et al.,* 2010). Rwanda is experiencing flooding events accompanied with landslides almost each year in its different party generally the north, south and western parties due to heavy rainfall. In 2016, 49 people died due to flooding caused by heavy rainfall where the worst hit areas were Gakenke, Muhanga, Rubavu and Ngororero districts. This flood affected the quality of water resources as former EWASA Ltd changed into WASAC Ltd temporally postponed water treatment at Nzonve treatment plants due to heavy rainfall, which caused flood ends up by increasing turbidity of water. Therefore, during that time water supply has been interrupted in some areas of Kigali city (Floodlit, 2016). Rwanda is facing droughts especially in the eastern party, based on rainfall trend analysis of rainfall is demonstrating that wet seasons are tending to become shorter with high rainfall intensity. The prone areas are Kayonza, Kirehe, Nyagatare districts of eastern part of the country. This drought make that party to have less water for different activities such agriculture, water supply, hence people put pressure on water resources by increasing the pumping action of groundwater (Nzeyimana, *et al.* 2013). Finally, a raise the cost of water supplied and time spent at the tap in rural areas, hence the people tend to fetch water from the lake and other waterlogging.

Soil Degradation**:** Soil degradation is affecting negatively water resources in Rwanda; the sediments deposition affects the water resources quality. In Rugezi Marsh, which is a main component in Akagera river watershed as it serves a link between land and water resources, it is the most essential water tower of Ruhondo and Bulera lakes where 50% of inflow to the lake Bulera are from runoff generated by Rugezi marsh. Since Rugezi Marsh is located in the region of high mountains with the high risk of erosion and flood, ends up by soil degradation, accompanied with soil loss, which brings sediments in the lakes (Hategekimana *et al.*, 2015).

3.5. Water Demand Management strategies and policy in Rwanda

Water policy in all sectors of Rwanda, aims at improving operations efficiencies, equitable water allocation, reforming water Tariff, and water use permit and reduction of Unaccounted-

for water (UFW). To achieve the sustainable water management, they use the different strategies like water metering, sectorisation; water auditing; leakage detection control, and District Metered Areas (UN-HABITAT, 2006). To implement all listed strategies, we need consumer's awareness; adequate laws and legislation; stakeholders' participation; financial support; institutional framework; and technical framework aiming at water resources a

3.5.1 Institutions Framework

In Rwanda, there are the different institutions that are in charge of water resources management and regulating the water demand management in general. They are using Sectorial wide approaches (MINRENA, 2011). and water demand management

3.5.1.1 Institutions in charge of policy and oversight:

All the institutions are working under sectorial wide approach and multi-sectorial approach as well, for sake of securing enough water to the country and riparian water resources. Both Ministry of Natural Resources (MINIRENA) is with main responsibility of Ensure the WRM policy and strategy. In addition, WRM links the cabinet and communicate to the stakeholders. Prepare and defend the strategy budget; proposed institutional reforms of cabinet coordinate the resource mobilization; provide policy oversight and Ministry of Infrastructures (MININFRA) which is in charge of development of institutional and legal frameworks, National policies, strategies and master plan related to water supply and sanitation and transport subsectors (MINIRENA, 2011).

3.5.1.2 Financial institutions

The financial institutions finance the implantation of the programs, policies, strategies, and projects aim at water resources management. On National level, there is Ministry of Finance, Planning and economic development (MINECOFIN) which allocates and mobilizes the financial water resources development. In addition, there are development partners, which help in financial supporting as well and technical for implementing the water resources project development and capacity building (MINRENA, 2011).

3.5.1.3 Regulatory institutions

The regulatory institutions are in charge of monitoring activities and implementations of all projects that affect water demand and water resources. Rwanda Environment Management

Authority (REMA) is in charge of developing, ensuring the protection and conservation of the environment across the country. In addition, there is Rwanda Utilities Regulatory Agency (RURA), which enforces the agreement by public utilities with the laws governing their activities. Rwanda Bureau of Standards (RBS) Provide the standards based solutions for Consumer Protection and Trade promotion for socio-economic growth in a safe and stable environment (MINRENA, 2011). Finally, there is Rwanda Water Forestry Authority (RWFA); is in charge of implementing the policies, laws, strategies and government decisions related to the management of forests and natural water resource; to receive the check and advice on the applications of permission for the water use of water resources. To monitor the respect of conditions to get a permission for water use; to provide advice on determining fees to be paid for the use of natural water resources (PRIMATURE, 2017).

3.5.1.4 Management and Water Service Institutions

The management and water service institutions are in charge of managing water infrastructure, water payment services and offering the technical support for the water supply and water use. Water Sanitation Corporations limited (WASAC) provide quality, reliable and affordable water and sewerage services in Rwanda. Rwanda Development Board (RDB) facilitates the investment and support services to investors. Users' communities manage water resources in the course of their daily productive and consumptive activities. Private sectors design, construct, operate and maintain water resources management infrastructure; conduct training and capacity building for both central and local government staff, and provide other commercial services (MINRENA, 2011). EUCL (Energy, Utility Corporation) supervise water demand for hydropower plant. Rwanda Agricultural Board (RAB) regulate water for irrigation projects and dams construction and National Agricultural Export Board (NAEB), which regulates the water demand for coffee washing, stations (Munyaneza *et al.*2017).

3.5.2 Water Resources management Policy framework

National policy for water resources management takes water as finite resources; human right; economic good; social good; integrated water resources management; participatory management; catchment based water resources management and takes water as internationally shared water resources and considers the impacts of climate change to water

resources; (MINRENA, 2011). All those principles seek how water demand and water resources have to be managed sustainably.

Under legal framework, there is a law which aims at having water committee for managing water infrastructures, managing water demand by fixing water users fees and giving the permission to big water users institutions like irrigations companies and industries. The law No 62/2008 of 10/08/2008 putting the use, conservation, protection, and management resources regulations. In its chapter 3, article 22 to 25 defines the roles of water committee at district levels and water associations on the level of micro catchment. In its chapter 5-article 32 to47, defines the regimes of water use, the procedures for registration of any water users by showing the projects that will present EIA report and those, which will not need it before their implementation (MINRENA, 2008).

3.5.3. Different NGOs and stakeholders in water demand management in Rwanda

The leading international organizations, NGOs and stakeholders in water resources management in Rwanda are USAID, DFID, Living water internal, AfDB, JICA, Water for people and World Bank (Munyaneza, *et al*.2017). They help to increase capacity building, knowledge transfer and they help the government to implement the different policies and projects related to water demand management and give financial support. NGOs like Living water from 2007; it built more than 200 water projects around the country. USAID constructed the well that are helping more than 30,000 people in driest region of Rwanda to satisfy their water demand as well as educating them management of infrastructures built and improving public health (USAID, 2017).

3.6. SWOT analysis tool for Water Demand Management

SWOT analysis is strategic planning method to evaluate the Strength, weakness, opportunity and threats involving in project (David, 1993; Jones, 1990). It helps to identify the internal factors (Strength and Weakness) affecting an organization or institution and External factors (Opportunity and Threats) for developing a complete awareness of any situation and establishing suitable strategic planning and decision making (Erhard, 2005). The SWOT analysis of water demand management helps us to enumerate the defensive, offensive, and reactive measures to be taken for sustainable water demand management to the population of Rwanda.

Available strength:

-Existence of clear National water policies, laws and institutions for managing water resources and water demand.

-Favourable climatic conditions with high precipitation and dense hydrological network.

-Presence of water resources management master plan.

-Regional cooperation for managing transboundary water resources.

-Local; regional and National committee of water conservation and water demand management.

Opportunities:

•Improved of water infrastructures.

•Public interest for sustainable water demand management.

•Water harvesting technology subsidizes.

•Presence meteorology Rwanda in charge of hydrological data.

•Different favorable Government program (Vision 2020; VUP, EDPRS, UBUDEHE).

•Donors commitment.

Weakness:

-Poor meteorological data collection and availability.

-Lack of water supply, sedimentation, and wastewater production from the industries and urban area.

-Few researches in water demand management sector.

-Low number of people served by water supply network.

-Inappropriate agriculture practices

-Insufficient technologies and experts on wastewater treatment and discharge.

Threats:

•High population growth and Urbanization

•Insufficient of financial support

•Water resources pollution

•Soil degradation and soil erosion

•Flood and drought risks in the different catchment of the Country.

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

Rwandan water resources are facing challenges due to population growth, pollution, urbanization, mining activities and climate change that degrade the quantity and quality of water resources. To achieve the water demand for present and future population, we need to have strengthened measures and strategies aiming at water demand management. Their implementation need a cooperation; full integration of government institutions in charge of water demand management and people participation with the different stakeholders on every stage of strategy initiation and execution on every levels catchment for providing water with good quality and quantity. For the last decades, current water use and water demand shows that there is a significant increase. The use of SWOT analysis tool of water demand management proposed the solutions and measures to overcome the water resources challenges by profiting the available opportunities and strengths by avoiding the weakness and threats to water demand management.

4.2. Recommendations

The SWOT analysis tool used to show how water demand management as, a solution to water resources challenges helped us to draw the general recommendations, which are considered as proposed measures to achieve sustainable water demand management.

4.2.1 Reactive measures**:**

1. Establishing the buffer zone along natural water resources for reducing the sediment and pollution.

2. Rehabilitate the water supply and irrigation infrastructures.

3. Improving agriculture fertilizer's use by increasing the organic fertilizer and proper agriculture practices.

4. Informing the public and different stakeholders on the water demand management strategies implantation earlier.

5. Publishing all necessary water demand and water use data.

4.2.2 Offensive measures:

1. Implement the water resources master plan for satisfying water demand.

2. Implementing all measures for managing wastewater from urban areas.

3. Initiating the measures for wastewater reuse mostly in Agriculture

4. Controlling the implantation of the agreement of water use permit for avoiding over exploitation of water resources

5. Strengthening the laws and policies that control the waste discharge in water bodies.

4.2.3 Defensive measures

1. Respecting and following the proposed master plan both in rural and urban area.

2. Allocate the water supply regarding the hours for equity and equitable sharing of the available water supplied.

3. Negotiating the water price with all stakeholders and take decision together.

4. Increase the rainwater harvesting technology and initiating wastewater treatment technology and give the subsidies.

5. Decentralise all decisions that affect water demand and public awareness.

6. Raising awareness on Family planning.

5. REFERENCES

1. Cole, M. and Hogarth, R. Mining sector working paper. Oxford, United Kingdom: Hayes House; 2011.
2. David, F. Strategic Management, 4th Ed. New York, NY: Macmillan Publishing Company; 1993.
3. Droogers, P., Kruisheer, M., Boer, F., Terink, W., Mechteld, A. and Pelgrum, H. Water balance allocation and modelling in Rwanda report; 2017. Available on : www.futurewater.nl/wp-content/uploads/2017/05/WatBal_Rwanda_v06.1.pdf
4. Erhard K. Valentin. Away with SWOT analysis: Use of defensive/offensive Evaluation instead. The journal of applied business research-spring, Vol 21 number2. 2005.
5. FAO. AQUASTAT Main Database - Food and Agriculture Organization of the United Nations (FAO). Website accessed on [2017/10/08].
6. Floodlist.com/Africa /Rwanda –floods –landslides- Gakenke –Muhanga, on 7-8 May 2016. Available from: http://floodlist.com/africa/rwanda-floods-landslides-may-2016. [Accessed on 12/11/2017].
7. Gatwaza, O., Cao, X., Mukete, B. Impact of Urbanization on the Hydrological Cycle of Migina Catchment. Kigali Rwanda; 2016.
8. Global Water Partnership. Water demand management, Mediterranean experience: Ljungbergs: Scriptoria. 2012; pp.19.
9. Government of Rwanda. President Kagame inaugurates Nyabugogo I hydropower plant to power Economic Transformation. Kigali, Rwanda: Government of Rwanda (GoR);2015.
10. Hategekimana, S. and Twarabamenye, E. The impact of wetlands degradation on water resources management in Rwanda: the case of Rugezi Marsh: Kigali, Rwanda; 2015.
11. International Monetary Fund (IMF). Regional Economic Outlook-Sub-Saharan Africa-Keeping the Pace; 2013. Available from: http://www.indexmundi.com/g/g.aspx?c=rw&v=66 [accessed on 11/10/2017].
12. Jones, B. Neighbourhood Planning a guide for citizens and planers. Planners press American planning association: Chicago and Washington DC; 1990.
13. Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda. Strategic plan for transforming Agriculture in Rwanda; 2012. Available from: www.minagri.gov.rw. [Accessed on 07/12/2017].
14. Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda. Master Plan for fisheries and Fish Farming in Rwanda. Kigali, Rwanda. 2011.
15. Ministry of Finance and Economic Planning (MINECOFIN), Rwanda. Economic Development and Poverty Reduction Strategy 2013-2018. Shaping our Development- Government of Rwanda; 2013. Available from: http://www.minecofin.gov.rw/index.php?id=149 [Accessed on 16/10/2017].
16. Ministry of Infrastructure (MININFRA), Rwanda. Forward-looking joint sector report (FLSP) Water and Sanitation sector 2016/2017. Kigali, Rwanda; 2016. Available from: http://www.mininfra.gov.rw, [Accessed on 08/11/ 2017].
17. Ministry of Natural resources (MINIRENA), Rwanda. Water resources management subsector Strategic plan 2011-2015. Kigali, Rwanda; 2011. Available from: www.minirena.gov.rw [Accessed on 9/10/ 2017].
18. Ministry of Natural Resources (MINRENA), Rwanda. LAW N°62/2008 of 10/09/2008 putting in place the use, conservation, protection and management of water resources regulations. Kigali, Rwanda; 2008. Available from: www.minirena.gov.rw [Accessed on 18/10/2017].
19. Ministry of natural resources (MINRENA) Rwanda. National policy for water resources management. Kigali, Rwanda; 2011. Available from: www.minirena.gov.rw/fileadmin/.../Water/IWRM_Policy-final-December_2011.pdf [Accessed on 16/11/2017]
20. Munyaneza, O.; Bukombe, B. Baseline study on Water users and water uses in level2 catchments in Rwanda. Kigali Rwanda: Final report; 2017.
21. National Institute of Statistics of Rwanda (NISR), Ministry of Finance and Economic Planning (MINECOFIN) Rwanda. Fourth Rwanda Population and Housing Census. Thematic Report: Population Projections; 2012.
22. Nhapi, U.G., Wali, B., Uwonkunda, K., Nsengimana, H., Banadda, N. and R. Kimwaga .Assessment of Water Pollution Levels in the Nyabugogo Catchment, Rwanda;2010.
23. Nzeyimana, I. and Kwitonda, P. Drought conditions and management strategies in Rwanda; 2013.

24. Office of Prime Minister (PRIMATURE) Rwanda. Law no 06/2017 of 03/02/2017 establishing Rwanda water and forestry Authority and determining its mission, organisation and functioning; 2017. Available from: www.primature.gov.rw/.../latest-official gazettes.html?no...1... [Accessed on 19/11/2017].
25. Rwanda Environment Management Authority (REMA). Rwanda state of environment outlook report: Kigali, Rwanda; 2009.
26. Rwanda Environment Management Authority (REMA). Rwanda state of environment and outlook report. Thematic report: Greening agriculture with resource efficient, low carbon and climate resilient practices; 2015.
27. Rwanda Natural Resources Authority (RNRA). Consultancy Services for development of Rwanda National Water Resources Master Plan, Main volume: Kigali Rwanda; 2014.
28. Rwanda Natural resources authority (RNRA). Rwanda water resources Master Plan. SHER ingenieurs-conseils: Kigali Rwanda; 2014.
29. UNEP. Africa Water Atlas". Division of Early Warning and Assessment (DEWA). Nairobi, Kenya: United Nations Environment Programme (UNEP); 2010.
30. United Nations-Human Settlements Programs (UN-HABITAT). Water demand Management Strategies and Implementation plan for Jabalpur: Nairobi, Kenya; 2006.
31. Urama. K. and Ozor, N. Impacts of Climate Change on Water Resources in Africa: The Role of Adaptation', in Africa Technology policy studies network; 2010. Available from: https://www.ourplanet.com/climate-adaptation/Urama_Ozorv.pdf. [Accessed on 29/08/2017].
32. USAID. USAID works to improve the sustainable management of Rwanda's water resources for food security, health, and climate change adaptation; 2017. Available from: https://www.usaid.gov/rwanda/water [accessed on 14/10/2017].
33. Warnest, M. and Hogarth, R. Water sector working paper. Oxford-United Kingdom: Hayes House; 2011.
34. World meters. World Population Projection; 2017. Available from: http://www.worldometers.info/world-population/rwanda-population/ [accessed on 17/12/2017]
35. Ministry of Finance and Economic Planning (MINECOFIN). Economic Development and Poverty Reduction Strategy 2013-2018''. Shaping our Development- Government of Rwanda; 2013. Available from: http://www.minecofin.gov.rw/index.php?id=149 [Accessed on 16/11/2017].