

# Sustainable Integrated Management Framework for Water Resources (SIMFWR) in Africa Arid Regions

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## Abstract

Water resources shortage and scarcity continue to be a major challenge in Africa arid regions due to climate change, population growth and urbanization. Considering these challenges, there is a need for sustainable management of the available water resources in these regions. Lack of implementation of sustainable integrated management framework for water resources, ineffective human resource capacity and limited efficient water infrastructure are the challenges face by most African arid regions for managing water resources. Investment in research, continuous capacity building of human capital and improved technology will mitigate the impacts of climate change, and associated challenges for water resources in Africa arid regions. In this paper, a sustainable integrated management framework for water resources (SIMFWR) has been developed for the available water resources in Africa arid regions based on the review of relevant literature. At the core of the framework, an integrated management system is designed for the available water resources and said system is girded with the components, and managerial tools that local and national governments can use as compliance factors for sustainable water planning and management. The various actors that can influence the unruffled implementation of the system due to conflicting desires and objectives are considered. The framework can serve as a tool for informing local and national governments as to their challenges and opportunities in water planning and management and can also inform decision-makers where improvements are necessary.

**Key words:** Water resources management, Africa arid regions, sustainable management, environment components, Actors/stakeholders

## 1. Introduction

Water resource availability remains a challenge in Africa due to its shortage and scarcity in most of its regions. Africa Arid regions continue to be victims as a result of this challenge. This striking challenge can be linked to many factors but a majority of these are the results of climate change, population growth and urbanization which are posing numerous threats to natural resources including water resources in Africa arid regions.

Mediterranean Africa is likely to experience as much as 20% drying by the end of the 21<sup>st</sup> century with hotter summer temperatures and decreased precipitation and increased likelihood of summer drought (Thomas, 2008). After Australia, Africa is the world's second driest continent. With 15% of the global population, it has only a percent of global renewable water resources. Africa's water availability is also constrained by its ground water resources, which represent only 15% of total renewable water resources, but supply about 75% of its population with most of its drinking water (UNEP, 2010). Water is the most crucial element in ensuring livelihoods since more than 40% of Africa's population lives in arid, semi-arid and dry sub-humid areas (UNEP, 2010b).

About 66% of Africa is arid or semi-arid and more than 300 of the 800 million people in sub-Saharan Africa live in water scarce environment meaning that they have less than 1000m<sup>3</sup> per capital per year (UNDESA, 2012). Africa faces endemic poverty, food insecurity and pervasive underdevelopment with almost all countries lacking the human, economic and institutional capacities to effectively develop and manage their water resources sustainably (UNDESA, 2012b).

The major challenges faced by most arid countries in Africa are the lack of sustainable integrated management framework for water resources, the lack of human resource capabilities, water infrastructures and inadequate funding to augment its water sector. This study is aimed at developing a sustainable integrated management framework for water resources (SIMFWR) and highlighting the components that must be considered by local and national governments for developing a sustainable management framework to improve Africa's water sector in term of sustainable management.

## 2. Challenges of water resources in Africa arid regions

### 2.1 Natural factors - Climate change

Climate change amongst other factors remains a major challenge to the available water resources in Africa arid regions. Evidence suggests that the adverse impact of climate change on agriculture is exacerbated in Africa by the lack of adapting strategies, which are increasingly limited to the lack of institutional, economic, and financial capacity to support such actions. This has the potential to lead to worsening food crisis and vulnerability among smallholder farmers on the African continent (Langyintou, 2011). According to Langyintou, a better

understanding of the potential impact of the current and projected climate change in African agriculture and to identify ways and means to adapt and mitigate its detrimental calls for the development and implementation of drought policies in Africa.

Hydrologists model Africa's surface water systems using data sets describing precipitation, temperature, evapotranspiration, topography, soils and human made diversions and impoundments. Recent research has used processes across the African continent, and in turn, to better estimate vegetation water use. Fig I show a water balance map (rainfall minus the lost to evapotranspiration). The red hatching shows areas within Africa's arid and semi-arid regions. These are areas in which food security is most tenuous in Africa (UNEP, 2010).

In fig I, it can be seen that North Africa and part of West Africa are areas with many of its estimates having no water balance data. Water balance data are essential for informing policy makers as to where opportunities can be exploited. The Greater Horn of Africa is challenged by aridity and large rainfall deficit. In summary, the three most challenges face by the African arid regions are large rainfall deficit, no water balance and aridity. These are a direct consequence of climate variability in these regions.

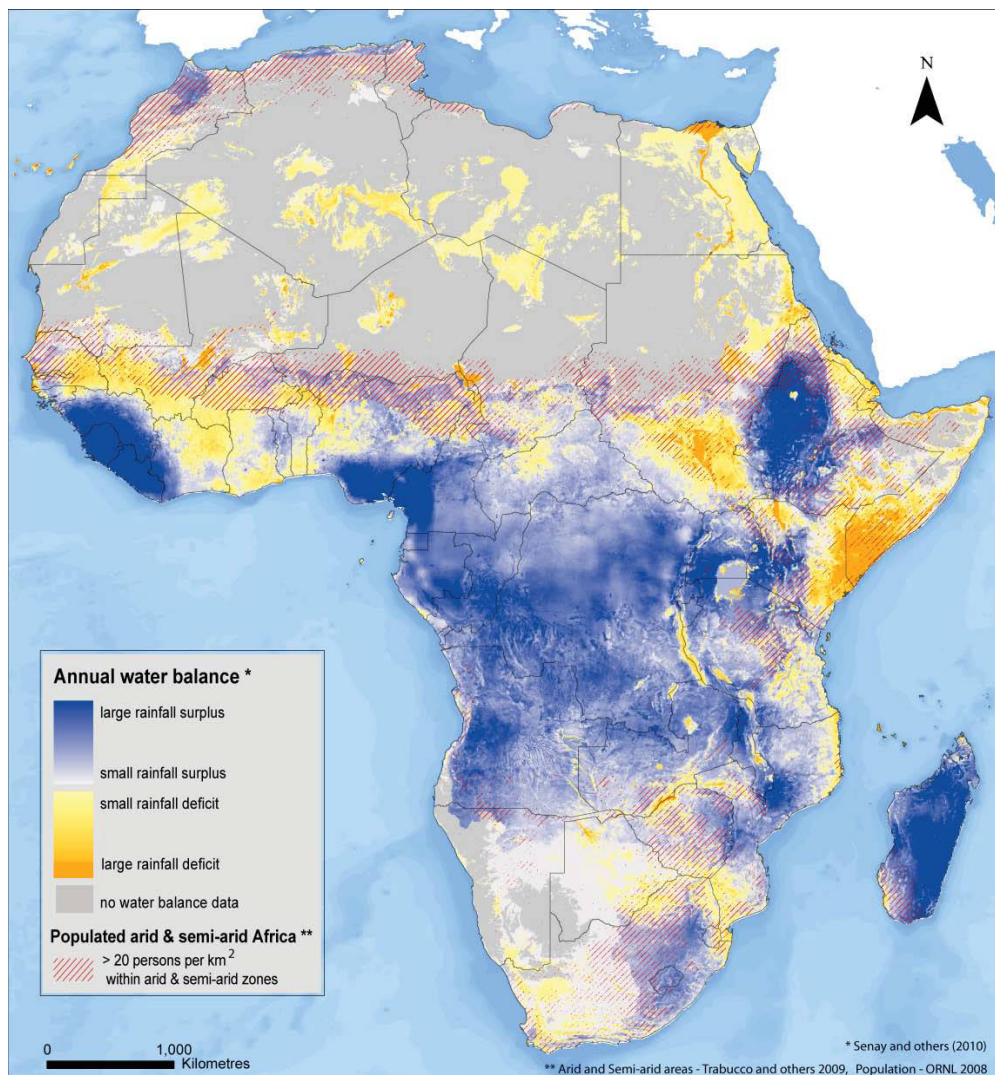


Fig I: Annual water balance is an estimate of the available runoff after evapotranspiration –water that is potentially available for water harvesting (Source: UNEP, 2010).

It has been established that the climate change in the next hundred years will be due to anthropogenic activities. The areas that are now dry-humid, semi-arid and arid will become semi-arid, arid and desert respectively (Matondo, 2012). Matondo has also pointed out that climate change would force people in drought prone areas of South Africa to abandon agriculture permanently in the next 50years. According to Matondo's study, some nations of southern Africa (Angola, Botswana, Lesotho, Malawi, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe) could lose about 30% of their staple food, maize, by 2030.

## 2.2 Human factors – Population growth

By 2050, Africa is forecasted as the second populated continent in the world. Population growth in Africa is creating pressure on the limited water resources. In rural communities, inhabitants are competing for the use of the limited available water sources. For example, the availability of renewable water resources in the North Africa regions has been just above 1000m<sup>3</sup> per capital per year, a level that is regarded as representing “water scarcity”. In the arid and semi-arid countries of the region, where trans-boundary river flows do not contribute significantly, ground water is the principal renewable water resource being used for domestic, industrial, agriculture and environmental purposes (MCIWEM et al. 2008). Most threats to water resources in general are as a result of poverty among the rural population, whose status often forces them to exploit whatever natural resources they can gain access to for their livelihood without much consideration for issues of sustainability in the long-term (Rubarenzya, 2008).

Africa’s rising population is driving the demand for water and accelerating the degradation of water resources. People in Sub-Saharan Africa live in a water scarce environment meaning that they have less than 1000m<sup>3</sup> per capital per year. By mid-2012, Sub-Saharan Africa population was around 902 million and its average natural rate of increases was 2.6% per year compared to the world average of 1.2%. By one estimate, its population will grow to 1,245 million by 2025 (UNDESA, 2012). This is an alarming challenge for the current and future water resources as the predicted demand for water by 2025 will be around 1380m<sup>3</sup> per capital per year. This calls for urgent planning and sustainable management.

## 2.3 Society developing factors - Urbanization

Over the next 20 years, Africa’s urban population will double. At 3.9 percent per year, urban population growth rates in Africa have been and will continue to be the highest in the world. Currently about 320 million Africans live in urban area which constitutes 37 percent of the African population, more than twice as many as in 1990. By 2030, Africa’s urban population is forecasted to rise to almost 50 percent of the population (Jacobsen et al. 2012). According to Jacobsen et al. 2012, African cities are growing quickly, and their current water management systems cannot keep up with growing demand. A concerted effort on the part of decision-makers is needed across sectors and institutions to find a way to provide sustainable water management for African city dwellers.

Owing to more facilities and opportunities being concentrated in most African urban communities, rural community’s dwellers are migrating from rural to urban cities which are also posing pressure on the limited water resources available for urban dwellers. Africa is yet to explore its industrial potential. With the growing development, industries in the urban areas will create a much more pressure for water resources. A foremost challenge for urbanization on water resources in Africa is the lack of efficient water management systems, the lack of efficient water infrastructure and poor quality of water due to poor treatment systems for unsafe water resources.

# 1. Review of water resource management practices in Africa arid regions

## 3.1 Ancient periods

The management practices employed by most African nations considering rural and urban practices evolved from traditions and cultural heritage. With the transitions of the various revolutions (Agricultural and Industrial), some nations have adopted new management practices while many rural communities in Africa arid regions still practice their traditional approach to water management. These traditional approaches though seem pleasant to rural communities as they are inherited practices from ancestral background, many are not sustainable in nature. Even developing and developed African arid nations with “sustainable integrated management practices” for water resources still faced numerous challenges in meeting water goals. There is a need to review these management practices and where necessary improve the current management practices in combating climate change, population and urbanization growth for meeting future demand of water resources in Africa arid regions.

For example, agriculture has been the major source of livelihood for most African arid nations and still continues to be the source of livelihood. Water management practices by rural farmers were based on observance of the changes in celestial bodies in harvesting water for seasonal use. Earth canals, ponds and water wells were used to conserve water for the dry seasons. Such observance of celestial bodies enables ancient African farmers to grow seasonal crops in relation to water availability.

## 3.2 Periods between 1960 –1990s

The emergence of the industrial revolution brought some changes in water management practices with irrigation

systems being designed to aid the conservation of water resources for farming purposes and domestic use. Over the years from the 1960s to the latest part of 1990s there have been some changes in the management practices in some African arid countries with the construction of irrigation systems, large dams such as the Akosombo dam in Ghana, the Aswan high dam in Egypt, the Kainji dam in Nigeria, the Kariba bordering Zambia and Zimbabwe and the Manatali dam in Senegal which have contributed to reducing death rate due to unsafe water being provided in the past. In the past, African governments shouldered the responsibility of making all necessary decisions as with planning and management of water projects thereby compromising the inclusion of the rural or illiterate population into the decision making process which is still being employed by some decision makers. A sustainable management framework to adequately manage water resources had been lacking in most arid regions in Africa and is still not available in some regions.

### 3.3 Current century periods

The shift toward the paradigm of integrated water resource management has never been triggered in Africa despite the numerous international experts meeting in the past on sustainable water management until 2002. Rahaman and Varis (2005), there have been numerous international meetings in integrated water resource management dating back to the Mar del Plata, Argentina conference in 1977, the International Conference on Water and the Environment held in Dublin, Ireland, January 1992, the World Water Forum and Ministerial Conference held in The Hague, 2000.

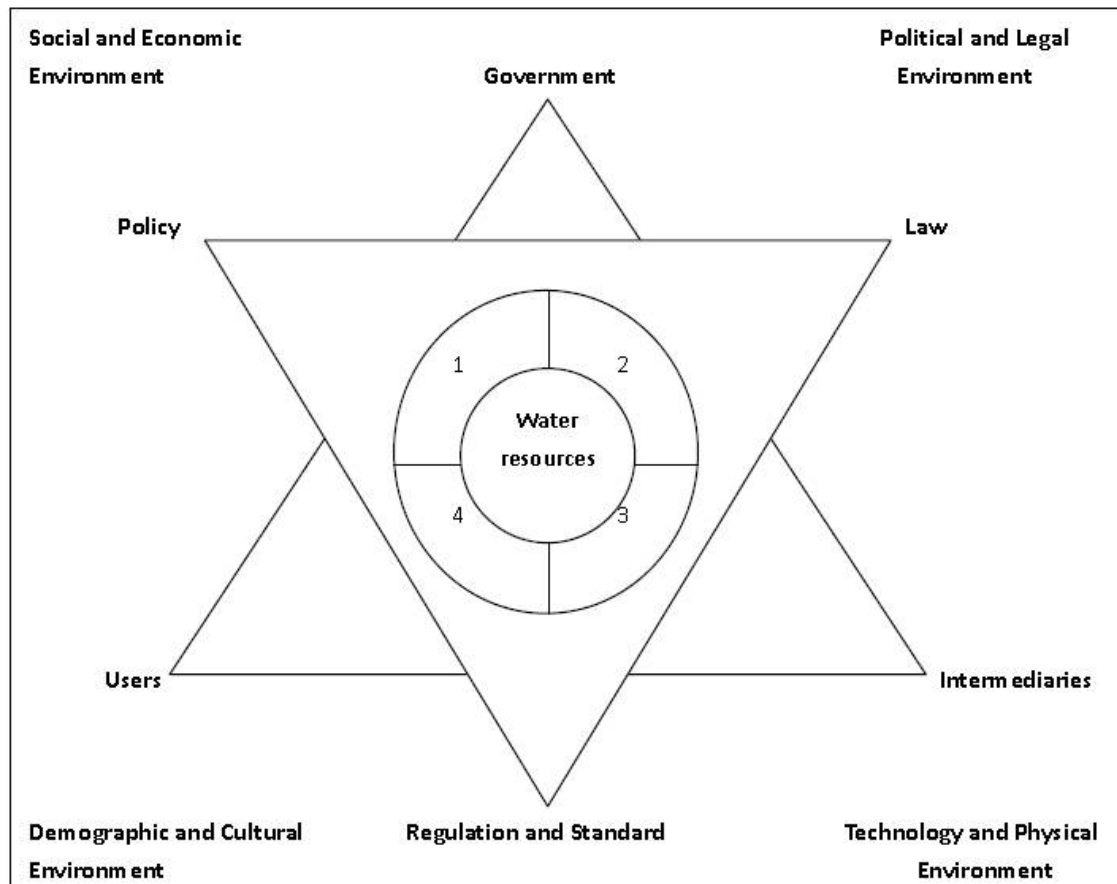
With all these meetings, most of Africa's water stressed regions still struggle to adopt integrated water resource management practices. The World Summit on Sustainable Development (WSSD) held in Johannesburg South Africa, 2002, triggered the concept of integrated water resource management in most African nations and its water stress regions. The WSSD's Plan of implementation includes integrated water resource management as one of the key components for achieving sustainable development. It provides specific targets and guidelines for implementing efficiency plan for all major river basins of the world; developing and implementing national and regional strategies, plans and programs with regards to integrated water resource management; improving water-use efficiency; facilitating public-private partnership; involving all concerned stakeholders in a variety of decision making, management, and implementation processes, enhancing education; and combating corruption. Though some African water stress regions have adopted the integrated water resource management practices for sustainable water use, there are still numerous challenges for many arid regions in Africa for the realization of sustainable management practices for natural resources including water resources. The lack of adequate plans and funding for water projects; limited human resource capabilities, high social disintegration between rural and urban communities in relation to water resources provision, rising population, with much of the population facing striking poverty for access to safe drinking water are amongst the numerous challenges. The development and implementation of a sustainable management framework for water resources in these arid regions of Africa considering the African environment and the gap between social and economic environment, demographic and cultural environment, technology and physical environment; and political and legal environment are crucial to sustainable management of water resources.

## 2. **How to build a proper Sustainable Integrated Management Framework for Water Resources in Africa arid regions**

Based on the extraction of qualitative and quantitative data from peer reviewed articles, and reports from the World Environmental and Water Resources Congress (1995-2012) on Africa arid regions; the review of the scientific literatures on water resources management in Africa arid regions and the Africa Water Atlas (2010), provided an insight on the past, present and trends of integrated water resource management in Africa from which a management framework has been developed for the available water resources in Africa arid regions.

Africa has 63 shared water basins, so it is a challenge to address potential conflicts over transboundary water resources. There is also an opportunity to improve water use productivity rather than develop new sources. Africa hydropower development potential is greater than the entire continent's needs (UNEP, 2010).

The below framework in fig 2 highlights the foremost actors/stakeholders in an integrated water management system which are label along the normal triangle and the components that are essential for successful and sustainable management of water resources in arid regions of Africa which are also label along the square. The inverted triangle represents the tools for a sustainable water management framework and the circles are considered the technical system for water resources distribution and control pending the adequate assessment of the components and the involvement of all relevant actors. The scrutinizing and assessment of these components; and the involvement of all relevant actors can enable local and national governments to have an understanding of their challenges and opportunities and where improvement is necessary for sustainable management of the available water resources in Africa arid regions.



**Fig 2. Proposed Sustainable Integrated Management framework for Water Resources**

1. Water resources information system, 2. Water resources planning system, 3. Water organization and implementation system, 4. Water control system

#### **4.1 Environment components of water resource management framework**

##### **4.1.1 Social and Economic components**

Drought in Somalia, Kenya, and Djibouti pushed tens of thousands of people from their homes as millions face food insecurity. About 12 million people were desperately in need of food assistance across the Horn of Africa, as the worst drought in 60 years continues to ravage eastern Africa. Severe droughts persisted over most parts of the eastern sector of the equatorial Greater Horn of Africa since the last quarter of 2010 with far reaching socioeconomic implications that include lack of water, pasture, energy and food (Sivakuar, 2011).

Agriculture is the mainstay of African economies, accounting for over 45 percent of the gross domestic product (GDP) and 60 percent of export earnings, an estimated 76 percent of the 987 million Africans living in the rural areas are employed in agriculture. Increase chances of conflict over commodities, water resources, and fertile lands can be triggered if there is a lack of understanding of socioeconomic factor in a drought policy of water resources in absolute term. Livestock is a store of wealth within African rural communities so if decimated by water stress, households lose assets and their purchasing capacity diminishes (Langyintou, 2011).

The gap between social and economic status for most African rural dwellers in the arid regions is still alarming as compare to those in urban communities. Sub-Sahara Africa is the world's poorest and least developed region, about two-third of its countries rank among the lowest in the Human Development Index. Among the developing regions, Sub-Sahara Africa is estimated to have the highest prevalence urban slums and it is expected to double to around 400 million by 2020 (UNDESA, 2012). Minimizing the social index gap between rural and urban communities can reduce human adverse action on water and other resources due to improved living standards.

The right of water implies economic cost that must be recovered to ensure the continuity of the service through the sustainability of public, private, and community-based service provider. Giving financial responsibility to local stakeholders creates an opportunity for additional resources, and improved governance; this has to go in hand with clear roles, capacity strengthening and regulation and monitoring (Nguyen-Khoa et al. 2012). In plainspoken terms, knowledge of the social status of the inhabitants and the economic drivers can mean developing a sustainable water management system or a short term system.

#### 4.1.2 Political and Legal components

The political system of a country shapes its legal system. As such, there is a need to understand the nature of different political systems. By political system, it means the system of government of a nation. Political system can be assessed according to two dimensions. The first is the degree to which they emphasize collectivism as opposed to individualism. The second is the degree to which they are democratic or totalitarian. The legal system of a country refers to the rules, or laws, that regulate behavior along with the processes by which laws are enforced and through which redress for grievances is obtained. The legal system is influenced by the prevailing political system (Hill, 2009).

The political and legal environment should create means for which institutions are empowered to regulate the use of the available water resources. For example, Still et al. (2010) in their study of water conservation by South African domestic and commercial users indicated that it is against a municipality's interest to persuade it customer to use water efficiently and to penalize them financially for high water use, as water sales are a prime source of income for local government structure in urban areas. UNDESA (2012), one other challenge Africa face is the lack of coordination among authorities, stemming from an unclear definition of roles and responsibilities, couple with lack of harmonization of laws and policies related to environmental management.

The legal system sets down the rights and obligations of those involve in the acquisition and utilization of water resources. Therefore, if there are a weak legal system and a continuous political game among politicians, the enforcement of policies, standards, and regulations will not be realized in any water management system as most African nations including arid regions still struggle to combat corruption and endemic poverty issue which continue to ravish most water projects.

#### 4.1.3 Demographic and Cultural components

When drought is severe, it is common to observe complete abandonment of cultural traditions, loss of traditions, loss of homelands, changes in lifestyle, and increased chance of health risks due to poverty and hygiene issues, all of which have implications for productivity growth. In the late 2000s and 2010/11, droughts in absolute states of water stress created tens of millions of refugees in Africa as well as up to 60% mortality of livestock in eastern Africa alone (Langyintou, 2011).

Research from various sources including the world population data sheet indicates that Africa will increase in population growth with a total of 1,245million by 2025 considering it rate of natural increase of 2.8%. Africa rising population is driving demand for water and accelerating the degradation of water resources in many countries on the continent (UNDESA, 2012). Diverse cultural practices by rural communities have some implications on water usage. Knowledge of these cultural practices can promote sustainability in water management. Building a management system that incorporates different cultural practices can mean well for sustainable water management.

#### 4.1.4 Technology and Physical components

A range of technological options is available to help Africa cope and adapt to climate change. Adaptive capacity relies on access to resources, information and technology. Skills and knowledge to utilize resources and information are required to suggest a need to focus on capacity building and communication (Thomas, 2008).

Africa is one of the most vulnerable continents to climate change and climate variability. Africa faces a situation of economic water scarcity and current institutional, financial and human capacities for managing water are lacking (UNEP, 2010).

Most African arid countries lack the necessary technologies to meet up with these challenges and therefore, rely on developed nations to help in term of technology constrain and human resource incapacities. Strategies and technologies employed in the past are inadequate to meet up with the changing environment; methodologies being used by many rural populations in water management and conservation are obsolete and lack sustainability consciousness. Investing into modern technologies to combat the rapid variability of climate and provision of the efficient water infrastructure to supply current and future demand due to population growth is crucial for a sustainable integrate management framework for water resources in Africa arid regions.

## **4.2 Actors of sustainable water resource management framework**

### **4.2.1 Government**

Government at all levels should re-evaluate legal, technical and economic approaches to managing water resources under possible climate change (Ragab and Prudhomme, 2002). The approach taken by essentially all governments including African governments at both national and local levels is reactive to drought through what is commonly referred to as the hydro-illogical cycle. However, no drought management plan is in place that oversees government agency responses or the coordination of those responses. Government agencies with responsibility for responding to the drought conditions are usually poorly coordinated (Wilhite, 2011).

Notwithstanding, the importance of agriculture is driving the economies of African states, with the demand for water resources in this sector, political will to support the sector appears weak (Langyintou, 2011). Water governance at all scales both horizontally between ministries and vertically between different governance scales is required in order to mainstream climate change development into broader development strategies (Nguyen-Khoa et al. 2012). It is incumbent upon African governments to ensure a sustainable management of water resources. Governments can achieve this if there is a shared vision of combating the challenges posed by climate variability in Africa arid regions and the increasing growth of population and urbanization.

### **4.2.2 Users**

By users in this study, it means agricultural, industrial, domestic, and environmental user of water resources. A major reason for not achieving sustainability of rural water projects in Africa is the fact that they are often designed without recourse to the circumstances of the population they are intended to serve. Water planners are known to assume wrongly that local populations will adapt their water use habits to newly provided facilities. This obviously has resulted in numerous underutilized facilities hindering sustainability (Nyong and Kanaroglou, 2001).

A countrywide assessment of the available water resources in Uganda summarized the main challenges affecting the management of the resources: competition amongst different water users for the right to utilize the same water source such as a river or stream; and excessive and unsustainable water resource exploitation by users. The challenges would need to be addressed for a realization of a sustainable water resource use (Rubarenza, 2008).

By creating a sustainable water management system; including monitoring and inclusion of users into decision making can lead to better transparency on tariff structure for everyday users, and a more efficient use of the available water resources. It can also help monitor the implementation of all criteria of the right to water (Nguyen-Khoa et al. 2012). An in depth understanding of the different user's demands and the sector the drives the economy of the state is crucial for developing and implementing a sustainable water resources management framework.

### **4.2.3 Intermediaries**

By intermediaries, it refers to third parties such as the private sector, Non-Governmental Organizations, international partners, advisers, experts of diverse professions. All of these actors have diverse objectives that can have some implications for an integrated water management system. With pressure on African government's national budget, privatization can be an option for African governments. On the one hand, if governments are not vigilant in their oversight responsibility, privatization can affect the water users in term of prohibitive tariff by the commodity provider.

Another key challenge faced by most African governments is the issue of financial incapability to undertake major water projects. African governments are always forced to align their policy with multi financial lenders policies which can hinder the flexibility of African government's water policies. Experts of diverse professions are usually in a fight for prioritization of ideas over the other during policy formulation. With these varying objectives, according to the World Water Council (2013), sustainability is achievable if, our ability to build the future of water security together will be define by our ability to organize our socioeconomic and political systems in such a way that challenges are turn into opportunities.

#### **4.3 Management tools and technical system for sustainable water resource management framework**

The Laws, policies, standards and regulations are the backwash for building a sustainable organization web considering the essential components for a sustainable water management. The Laws are the basis from which policies are formulated. Therefore, if the political component weakens the legal components, the laws can be ineffective to support the policies. The policies give meaning to the standards and regulations in a water management framework. Policy with legal backing creates enforcement for the standards and regulations. When the tools in a water management framework give meaning and support to each other, the technical systems can be effective. The water resources information system can serve as a database for the framework; the water resources planning system transforms data into strategies. The water organization and implementation system transforms strategies into actions and the water control system serve as a checkmate for the entire system.

### **5 Conclusion**

The improvement or stagnation of Africa arid regions economies will be due to their ability to employ efficient strategies and policies in combating climate change and the development of necessary technologies and water infrastructure to meet current and future water demand in various sectors. Amongst the major factors that are responsible for water stress in Africa arid regions, climate change, population and urbanization growth will create high pressure on Africa water resources if there are inadequate planning and management for future water demand. In order to improve the present management systems being employed by arid countries in Africa the following if considered will create awareness for sustainable management of water resources:

- a. Revision of laws, policies, standards and regulations and adopting modern laws, policies, standards and regulations in relation to the African situation. i.e. where improvements are crucial for policies, laws, regulations and standards of the current and future shift in the demographic and cultural environment, economic and social environment, political and legal environment.
- b. Investing into human resource development holistically to management water resources, investing into research and development, investing into new technologies in all sectors of water consumption to avoid vulnerability to climate change.
- c. Inculcating water sustainability practices as a core in poverty reduction strategies and mainstream water management as a developmental resource vital for economic growth.
- d. Governments and policy makers must include the rural communities as central actors to decision making. In so doing rural communities can be made aware of aligning the cultural practices to sustainable water management.

The employment of the proposed framework can serve as a metric and base in gaining knowledge of the challenges and opportunities for water resources in Africa arid regions and to a greater extent can assist local and national governments to understand the conflicting objectives of the various actors in ensuring a sustainable management of water resources. This framework is not limited to arid regions in Africa, but developing African countries where there are still challenges for sustainable management of water resources.

Integrated water resources management has unquestionably become one of the mainstream initiatives discussed by governments. The major challenge remains its effective implementation in the field (Rahaman and Varis, 2005). All of the relevant components and issues pertinent to managing water resources in Africa arid regions sustainably may have not been discussed here and we hope to consider these in future studies.

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