INTEGRATED WATER RESOURCES MANAGEMENT IN KHARTOUM, SUDAN: A FEASIBILITY STUDY WITH A FOCUS ON ISLAMIC PRINCIPLES

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ABSTRACT

Integrated Water Resources Management (IWRM) is a promising concept which is widely used as means for poverty alleviation, enhance the provision of drinking water and to improve the public heath situation for different community. Khartoum state suffering from population increases and urban expansion which, result in water shortage, water pollution and water related disease. The issue of water problems in Sudan is mainly attributing to poor water resources management rather than water scarcity. This research conducted to explore the feasibility of implementation of IWRM among Khartoum population Sudan, through the identification of the different factors that have potential to enhance and impede the IWRM implementation. The interview, documentation sources and public survey technique was conducted to collect related data. The data was analyzed by using thematic analysis, SWOT analysis as well as simple statistical analysis. The result of analysis showed that most important factors that impact the IWRM application are the institutional capacity of the water sector, water legislation as well as the community participation. It also indicates that the Muslims community in Khartoum has a high potential to improve the IWRM implementation. This research will contribute to the current status of the IWRM in Khartoum in determining the most important steps towards implementing an appropriate action plan for successful IWRM, where now Khartoum government in the pre-stage of IWRM implementation.

Keywords: Integrated Water Resources Management, Khartoum, Water Legislation, Islamic Principles, African Countries.

PENGURUSAN SUMBER AIR BERSEPADU DI KHARTOUM, SUDAN: SATU KAJIAN KEBOLEHLAKSANAAN DENGAN FOKUS TERHADAP PRINSIP ISLAM

ABSTRAK

Pengurusan Sumber Air Bersepadu (PSAB) merupakan konsep yang sangat penting dalam usaha membasmi kemiskinan, meningkatkan bekalan air minuman dan juga kesihatan awam untuk pelbagai komuniti. Khartoum mengalami peningkatan dari segi populasi dan perubahan urbanisasi sehingga menyebabkan kekurangan bekalan air, pencemaran air dan pelbagai gejala penyakit serta masalah kesihatan yang berkaitan dengan air. Isu utama mengenai air yang dikenalpasti di Sudan adalah disebabkan pengurusan bekalan air yang lemah di samping isu kekurangan bekalan air itu sendiri. Justeru, kajian ini dilakukan bagi mengkaji kemampuan dalam melaksanakan PSAB untuk populasi di Sudan, melalui pengenalpastian pelbagai faktor yang mempunyai potensi untuk meningkatkan pelaksanaannya. Teknik temuduga, pengumpulan dokumentasi dan tinjauan awam juga dijalankan bagi mendapatkan maklumat mengenai pengurusan bekalan air. Analisis tema, analisis SWOT dan statistik turut dijalankan. Hasil kajian menunjukkan bahawa faktor-faktor yang memberi kesan kepada perlaksanaan PSAB di Sudan ialah kapasiti institusi dalam sektor pengairan, penguatkuasaan undang-undang berkaitan sistem pengairan dan penglibatan masyarakat. Kajian ini juga membuktikan bahawa masyarakat Muslim di Khartoum juga memiliki potensi yang besar untuk membantu meningkatkan perlaksanaan PSAB. Jadi, diharapkan kajian ini bakal menjadi platform dalam usaha untuk memperkenalkan pelan tindakan yang sesuai dan betul bagi memastikan kejayaan perlaksanaan PSAB di Khartoum yang masih lagi di peringkat pra-perlaksanaan.

Kata kunci: Pengurusan Sumber Air Bersepadu, Khartoum, Undang-undang air, Prinsip Islam, Negara Afrika.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	:	Agricultural Corporation
AfDB	:	African Development Bank
AWWA	:	American Water Work Association
CBNRM	:	Community Based Natural Resources Management institution
CEDARE	:	Centre for Environment and Development for Arab Region and Europe
CESCR	:	Committee on Economic, Social and Cultural Right
CEWA	:	Central Electricity and Water Authority
CNRH	:	National Water Resources Council
COD	:	Chemical Oxygen Demand
DHI	:	Danish Hydraulic Institute
DoP	:	Declaration of Principle
DWAF	:	Department of Water Affairs and Forestry
EIA	:	Environmental Impact Assessment
ECOSOC	:	The United Nations Economic and Social Council
ESI	:	Environmental Sustainability Index
EU	:	The European Union
EU WFD	:	European Water Framework Directive
E WFW	:	Ethiopian Water Framework Directive
FAO	:	Food Agriculture Organization
FOP	:	Field Outlet Pipes
GDP	:	Gross Domestic Product
GERD	:	Great Ethiopian Resinance Dam
GPM	:	Gallon per Minute
GWP	:	Global Water Partnership

GWWD	:	Ground Water and Wades Direction
HCENR	:	Higher Council for Environment and Natural Resource
IADB	:	Inter-American Development Bank
IAM	:	Infrastructure Assessment Management
ICESCR	:	International Convention on Economic, Social and Cultural Rights
ICWE	:	International Conference on Water and Environment
IES	:	Institute of Environmental Studies
IUCN	:	International Union for Conservation of Nature
IWRM	:	Integrated Water Resources Management
IWRAM	:	Integrated Water Resources Allocation Management
JPOI	:	Johannesburg Plan of Implementation
km^3	:	Kilometer Cubic
km^3/yr.	:	Kilometer Cubic per Year
KSWC	:	Khartoum State Water Corporation
LOHAP	:	Leadership Office of the Hamadab Affected People
LPCD	:	Liter Per Capita per Day
MDGs	:	Millennium Development Goals
MENA	:	Middle East and North Africa
MIWR	:	Ministry of Irrigation and Water Resources
MWRE	:	Ministry of Water Resources, Irrigation and Electricity
m^3	:	Meter Cubic
mm	:	Millimeter
MWR	:	Ministry of Water Resources
NBI	:	Nile Basin Initiative
NCS	:	National Comprehensive Strategy

NEC	:	National Electricity Corporation
NGOs	:	Non-Governmental Organization
NPEM	:	National Plan for Environmental Management
NRW	:	Non-Revenue Water
NWRS	:	National Water Resources Strategy
OECD	:	Organization for Economic Cooperation Development
PBUH	:	Peace Be Upon Him
PWC	:	Public Water Corporation
SADC	:	South Africa Development Community
SDGs	:	Sustainable Development Goals
SNWP	:	Sudan National Water Policy
ST	:	Sbuhanuh w Taala
SWOT	:	Strengthens, Weaknesses, Opportunities and Threats
TAC	:	Technical Advisory Committee
TVA	:	Tennessee Valley Authority
UN	:	United Nations
UCOWR	:	University Council on Water Resource Research
USA	:	United States of America
US ACE	:	United States Armey Corps of Engineers
UNCED	:	United Nations Conference on Environment and Development
UNDP	:	United Nations Development Program
UNEP	:	United Nations Environmental Program
USAID	:	United State Agency for International Development
UNICEF	:	United Nations International Children's Emergency Fund
UN-DESA	:	United Nations Development for Economic and Social Affairs

UNESCO	:	United Nations Educational, Scientific and Culture Organization
UN-Habitat	:	United Nations Human Settlements Program
WAMAKHAIR	:	Water Management in Khartoum International Research Project
WCED	:	Water Commission on Environment and Development
WHO	:	World Health Organization
WMO	:	World Metrological Organization
WSSD	:	World Summit on Sustainable Development
WUA	:	Water Users Association

CHAPTER 1: INTRODUCTION

The problems and issues facing water resources result mainly from three factors: population growth; expansion of economic activities and climate change (Bouwer, 2000; Eslamian *et al.,* 2017). According to Agarwal (2000), the 20th century witnessed a threefold increases in population, which created a sevenfold increases in water consumptions. However, estimates display the population will further increases from current figures 7.6 billion to 8.6 billion in 2030. Africa frequently records the highest rate of population growth of 2.5% (UN, 2017). Majority of the population growth was found within the developing countries, which are currently experiencing water scarcity and limited sanitation services (Bouwer, 2000). Dungumaro and Madulu (2003) stated that the population growth rates in the more developed countries is about 0.3% while less developed countries have seen a population growth of about 1.6%; on the other hand, least developed countries have shown a larger population growth rates of about 2.5%. For the developing countries, the rates of population growth have increased from 79% in the 1980s to 84% in 2017 (UNESCO, 2017). Secondly, the agricultural and industrial boom in economic growth was considered the main sources of water pollution. The effect of these activities on water usability consequently results in water shortages and causes competition among different water consumers. In addition, water pollution negatively impacts the human health evidence has shown that about 1400 people (mostly children) die every hour due to waterborne diseases (Bouwer, 2000). Thirdly, expected weather changes in rainfall distribution and intensives, as well as rising temperature, will add more stress to water resources in many regions (Bouwer, 2000; Lenton & Muller, 2009; Gosling & Arnell, 2016). According to UNESCO (2017), 15% of the world's population lives in Africa, depends on only 9% of renewable resources, which may impact patterns of demands and available water resources, especially when urban growth in sub-Saharan Africa was predicted to nearly quadruple

by 2037. Therefore, the trade-offs between the availability and the population demand for water resources was considered a challenge, necessitating the shift from inadequate water management approach to a holistic water management approaches.

Lenton and Muller (2009) cited a 1976 study conducted by Adam Smith the differences between the economic signs of the progress of different countries. His results showed that water management was influenced by economic as well as social development. There was a strong link between the water and the economy in agrarian countries, as agriculture, mainly depends on water and fertile soils. This was compounded by water cycle variables, such as drought and flood events, which imposes huge costs onto the vulnerable people and economy. Public health was also affected, as there are many diseases associated with water pollution and water shortage. Water was a key natural resource for human society and an essential element in society's development and poverty eradication, regarding this issue Napoleon Bonaparte when he was in Egypt stated that "under a good administration, the Nile gain on the desert; under a bad one the desert gain on the Nile" (Lenton & Muller, 2009). Therefore, water management takes priority in the entire world, however effective water management should consider the economic and social dimensions of water (Lenton & Muller, 2009).

A universal water management goal was to ensure water provision of good quality and sufficient quantity, which can led to the improvement of public health, productivity, and labor power due to minimizing the time and energy otherwise expended in water collections (Lenton & Muller, 2009). In the past water management was characterized by supply management and therefore dominated by specific groups. These mainly sectoral top-down approaches excluded stakeholders from the decision-making processes (Pahl-Wostl, 2007). However, the current population, are more environmentally aware than previously, now they recognized the unsuitability of this

approach to solving water issues (Pahl-Wostl, 2007). Lenton and Muller, (2009) showed evidence of the water issues still serving as challenges in many countries, even within developed ones. This was because of the interdependent nature of water which requires a holistic approach involving water consumers, usage, and other issues that are related to water in an integrated water resources management (IWRM). The concept of IWRM only gained popularity in 1992, despites being around since the 1960s (Eslamian *et al*., 2017). In 1992, when the United Nations Conference on Environment and Development (UNCED) was held. In the Johannesburg, World Summit on Sustainable Development (WSSD) in 2002, the Technical Advisory Committee of the Global water partnership, for the first time defined integrated water resources management as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem" (Agarwal *et al*., 2000).

The main goal of IWRM implementation is to achieve sustainable development, accompanied by social equity and economic efficiency (Lenton & Muller, 2009). IWRM was a promising concept in the context of developing countries in Africa, where the issues of poverty and provision of drinking water and sanitation are the main challenges. IWRM can be used to achieve some of the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) such as tackling poverty and achieving gender equity and environmental sustainability (Van der Zaag, 2005; Eslamian *et al*., 2017), SDG Goal 6 advocates for universal availability and sustainable management of water and sanitation, pushing for equitable access to safe and affordable drinking water, as well as increasing water usages efficiency across all sectors and ensures sustainable withdrawals and supply of freshwater. Moreover, one of SDG 6's targets was the implementation of IWRM (UNESCO, 2017).

1.1 Problem statement

Sudan is located in North-eastern Africa and was classified as the Middle East and North Africa region (MENA) country, and which was also one of the most water-stressed regions on the planet. Holding only 1.5% of the world's water resources, it was home to 7% of the world's population (Michel *et al*., 2012). Moreover, Sudan was one of the Nile basin countries, falling within a tension-driven zone where countries share their water resources with neighboring countries (Absar, 2013). One-third of Sudan's water resources originated from outside its territory (Michel *et al*., 2012). Effective water resources management is critical to ensure social and economic development and sustainability as well as water security. The concept of IWRM has been well-addressed in the 1992 National Water Policy, the 2000 Sudan National Water Policy (SNWP) draft and in the 2007 National Plan for Environmental Management (NPEM). However, efforts to achieve successful implementation are still lacking. Although there was evidence that indicates that Sudan has a national water policy and master plan for its Nile water, and its status towards IWRM implementation was expected to be finalized in the 2005 IWRM plan (AWC, UNDP & CEDARE, 2005). Unfortunately, after six years Adam (2011) conducted a study to evaluate the IWRM progress in Sudan, he found that still yet just some few steps have been taken towards the adoption of IWRM. Knowing that, the Ministry of Water Resources Irrigation and Electricity, in cooperation with Groundwater and Wadis Directorate (GWWD) and the United Nation for Development Program (UNDP until 2014) implemented the IWRM Program, starting in Darfur, however, in Khartoum, a pilot study was conducted since 2011 (Sudan, 2012); nevertheless it has been conducted without systematic analysis or feasibility study for IWRM implementation, this study aimed to identify the main factors that impedes the IWRM implementation, as well as those which supports in order to enable the IWRM implementation plan to be fully realized.

1.2 Research objectives and questions

The aim of this research was to determine the possibility of implementing IWRM to improve water management practice in Sudan, specifically in the capital city of Sudan. In order to achieve this aim, the following objectives need to be fulfilled:

a) to investigate the feasibility of IWRM implementation in Sudan, especially in the context of the Khartoum state;

b) to identify critical factors that both drives and impedes the implementation of IWRM in Sudan;

c) to explore the socio-religious aspects of the Sudanese people that can enhance the implementation of IWRM.

Based on these objectives, the research questions are as follows:

a) What was the feasibility of IWRM implementation in Khartoum based on the key critical factors of IWRM?

b) What are the internal and external factors that affect the IWRM processes in Khartoum, Sudan?

c) What were the contributions of basic Islamic principles in the promotion of IWRM implementation?

1.3 Scope of the study

The geographical scope of this study was the developing African country Sudan, focusing on the Khartoum state community, the scope of the study covers the factor that impedes or assist IWRM implementation focus on religion namely Islam as one socio-

cultural aspect that could affect the IWRM strategy, the field study was conducted from July to November 2015.

1.4 Thesis outlines

This research was arranged into six chapters. Chapter one was an introductory chapter, which gives a general idea of the research concerns, encompassing the research background, problem statement, research questions and objectives, and finally the scope of the study and the thesis structure.

Chapter two is the literature review, which consists of three sections. The first section was about the IWRM concept; its general background, history and definitions. Then, IWRM guiding principle and indicators, as well as IWRM implementation's challenges and the framework of IWRM, were highlighted. The second section details IWRM implementation in the context of least developing countries in Africa. Within this section IWRM progress in some Arab countries of Africa and in Sudan was discussed. Later, the chapter presents some stories of successful and failed implementations of IWRM including success and failure factors. The last part of section two represents the current status of water management and the IWRM progress in Sudan. The last section deals with IWRM from an Islamic perspective. This section discusses the importance of water in Islam in addition to water rights in Islam together with water rights and property, including some opinions about selling water in Islam. Water consumption in Islam and Islamic principles of water conservation are also presented.

Chapter three discusses the methodology employed in this research, which is a qualitative and in-depth case study method using three data collection methods: documentation, interview, and public survey. Within this chapter, the framework of analysis is also highlighted. Chapter four contains the results and complete data

analysis. Chapter five is the discussion of the results of the analysis in comparison with the research findings from previous studies. Chapter six is the concluding chapter, which contains the conclusions of all chapters and suggestions for future researches. The reference section includes all references that have been used in this research.

1.5 Concluding remarks

Chapter one is an introduction chapter, however, it highlights the research problem as Sudan located within the semi-arid zone, and most of its water resources are shared with neighboring countries, therefore, it's classified as one of the countries that fall into a tension driven zone. Despite Sudan is one of the first countries that formulate their water based on IWRM approach, but still some steps have been taken for the IWRM application.

CHAPTER 2: LITERATURE REVIEW

The review of the literature was synthesized in order to understand the feasibility of IWRM implementation in Khartoum, Sudan. The relevant literature in this chapter was divided into three sections. In section (2.1) the concept of IWRM and its implementation. Section (2.2) discusses IWRM in the context of least developing countries in Africa. Section (2.3) discusses IWRM from the Islamic perspective.

2.1 The concept of IWRM and implementation

This section explains water as a basic human need, by showing the importance of water for human, water interests or different water users, conventional water management and the history of water management. Then, discusses the meaning of integration; elements that should be integrated and the history of IWRM. It explains the definition, some proposed definitions, and its guiding principles. This section will present arguments about water as a human rights and economic source, and end with a theoretical framework of IWRM implementation, its planning and implementation stages and the implementation challenges.

2.1.1 Water as a basic human need

Water is the most important element for all living beings to survive. Furthermore, it considered a basic human need, where it was placed at the base of Maslow's hierarchy of needs, which consists of six basic human needs. The first and foremost need to include the physical survival needs, namely, water, food, and sleep, among other needs (Mc Leod, 2014). Streeten and Burki (1978) further asserted that basic needs have several levels. The first one is the need to ensure human survival, as whoever lacks these needs dies. Water was ranked within the second basic needs category, defined as needs that have to be satisfied to ensure the human survival. Hence, the sustainable development of a country must guarantee the basic human need for water.

The basic needs of human are not all the same, according to different authors. For example, Gleick considers the essential requirements was basically represented by the four basic human needs, food production, and ecosystem protection, while Brundtland *et al*. (1987) highlighted the basic human needs as a livelihood, food, energy, basic needs of housing, water supply and sanitation and health care. If these basic needs are not met, the result will be environmental stress. The minimum water required of citizens basically for drinking, personal hygiene, sanitation, and cooking as suggested by Gleick (1996) should be about 50 l/p/c/d. It should be mandatory for a government to ensure the provision of water in suitable quality and quantity. In sub-Saharan Africa, water supply was below 50 l/p/c/d (Michel *et al*., 2012); moreover, some areas of Khartoum, the per capita of water consumption is below 20 l/p/c/d, less than WHO minimum (Laure, 2011).

The minimum water need for human differs according to different authors, but Gleick's suggests most widely accepted one. This falls into three categories:

a) Drinking Water Requirement:

Water that is needed for human survival was mainly for drinking purposes. As the human body was made up of two-thirds water, this was considered the main limiting factor for all living beings.

b) Sanitation:

Sanitation are always defined as cleansing and hygiene activities, which are mainly performed using water and are linked strongly with the general public health. When water is sufficiently provided, it will be reflected in good public health, the appropriate cleaning of the human waste minimizes the vulnerability of infectious diseases. The amount of 20 l/p/c/d was enough for sanitation and adequate hygiene. Water was used

to remove the personal dirt that may cause odor and discomfort. Bathing ensures a healthy feeling and it was done once or twice daily. It also depends on the climate, culture, and lifestyle. The suitable quantity of water for bathing was 15 l/p/c/d.

c) Food Preparation:

The last need for water are for domestic purposes, namely, the preparation of food, which differs according to the population's food culture, economic conditions, Gleick added that 10-20 l/p/c/d are recommended, however, he believes that 10 l/p/c/d are satisfactory for food preparation.

2.1.2 Conventional water management

The previous approach to water management reveals its failures to settle the present water problems, which have become more interconnected. In the past and even currently in many countries, water was managed through top-down approaches with single domain users without the participation of other stakeholders (Jewitt, 2002; Pahl-Wostle, 2007; Lenton & Muller, 2009; Henkel, 2017). Managing water without considering the interconnected nature of water results in ecosystem deterioration as it fails to solve different water problems. Since, it was mainly based on technical solutions such as wastewater plants design and maintenance (Jewitt, 2002; Pahl-Wostle, 2007; Lenton & Muller, 2009). The first problem with traditional water management approaches was that it did not takes into account the nature of water, which is mainly interdependent (Gleick, 2000); for example, the diversity of water interests of different users as in the case of industry or agriculture. These can be individuals, a group or a nation. Water needs can be organized according to the most need for water by different users. The second issue was that the conventional water management concerns the supply management rather than the demand management. Meaning that, the water manager attempt to explore new water supply rather than try to use water efficiently (Xie, 2006;

Henkel, 2017). The third defect was that when there are an individual domain in the water decision-making, they will definitely prefer their desires and objectives this duly will decrease the stakeholders' participation (Xie, 2006; Lenton & Muller, 2009).

There are many water problems regarding water management, such as the incapability of the government to provide water for all. Especially, for the poor, that resorts to purchasing water from water vendors with high prices and low quality. There are also problem of allocating water resource equally for different water users. This issue was discussed in the Second World Water Forum and Ministerial Conference at The Hague, the Netherlands, 2000. Accordingly, they proposed that the water price for the poor must be considered. On the other hand, from a neo-liberal perspective, water should be allocated through the market base. In order to, ensure more efficiency and adequate allocation according to the highest value uses to enable the providers to recover their cost and enhance investment in infrastructure. In addition to, this water regulation, as well as private sector engagement in water management system, are important factors to be considered.

2.1.3 History of Integrated Water Resources Management

During the last few decades, water management passed through several developments from 1850 to 2000. With the main features in the 19th century dominated by the agricultural sector, which was clearly organized by Mollinga *et al*. (2006) as pre-modern. Technology in this era was limited, which resulted in the low capacity of the water sector. Industrial modernity from 1900 onwards featured engineering investments and innovations. It was modernized in the mid-20th century, a period characterized by water sector privatization (1960-1970) and the green movement (1950) that witnessed the changing of water allocation. The latter channeled more water towards the environment and away from agriculture, and was guided by the environmental

awareness, which influenced the 1980 policy. The economist's era in 1990 was inspired by economists who gave water an economic value.

IWRM appears in numerous regions of the world such as Latin America, the European Union, USA and Australia (Dourojeanni, 2001; Dukhovny & Sokolov, 2005; Mollinga *et al*., 2006; Grigg, 2008). There was no an agreed date of IWRM emergence, however, three groups of authors can be recognized the first group stated that it is an age-old concept (Biswas, 2004; Rahaman & Varis, 2005; Giordano & Shah, 2014). The second group advocated that the Tennessee Valley Authority (TVA) in 1913 marked a beginning of IWRM emergence (Dukhovny & Sokolov 2005; Rahaman & Varis 2005; Stålnacke & Gooch 2010; Kadi, 2014; Benson *et al*., 2015). The last group reported that it emerged through the United Nations conference held in Mar del Plata, Argentina 1977, in one of its recommendations and as an approach incorporating the different water interests and stakeholders. IWRM has been advocating in the Brundtland Commission report "Our Common Future" World Commission on the Environment and Development, 1987 (WCED). IWRM formally appeared in 1992 in two international conferences, i.e. the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro, Brazil, which is known as the Earth Summit, and the International Conference on Water and Environment (ICWE), which took place in Dublin, Ireland (Rahaman & Varis, 2005; Najafi &Vantafada, 2013; Giordano & Shah, 2014; Kadi, 2014; Mehta *et al.*, 2014; Benson *et al*., 2015; Acheampong *et al*., 2016; Chidammodzi & Muhandiki, 2017 ; Eslamian *et al*., 2017; Henkel, 2017).

The question that has been raised by many authors was, why did IWRM becomes famous in the 1990s? Many authors stated that it was "old wine in a new bottle" (Mollinga *et al*., 2006; Merrey, 2008). According to Mollinga *et al*. (2006), the popularity of the concept was attributed to the emergence of global water policy and

politics, and the establishment of numerous global water institutions such as the GWP, World Water Council. In addition to that there are two water conferences took place in the year 1992, which are stated above as a result of globalization. Biswas (2004) argues that IWRM's popularity in the 1990s was due to its promising as a holistic approach to tackling the water management problems. Secondly, the 20th century witnessed an evolution of knowledge, information, natural science and technology, it also witnessed the emergence of the reductionist phenomenon, which called for more specialists, and establishment of new institutional machinery enable to deal with current complicated societies. The international event related to the concept of IWRM is depicted as follows.

Table 2.1: International Conference Concerns with IWRM

Name of Conference	Year	Main outcomes
United Nations Conference on Water, Mar del Plata, Argentina.	1977	Mar del Plata action plan: a holistic approach to, water and sanitation provision for all, and to foster the political will, in order to improve water sector. It also suggests 1980-1990 as the International Water Supply and Sanitation Decade. Cited in Rahaman and Varis (2005).
The International Conference on Water and Environment, Dublin, Ireland. (ICWE)	1992 (January)	Action plan and outcomes encompassing the four Dublin principles: i. Fresh water as a limited and vulnerable resource essential for living beings, development and the environment. ii. Water management must be based on a participatory approach, involving users, planners and policy-makers at all levels. iii. The role of women in water provision, protection and management. iv. Water should be considered as an economic good. These principles are proposed to act as a guideline for the action program at the local, national and international levels. Cited in Rahaman and Varis (2005).
The Rio United Nations Conference on Environment and Development.(UNCD)	1992 (June)	Agenda 21, chapter 18 within which the four Dublin principles were embodied. Cited in Rahaman and Varis (2005).
Second Water Forum and Ministerial Conference, Hague, Netherland.	2000	Regarding the issue of the implementation constraints, which led to the formulation of the Global Water Partnership, which has a clear role in formulating the framework for action. Cited in Rahaman and Varis (2005).

Table 2.1, continued

Name of Conference	Year	Main outcomes
The International Conference on Fresh Water Bonn, Germany.	2001	Concerning IWRM implementation challenges. It provided an action plan to translate IWRM from theory into practice. The key success of the Bonn conference is that all its recommendations have been addressed in the WSSD plan of implementation. Cited in Rahaman and Varis (2005).
The World Summit on Sustainable Development, Johannesburg, South Africa in	2002	The conference provides a plan for implementation of IWRM as an important factor for sustainable development, with targets and guidelines for the worldwide implementation. It also provides a plan for the IWRM and water efficiency to be adopted by 2005. The key outcome of the conference is that it encouraged donors to commit themselves to implement IWRM in the developing countries. Moreover, a number of broad strategic partnerships were declared at Johannesburg. For example, the European Union launched a series of partnerships on water for sustainable development in Africa, Eastern Europe, Caucasus and Central Asia. Cited in Rahaman and Varis (2005).
3rd World Water Forum in Kyoto, Japan.	2003	The conference commits to support the developing countries to achieve the UN MDGs and for developing IWRM and water efficiency plans in all river basins worldwide by 2005. The target was set at the WSSD. A number of countries and organizations committed to developing the water sector, such as the Water Council, the Global Water Partnership, UNESCO, UN-HABITAT, FAO, UNEP, IUCN, UNICEF, Australia, the Netherlands, the EU and Japan. The Forum recommended IWRM as a mechanism to achieve water resource sustainability. Cited in Rahaman and Varis (2005).
6th World Water Forum in Marseille, France.	2012	Time for solution is the theme of conference concerned with IWRM in section 2.1: "balance multiple uses through IWRM " http://www.worldwaterforum6.org/home/

2.1.4 IWRM meaning and definition

The concept of IWRM faces many debates among the scholars regarding three issues, first; the meaning of integration: Integration was defined as a combination of different items as one unit. Viessman (1997) states that IWRM joins all segments together, he also emphasizes the social, environmental and technical aspects to be considered. Agrawal *et al*. (2000), Medema *et al*. (2008), Chidammodzi and Muhandiki (2017) and Eslamian *et al*. (2017) claimed that the integration of water resources was challenging because it has a strong link with other resources, as well as human and

economic aspects. They also claimed that managing water and all its related resources will become unworkable approach. Coordination among the existing institutions are important for integration (Biswas, 2004; Eslamian *et al*., 2017), while Lenton and Muller (2009) asserts that the IWRM encompasses a good practice, not just a new idea; it wasn't necessary to combine all parts together as it results in an unworkable concept. The IWRM needs some degree of target and focus; according to Cardwell *et al*. (2006), "integration is a matter of degree; it is not all or nothing". They assert that integration is less normative because coordination will vary according to the needs and priorities. So, integration should be understood as coordination and cooperation among different water-related sectors to seek a consensus regarding the water decisions. Similarly Jønch-Clausen and Fugl (2001) and Grigg (2008) stated that "integration means different things to different people" Jønch-Clausen adds that there was a need to bring different water views and interests together.

Second, the meaning of IWRM as a concept: Most of the authors believed that IWRM intends to harmonize between human water needs, economic development and the environmental sustainability (Jønch-Clausen & Fugl 2001; Van der Zaag 2005; Lenton & Muller, 2009). The concept of IWRM was complicated on decision-making on water, which entails balancing of different interest perspectives with two goals, to balance the viewpoints of the stakeholders and to improve the management of water resources (Grigg, 2008). Van der Zaag (2005) believes that IWRM is "a perspective, a way of looking at problems and how to solve them" (p. 868). He also thinks that IWRM has an effective contribution to the MDGs achievement, particularly in poverty reduction. Also, he proposes that IWRM is considered as a framework. However, Al Radif (1999) argues that IWRM was the establishment of a team, which represents different water sectors at all levels, such as local, national and international level, which necessitates agreement on the conservation of water resources and the ecosystem as

well. Braga (2001) agrees with Al Radif, but he didn't specify an objective or even the levels at which the integration should take place. Therefore, it wasn't necessary to combine all the parts together, which results in an unworkable concept. IWRM needs some degree of target and focus (Lenton & Muller, 2009). Interestingly Jonker (2007) argues that IWRM are different since he believes that it's about the people rather than the water and posits how we can manage people's activities for better livelihood without compromising the water cycle. Also, IWRM requires integration and coordination across different public and private institutions, and active involvement of the stakeholders and water users in water management for better water governance (Gallego & Juizo 2011; Eslamian *et al*., 2017; Henkel, 2017). It was also defined according to Gordiano and Shah (2014) as a set of ideas to help manage water holistically. IWRM was a replacement of techno-centric top-down supply-oriented water management with a holistic participatory demand-driven approach (Acheampong *et al*., 2016). Chidammodzi and Muhandiki (2017) argued IWRM was an approach to assist the implementer towards efficiency and sustainable water management. IWRM was regarded as an approach for water development and management that seeks to balance between the three dimensions of sustainable development economic efficiency, social equity and environmental sustainability (Lenton & Muller, 2009, Henkel, 2017).

Third, the IWRM definition, however, the main or formal definition of IWRM was formulated in 2002 at the Johannesburg World Summit on Sustainable Development (WSSD) by the Technical Advisory Committee (TAC) of the GWP. They defined IWRM as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resulting economic and social welfare in an equitable manner without compromising the sustainability of vital" (Agarwal *et al*., 2000; Biswas, 2004; Hering & Ingold, 2012; Mehta *et al*., 2014; Kadi, 2014; Acheampong *et al*., 2016; Chidammodzi & Muhandiki, 2017; Eslamian *et al*.,

2017). However, it has been criticized by several authors who have proposed alternative definitions for IWRM (See **Table 2.2**).

Biswas (2004, 2008) argues that the definition of IWRM wasn't clear, therefore it would be very difficult to implement, because it has been suggested that integrating many items and some of which cannot be integrated. He posed questions about the items that should be integrated, how and by whom. Moreover, this concept has to be adopted by the entire the world with a variety of cultures, religions, policies, institutions, and nature of water resources (Hashemi, 2010; Kadi, 2014; Karthe *et al*., 2015; Eslamian *et al*., 2017; Henkel, 2017; Worte, 2017). The GWP definition was also criticized by Jonker (2002) argues that the definition implies managing natural processes; he maintains that we can manage people's activities more realistically than a natural process, thus, he suggests that IWRM can be defined as managing people's activities. While other authors argued about the IWRM, Merrey (2008) believes that the concept of IWRM could not improve the water management. He insists that by focusing on IWRM, we've lost sight of achieving the main goals of water resources management. Instead, he proposes an expedient water resource management as an alternative concept.

According to this line of debates, there are evident that IWRM concept was defined by numerous international organizations such as the UNDP, USAID, UNEP, IADB, U.S. Army Corps of Engineers and other authors. For example, Allan (2003) proposes to add the term "allocation" to the IWRM and Merry *et al*., (2005) stated that poverty should be included.

Duchovny and Sokolov (2005) argued that in order for the IWRM to be more precise, it should not be defined as a process. Instead, they suggested a definition for the IWRM as a management system because they think that management systems must have a flexible approach in order to ensure the sustainability of the water resources.

As there are controversies about the IWRM as a process, Cardwell *et al*. (2006) analyzed five definitions of the IWRM which was developed by the different organizations in the U.S. The authors observed that IWRM was a process, which are used to achieve a goal and it was a matter of degree. Jonker (2007) disagree with the idea of considering the IWRM as a process; furthermore, he believes that it's the main cause that constricted IWRM implementation. According to Al-Saidi (2017), IWRM should be redesigned based on the current sustainability framework, which consists of the three pillars of sustainability, in addition to peace and security as the fourth pillar.

Although, the GWP definition of IWRM was being considered as the most authorized definition, it put forward many issues such as lack of measurements and implementation guidance (Biswas, 2004, 2008; Gallego & Juizo; 2011; Eslamian *et al*., 2017). Despite general endorsements of IWRM in the U.S., full implementation of IWRM globally was hampered by inconsistent concept definitions and basic framework for concept implementation (Cardwell *et al*., 2006). Furthermore, it was concerned with the secondary issues, ignoring basic matters like poverty reduction, better livelihood, and economic growth. All these issues encourage many authors and international organizations to formulate an alternative definitions (Allan, 2003; Merrey *et al*., 2005), which they consider being a better guidance for the implementation processes.

Fourth, integration items: Agarwal *et al*. (2000) asserted that according to the Webster Dictionary, the need for integration arises when dealing with the situation of regular interventions of interdependent groups of items forming a uniform whole. It requires focus and priorities of the water issues, according to the particular communities. The IWRM concept has been criticized in terms of the items that should be integrated within the concept and its definition as stated by Giordano and Shah (2014).

Table 2.2: Summary of IWRM Proposed Definitions

The author	IWRM proposed definition
UNDP (1990)	IWRM is based on perception of water as an integral part of ecosystem, a natural resource and social and economic good. Cited in (Cardwell *et al*., 2006)
IADB (1998)	IWRM is water resources management where the aim of its action and projects also includes the allocation of water and decrease of conflicts between competitive water resources subsectors and uses, both in quantity and quality. Sometimes it is also refer to as a comprehensive water resources management… it is the process of diagnosing responses to resolving water use problems while acknowledging their interrelationships. Cited in (Cardwell *et al*., 2006).
GWP (2000)	IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Cited in (Cardwell *et al*.,2006)
Duda and Al-Ashry (2000)	IWRM is a change from single-purpose to multi-purpose water projects.
Jonker (2002)	IWRM is managing people's activities in a manner that promotes sustainable development (improves livelihoods without disturbing the water cycle).
Dungumaro & Madulu (2003)	IWRM requires integration and coordination across different public and private sector institutions and greater involvement of stakeholders and water users in water management to improve water governance.
USAID (2003)	IWRM brings together government, communities, and other stakeholders to choose among alternative uses of freshwater and coastal resources. Using a participatory planning and implementation process, these stakeholders identify ways to meet their diverse water needs without depleting or damaging water resources and their underlying ecosystems. Cited in (Cardwell *et al*., 2006)
World Bank (2003)	Integrated water resources perspective ensures that social, economic, environmental, and technical dimensions are taken into account in the management and development of water resources. Cited in (Cardwell *et al*.,2006)
Zaag (2005)	IWRM is an approach, a perspective, a way of looking at problem and how to solve them.
Merrey *et al*. (2005)	IWRM as involving the promotion of human welfare, especially the reduction of poverty, encouragement of better livelihoods and balanced economic growth through effective democratic development and management of water and other natural resources in an integrated multilevel framework that is as equitable, sustainable, and transparent as possible, and conserves vital ecosystems.
U.S Armey Corps of Engineering (2006)	IWRM is a coordinated, goal-directed process for controlling the development and use of river, lake, ocean, wetland, and other water assets. (Cardwell *et al.,*2006)
Grigg (2008)	IWRM is a framework for planning, organizing, and operating water system to unify and balance the relevant views and goals of stakeholders.
Benson *et al.* (2015)	Define IWRM as umbrella concept and encompasses multiple principles which overall aim at more holistic and coordinated management between different concepts of water resource systems.

IWRM precepts such as equity and efficiency are often incompatible (Medema *et al*., 2008; Eslamian *et al*., 2017), and they also highlighted that IWRM is flawed because it

puts water at the center, though it was only one aspect of holistic problem management. Perhaps most damning, Jeffrey and Gearey (2006) stated that there was no evidence that IWRM was actually worked (Giordano & Shah, 2014; Eslamian *et al*., 2017), the items that need to be integrated within the process of IWRM are varied, according to different authors' point of view. Among them, Biswas (2004) also analyses the literature of the IWRM, by concluding that, according to the authors, the integration can be represented with many different meanings. He asserts that the IWRM means integration of more than 30 items. Biswas (2004) and Acheampong *et al*. (2016) argued that if we try to integrate all these items, the water issues could be worsened rather than solved. Biswas's list can be summarized in a short list containing eight sets of issues (Grigg, 2008). A list of 14 issues that needs to be considered within the IWRM process was proposed by Viessman (1997). Al Radif (1999) also claims that the IWRM application entails seven factors that we must deal with. The integration should include geographical scale (which consists of catchment, sub-catchment and political boundaries), socioeconomic and jurisdictional scale, groundwater and surface water, wastewater treatment and water supply, water use and water protection, identification and implementation, trans-sectoral integration, deficits and services from activities outside the water sector (Hering & Ingold, 2012; Giordano & Shah ,2014). **Table (2.3)** below depicts different author's opinions regarding the integration items.

Table 2.3: IWRM Proposed Integrated Elements

Author	Proposed integrated elements
Viessman (1997)	Providing the right forums, reshaping planning process, coordinating land and water resources management, recognizing water resource and water quality linkages, taking an integrated watershed management focus, addressing institutional challenges, protecting and resolving natural systems, reformulating existing projects, capturing society's views, articulating risk, educating and communicating, uniting technology and public policy, forming partnerships, focusing on preventive measures.
Al Radif (1999)	Strengthening of the human resource development, training of water managers, the development of a new institution that will serve and match this goal, effective information management, environment and development, the integration of water planning into the national economy and finance, scientific means.

Table 2.3, continued

Author	Proposed integrated elements
Agarwal *et al.* (2000)	Integration of human and natural systems which include the integration of water and land management, integration of surface water and groundwater management, integration of up and downstream, integration of freshwater management and coastal zone management, integration of water quality and quantity in water resources management, and green water and blue water. And human system: mainstreaming of water resources, cross-sectoral integration in national policy development, integration of all stakeholders in the planning and decision process, macroeconomic effects on water development, basic principle for integrated policy-making, influencing economic sector decisions, and integrating water and wastewater management.
Jønch-Clausen and Fugl (2001)	Integration of human and natural system with the same elements proposed by Agarwal *et al.* (2000) and he also agrees with Agarwal on the first three elements of human system plus the integration of holistic institutional approach, integrated water resources planning with poverty alleviation, linking water resources planning for national security and trade policies integrated among different management levels.
Jønch-Clausen (2004)	Jønch-Clausen agrees with Agarwal on first three elements of natural system. Human system consist of the second and third elements proposed by Agarwal *et al*.(2000).
Grigg (2008)	Policy sectors, water sectors, government units, organizational levels, the function of management.
Biswas (2004)	Water supply and demand, surface water and groundwater, water quality and water quantity, water and land-related issues, different types of water use, river, aquifers, estuaries and coastal waters, water, environment and ecosystem, water supply and wastewater collection, treatment and disposal, macro, meso and micro, water project and. programs, urban and rural water issues, water-related institutions at all levels, public and the private sector, government and NGOs, the timing of water release from the reservoirs to meet different water users, all legal and regulatory systems for water, not only from the water sector but also from other sectors that have implications on the water sectors, application of different economic tools in water management process, upstream and downstream interests and issues, national, regional and international issues, water projects, programs and policies, policies of water-related sectors, which have included water, both in terms of quality and quantity, and also direct and indirect impacts, intrastate, interstate and international rivers, bottom-up and top-down approaches, centralization and decentralization, national, state and municipal water policies, climatic, physical biological and human environmental impacts, all social group, different stakeholders, present and future generations, all gender-related issues, present and future technologies, water development and regional development.
Hering and Ingold (2012)	Geographical scale (catchment, sub-catchment and political boundaries), socioeconomic and jurisdictional scale, surface and ground water, wastewater treatment and supply water, water use and protection, identification and implementation, trans-sectoral integration, deficits and drives from activities outside the water sector.
Grigg (2016)	Controlling floods or issuing insurance, alignment of jurisdiction and authorities and allocation of role and responsibilities.

2.1.5 IWRM guiding principles

The emergence of the concept of IWRM and its popularity was always attributed to the year 1992, which witnessed two international conferences. First, was the ICWE, which was held in Dublin, Ireland. It was considered a preparatory meeting for the Rio

conference. As a result, four principles were formulated as conference recommendations in order to be used as guidance for action at all levels and to be considered in the Rio conference. The second was the UNCED which was held in Rio de Janeiro, Brazil in 1992. In that conference, the Dublin principle was embodied in Chapter 18 of Agenda 21, which was considered the main outcome of this conference (Rahaman & Varis, 2005; Eslamian *et al*., 2017; Henkel, 2017). According to the GWP, the Dublin principles are ranked as follows:

Principle No. 1: Freshwater is a limited and vulnerable resource, and it is essential for living beings, development and the environment. It must consider technologies to stretch the water supply, such as effective wastewater treatment, water reuse, rainfall harvesting, artificial rainfall, control of evaporation, and unconventional methods such as cloud seeding. In Windhoek, Namibia treated wastewater is used for potable uses as well as 30% of the city's water supply during droughts since 1968. Israel used up to 70% of reclaimed water for irrigation (Gleick, 2000). Plus, increase the efficiency of water usage in agriculture by replacing the gravity irrigation to sprinkling and direct dripping at the roots of the plants. And enforce the automatic irrigation system which reliably supplies the exact quantity needed by the crops.

Principle No. 2: Water management must be based on a participatory approach which entails the involvement of users, planners, and policy-makers at all levels. Good governance is one of the most important factors to manage the water resource successfully, which takes into account the stakeholder involvement and the complexities of the water resources system. Information exchange, building trust and reciprocity and sharing authority within the IWRM approach is important. The individuals, societies, institutions, and stakeholders, who must act in an integrated manner should be considered. Public participation depends on the cultural context, the issues at stake, the

types of stakeholders, and the relationships between the stakeholders, authorities, experts who answer to both the decision-makers and the community.

Principle No. 3: the role of women in water provision, protection, and management. Women spend almost all of their time in collecting water as they are mainly responsible for this task, especially in the developing countries. They should be more aware of the related issues of hygiene and water management, and because their input is very important, they should be more involved. Women's role in both production and consumption of water should be considered when designing effective programs in order to achieve an integrated water management objective. Women should have a voice in the water resource management decision.

Principle No. 4: Water should be considered economic goods. This entails applying economic instruments, such as the water recovery cost and water prices in order to achieve demand management which aims to balance water demand and supply. Furthermore, an alternative source of water supply such as water desalinization and wastewater to recharge the groundwater used in different industrial processes can also be used to irrigate crops.

The fourth Dublin principles recognized as a social or economic good, which contributed strongly to the understanding of IWRM. Besides, it was used as a guide for the IWRM implementation. On one hand the fourth Dublin principle creates a strong arguments regarding water to be treated as an economic resource; however, the human rights to water access and the equity principle necessitates the consideration of water as a social good as water was an essential element for humans to survive. Nevertheless, there are still over one billion people without sufficient water and approximately half of the developing countries' population are prone to water-related diseases. In some developing countries the lack of water compels the poor to pay a high price for low-

quality water; street vendors and tanker truck charge prices 12 times the price of public water supply (Bluemel, 2004). Despite all these facts, the human rights to water weren't considered independently by the international community. It has been included with other human rights such as health, well-being, and life (Gleick, 1998; Bluemel, 2004; Hardberger, 2005).

The first recognition of human rights was in the Mar del Plata Water Conference in Argentina in 1977. "All people, whatever their stage of development, social and their economic condition, have a right to have access to drinking water in quantity and of quality equal to their basic needs" (Gleick, 1998). Secondly, the Committee on Economic, Social and Cultural Right was held in 1987. The committee was asked to comment on the International Covenant on Economic, Social and Cultural Right in 2002, whereby the following was issued: No. 15 "the human right to water entails everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses. An adequate amount of safe water was necessary to prevent death from dehydration, to reduce the risk of water-related diseases and to provide for consumption, cooking, personal and domestic hygienic requirements" (Bluemel, 2004). It states that the human rights to water means that a quantity of water in order to satisfy the basic needs of humanity must be provided. And that it should meet the quality standard, which ensures that water doesn't contain any pathogenic agents and was easily accessible. The United Nation proposed "the human rights to water as to be in sufficient amount 50-100 liter/p/d, in a good quality follow WHO guidelines for drinking water quality, acceptable in color, odor, and test, and it should be far about 1000 meter from the home and the collection time should not exceed 30 minutes and it should be affordable for all as UNDP proposed that water costs should not exceed 3% of household income" (UN, 2010).

On other hands, when water is regarded as economic goods, in most countries it was underpriced and was failed to be treated as an economic resource. Winpenny (1994) states that water was provided at a low price or even free of charge in many countries. Traditionally, water was considered as public goods because the society acknowledges that water was a gift from God and it was available in great quantities. Therefore, it should be free goods, so it wasn't surprising that we're challenged to extract an economic price from users. Furthermore, the environmental externality as water users should be considered, with regards to water prices (Winpenny, 1994). Moreover, the water distribution networks were designed to supply more than just the basic needs, and even the rich consumers such as the industrial sector have access to water subsidies (Ako *et al.*, 2010). Gleick (2000) asserts that subsidized water will result in its overuse, and he claims that urbanization in many regions of the world such as Israel and California led to the needs for more water. High expenses for new water supply construction have compelled water managers to implement water conservation approaches through water-pricing systems and wastewater reuse. The failure of the conventional water management system to consider water as an economic good was considered the main factor leading to the failure of water management systems (Agarwal *et al*., 2000; Dungumaro, 2006; Chikozho & Mepedza, 2017). Thus, Gleick (2000) asserts that it would help shift the current water resources development approach. So, the notion of treating water as an economic resource emerged at the Dublin conference, where water was recognized as economic and social goods. However, they used the notion as a means to achieve more efficient usages of water and equitable benefits. Water was one of the basic elements; furthermore, it has many characteristics that are different from any other goods.

Savenije (2002) maintains that water was special economic goods. Moreover, the new EU Water framework directive stated that: "water is not an ordinary economic

good, but a social inheritance that has to be protected, defended and handled as such" (Jaspers, 2003, p. 88). This issue was also discussed by Bluemel (2004), who argues that the fourth Dublin principle required using the approach of full cost recovery for water, which adversely affects the poor. For this reason, the fourth principle should reconcile water as both economic goods and human rights. In order to ensure the human rights to water, water should be provided at a lower price, or free if it's possible to fulfill basic needs, then charged the full cost recovery for extra usage of water, as stated by Ako *et al*. (2010). However, 50 liter per capita per day, with high quality was recommended by Gleick (1998). However, Chikozho and Mepedza's (2017) founded that the effectiveness of water prices principle depends basically on the socio-cultural and political context of the particular country. For example, in Africa, the block-rate and the lifeline-rate principles of water prices was applied in order to achieve equity between the poor and the rich. However, in some cases, the public water supply doesn't cover all the poor. As a result, it has an adverse impact and encouraging wealthier people to waste more. Similarly, in Africa, the full water recovery cost reflects the fraught relations between the government (which claims the full recovery cost of water services without considering the quality of water supply) and the public who are unwilling to pay for bad water services.

2.1.6 The IWRM theoretical framework

The GWP has developed a general framework authorized by Agarwal *et al*. (2000), in order to enhance the IWRM application. The framework was very comprehensive it consists of (78) items that could use differently according to the needs of the particular implementer. However, it comprises of three main categories enabling environment, in the middle and the institutional role and management instrument at the edge of the triangle shape (Refer to **Figure 2.1**). Each one of these categories contains multilevel subcategories.

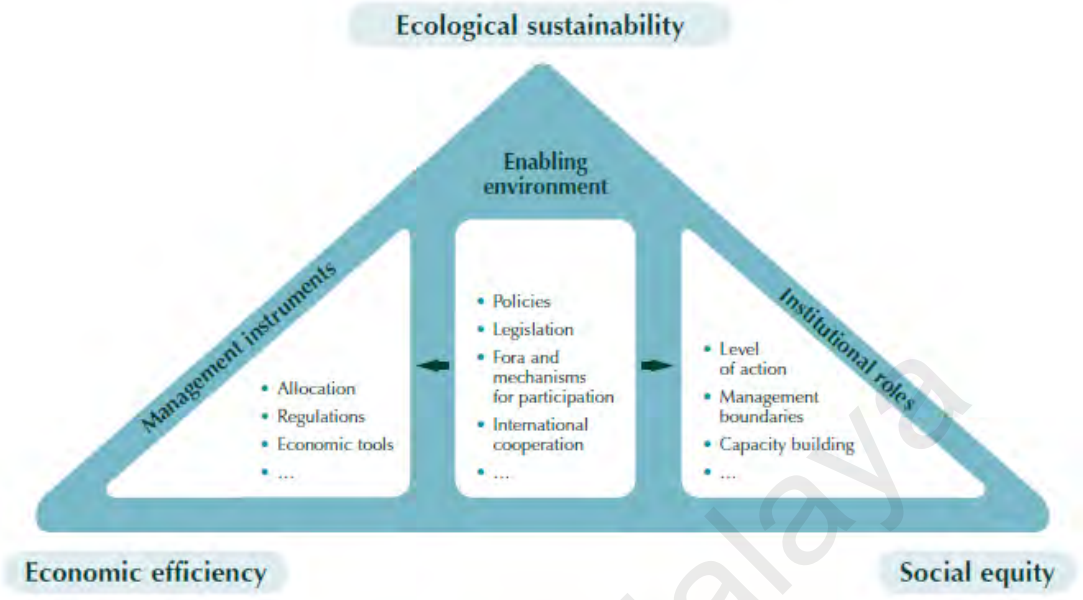

Figure 2.1: The framework model of the IWRM.
(Source: waterandmegacities.org)

The first category, enabling the environment:

The legislation, policies, and guidelines must reflect the IWRM principles, in order to support the sustainable management and development of water resources. The enabling of the environment was meant to make a change in all aspects of water management that has been used previously. The water decisions which were characterized by a top-down approach should be replaced by top down and bottom up, which will be formulated and consulted by all stakeholders at all levels. The role of water management will be re-distributed so that the government will be able to act as a controller, monitor, and regulator of the private sector, who will play the role of water provider. According to Agarwal *et al*. (2000), private sectors mean private companies as well as the community-based organization. The legislation must provide a framework for all parties to perform their functions. Accordingly, it should be facilitating with bylaws and detailed penalty guidelines, which will be implemented through an enforced

regulatory body. Previously the water was managed through sectoral or fragmented approach that needs to be reversed into a cross-sectoral perspective. In order to ensure all stakeholders are incorporated and participated in decision-making processes so, they can formulate an appropriate water decisions, which are satisfactory to all stakeholders' interests at all levels local, regional and internationally. Since, water flows without considering any political boundaries, the country from which the water resource originates was called an upstream country, while the others through which it flows are considered down-stream countries. The relationship between the upstream and downstream nations was at risk of tensions and conflicts, since the down-stream riparian conditions are subjects to the up-stream withdrawal and use of common water; these activities may affect the water source's quality and quantity. Therefore, coordination among the river basin countries was crucial and is always controlled via international laws, with the main features of equitable benefits and avoidance of significant harm to others. In order to achieve an integrated river basin management, the river basin countries try to create an international cooperation through the establishment of a regional partnership. For example, the Nile basin includes nine co-riparian countries; they established the Nile Basin Initiative (NBI) with a shared vision "to achieve sustainable socioeconomic development through the equitable utilization of and benefits from common Nile Basin water resources".

The second category, institutional role:

The relevant regulatory bodies, local communities, and government agencies must be set up to ensure the legislation, policies, and guidelines are put into practice. An institution with a role in the IWRM, it should function through capacity building. As the institutions consists of human as well as the physical resources or organizations, the efforts should enhance the human resource knowledge and awareness about IWRM through training and incentives. The awareness should be raised to change their

practices and to be willing to integrate with other water-related institutions (Agarwal *et al*., 2000).

The third category, management instruments:

These are the systems and tools, which help decision makers perform their tasks. This research will focus on four management instruments namely water resources assessment, which entails an assessment of water resources in terms of quality and quantity. In addition to supply and demand approach. Environmental Impact Assessment (EIA), which helps assess the impacts of water development projects on the social and environmental matters. Currently, it has becomes one of the project requirements to be approved and considered as a base for the water resource management process. It also includes many economic tools, which contribute to the water conservation and efficient usage of water, such as water prices, water tariffs, and fees structure. For example, the flat rate charge system in which the users are charged regardless to their consumption; this system encourages the wastage of water. There are supporting concepts such as Economic efficiency, social equity and the environmental sustainability are considered objectives or principles and they allocated at the each edge of the triangle shape (Agarwal *et al*., 2000).

2.1.7 IWRM implementation

Although, the provision of safe drinking water was one of the sustainable water management goals, one-fifth of the world's population lives in conditions of water scarcity. This may be attributed to the natural distribution of water, but nevertheless leads to economic deterioration, social disturbance, and poor institutional roles (Hering & Ingold, 2012). In order to overcome these challenges, the implementation plan calls for IWRM adoption and a water efficiency plan by 2005.

Rahaman *et al*. (2004) compared EU countries' Framework Directive with the outcomes of the international conferences on water from Dublin (1992) with the World Summit on Sustainable Development (WSSD) held in Johannesburg, 2002. They found that there were seven mismatches, even though several EU countries have played a leading role in those conferences. They asked whether the outcomes of these conferences were not efficient enough to influence EU policies. They raised the question whether these conferences only produce buzzwords, or is there a requirement for different principles of IWRM for developed and developing countries? The wide acceptance of IWRM as an approach for the water resources management happened after the WSSD, during which they suggests that all countries must adopt the IWRM and water efficiency plan by 2005, resulting in a wide acceptance of most of the countries. Despite many countries successfully including it in their national policy, in reality, the implementation of IWRM was rare and faces many challenges. Jeffery and Geary (2006) argued that the gap between IWRM in theory and practice remains extensive (Eslamian *et al*., 2017). "There is still long way to go to achieve a common understanding of the IWRM, to develop and refine approaches for its successful implementation" (Jonker, 2002).

The IWRM has two serious issues: its definition lacks clarity, and its implementation in reality, requires the determination of the elements that should be integrated. In addition to, the possibility of IWRM principles to be used as guide for the IWRM adoption (Agarwal *et al*., 2000). "IWRM is easy to talk about but hard to be implemented" (Garcia, 2008), Eslamian *et al*. (2017) asserted Garcia's thought. Scientific and water experts recognized that the IWRM lacks clear application methods (Stålnacke & Gooch, 2010; Eslamian *et al*., 2017). Gallego and Juizo (2011) and Eslamian *et al*. (2017) also asserted that the lack of the IWRM clarity creates difficulties in its implementation.

It was stated in Paragraph 26 of the Water Summit on Sustainable Development (WSSD), 2002, Johannesburg that "developing IWRM and water efficiency plan [must happen] by the year 2005, with support to developing countries". All countries that attended the conference were committed to developing an effective plan by 2005, to facilitate the process of IWRM implementation. Moreover, the GWP were developing a general framework for the IWRM (Agarwal *et al*., 2000), which was mentioned earlier in this section.

2.1.7.1 IWRM indicators

The indicators that showed the IWRM implementation level, differs according to the general understanding of the concept of IWRM among the international organizations and authors such as Centre for the Environment and Development for the Arab Region and Europe, CEDARE, UN-Water, African Development Bank (AfDB) and the GWP. According to Wagdy and AbuZied (2006), GWP was used to indicate the status of IWRM readiness, planning and implementation. CEDARE conducted a survey for some Arab countries in North Africa using GWP indicators, together with the Danish Hydraulic Institute (DHI) and the UNDP in order to assess the IWRM implementation status. Furthermore, they formulated a questionnaire based on some elements.

Box 2.1 and 2.2 showed the differences between GWP and CEDARE indicator elements for IWRM.

Box 2.1: The GWP Indicator elements (Source: Wagdy & AbuZied, 2006)

- Awareness rose about the IWRM and the political will to support the process.
- A framework for broad stakeholder participation.
- IWRM issues and challenges should be identified.
- Management potential and constraints: identified?
- Adoption of the IWRM plans at the highest political level: ensured?
- Capacity building: initiated?
- Portfolio of implementation projects and financial strategy of the plan: prepared?

Box 2.2: CEDARE Indicator Elements (Source: Wagdy & AbuZied, 2006)

- National Water Policy, which must be relevant to IWRM principles.
- National Water Legislations that concern water ownership, to emphasize stakeholder participation among other issues.
- Institutional Capacity for undertaking IWRM, the institution must support the IWRM aspect, such as formulating relevant policies and legislation, cost recovery, data and information system
- Institutional Framework, which ensure coordination among different water related sectors and stakeholder at all levels.
- Institutional Constraints include the lack of good governance, financial resource and clear and definite institutional mandate.
- Adequacy of human resources to handle IWRM, the qualified and professional staff, as well as their awareness of IWRM application.
- Level of awareness of the IWRM among different stakeholders, including the water managers, policy makers, NGOs and others.
- Implementation status of IWRM, in order to assess whether there is an action plan which consists of capacity building program, budget strategy, follow-up and evaluation of IWRM implementation.

So, the differences of the indicators of the implementation progress indicate that the IWRM concept is a relative concept, and its implementation progress varies according to the implementer. Therefore, IWRM is a good practice resulting in better water resources management.

2.1.7.2 IWRM planning and implementation stages

All over the world countries struggle to convert the concept of the IWRM from theory to practice. In order to do this, we need to formulate an action plan. Jønch-Clausen (2004) argues that IWRM was described as a cyclical process starting with establishing an overall goal stage. Within this stage the country tries to prioritize its urgent issues and enable the environment through frameworks; the next stage was to build a commitment to a reformation process. The most important issue was to focus on raising awareness among all stakeholders and to bring the water management issue to

the top of the political agenda; to match the current situation of legislation and institutions with the IWRM framework to assess the gap and attempt to bridge it; and as well prepare a strategy and action plan, which will be a prerequisite contribution and a guide to finalizing the water resources management framework and to build a commitment to act. There are three factors that are needed to facilitate the implementation process towards progress and success. The political commitment to action plan should agree by the different stakeholders and the financial support must be secured. The framework must be implemented, as it consists of three basic elements. Namely, to enable the environment and to ensure that the institutional role was already been implemented. And finally, to utilize the management instruments, which will be discussed in the next section. The frameworks end with the monitoring and evaluation of progress to assess the efforts and benefits by using an appropriate progress indicator that will give good results. There is no specific stage to start with as it varies according to the country that uses the framework. However, the framework stages can be repeated if it's important, the repetitions depend on the country's situation (Eslamian *et al*., 2017). **Figure 2.2** shows the IWRM process.

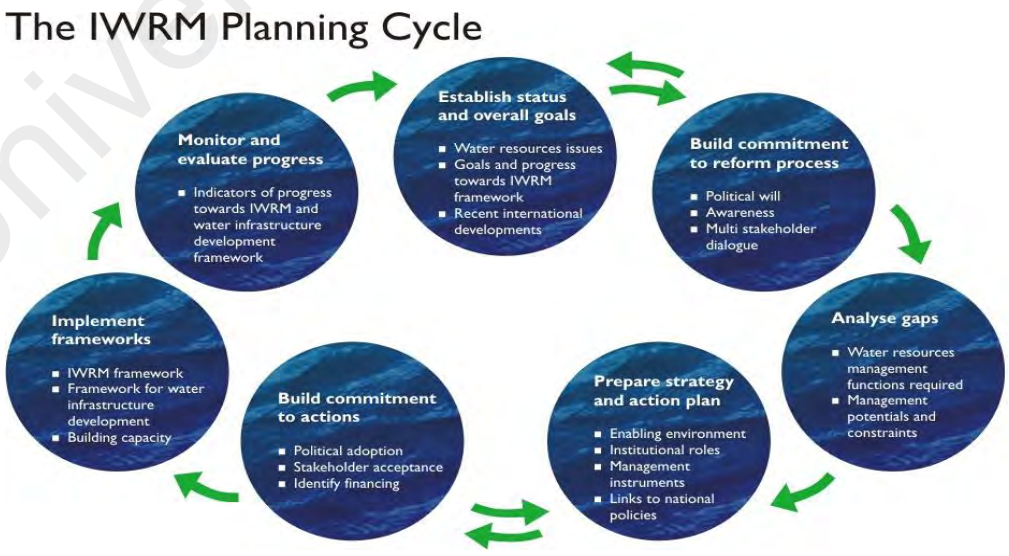

Figure 2.2: IWRM implementation stages
(Source: gwp.org)

2.1.7.3 IWRM implementation challenges

The practical evidence for the IWRM application and its outcomes was described as poor or missing (Jeffrey & Gearey, 2006; Eslamian *et al*., 2017). As the world's countries are differs in their stages of development, economy, social, culture, water resources, nature and institutional arrangements (Agarwal *et al*., 2000; Eslamian *et al*., 2017). Consequently, each country or region will vary in their way of the IWRM implementation. Jønch-Clausen (2004) claims that "there is no one size that fits all" and that also states that: “put it means many different things to different people" (Jønch-Clausen & Fugl, 2001; Grigg, 2008). The IWRM aims vary significantly for example, in the developing countries; poverty, health, and environmental sustainability are the main issues to be addressed within the IWRM. For countries in transition, in terms of economic development are being targeted through the water resources management. While developed countries, find inspiration in the IWRM strategy to achieve their own targets such as environmental protection. The latest considered the main focus of the EU Water Framework Directive (Jønch-Clausen, 2004; Eslamian, *et al*., 2017).

In this regard, Merrey (2008) agrees with Biswas (2004, 2008) that the implementation of the IWRM concept is unfeasible, especially in the poor countries, which lacks water infrastructure. Merrey also claims that IWRM affects the main objectives of the water resources management; he duly suggested introducing the concept of expedient water resources management.

Rahaman and Varis (2005) discussed the IWRM evolution; to counter the IWRM implementation difficulties, they suggests privatization, water as an economic good, trans-boundary River Basin management, restoration and ecology, fisheries and aquaculture. The need to focus on past IWRM experience, integrated lessons learned, and the spiritual and cultural aspect of water as issues to be handled for successful implementation process (Eslamian *et al*., 2017). Van der Zaag (2005) asserts that the

institutional capacity, the conceptual issues of IWRM and the trans-boundary nature of water sources are interlinked issues to be considered (Chidammodzi & Muhandiki, 2017). Hering and Ingold (2012) emphasized that as IWRM is internationally accepted, its implementation barriers should be well-addressed. As such, the identification of the IWRM barriers will make it more practical (Kadi, 2014; Eslamian *et al*., 2017).

The implementation of IWRM significantly constrained by ten factors:

(a) The definition of IWRM:

Although, the most authorized definition was formulated by the GWP in 2000, it was criticized by Biswas (2004, 2008), among others. It's also considered the main constraint in the implementation process (Eslamian *et al*., 2017). Medema *et al* (2008) believed that the ambiguity of the IWRM definition was considered one of the four major barriers to the IWRM implementation (Eslamian *et al*., 2017). They also agreed with Biswas (2004, 2008) regarding the definition, which lacks measurement and worldwide validity. Other authors criticized the IWRM definition because of its vagueness and it focuses on the secondary issues while ignoring the basic issues (for example, the definition doesn't address the infrastructural aspect, and it also neglects the political nature of water management (Biswas, 2004, 2008; Merrey, 2008; Gordiano & Shah; 2014; Chidammodzi & Muhandiki, 2017; Eslamian *et al*., 2017). Cardwell *et al.* (2006) attributed the IWRM implementation difficulties to its unsteadiness. Jeffrey and Gearey (2006) explained that the implementation difficulties of IWRM can be attributed to the lack of clarity of the concept as well as its definition which lacks measurements (Eslamian *et al*., 2017).

Gallego and Juizo (2011) concurred that the definition are unclear. As a result, it was difficult to guide the implementation plan.

Grigg (2008) and Acheampong *et al*. (2016) claimed that the definition's clarity was crucial for a successful implementation. They also emphasized the items to be

integrated must be compressed, therefore, they proposes a brief definition. Jeffery and Gearey (2006) stated that it wasn't easy for the IWRM to be implemented. They associates this for two reasons; the first being its unclear definition, and the second, the lack of measurements to facilitate the implementation process needed to overcome all these issues of the IWRM definition. For a more practical definition, Allan (2003) asserts that in order to ensure a successful implementation of IWRM, we must consider the political processes. Allan proposes adding the allocation to the concept to become Integrated Water Resources Allocation Management (IWRAM), yet it still lacks the practical guidance. Rahaman and Varis (2005) suggested five issues that must be solved before the IWRM implementation (Eslamian *et al*., 2017).

Merrey *et al*. (2005) proposed that poverty should be included within the concept and they suggested a new definition, but nevertheless, it is unable to assist the IWRM implementation process. IWRM suffers from conceptualization issues hence some authors such as Van der Zaag (2005), Grigg (2008) and Karthe *et al*. (2015) proposed that IWRM must be defined as a framework and not as a process. Moreover, when IWRM is defined as a process, it will become more difficult to move towards an implementation (Jonker, 2007). IWRM should be defined as a "boundary term" to be implementable in different contexts (Mehta *et al*., 2014).

(b) The institutional barriers regarding this issue, Galaz (2007) argues that the IWRM was accepted because the policymakers and researchers believe that it will ensure an appropriate governance institution through which the IWRM goals can be attained. From literature, good governance was considered a key factor for a successful implementation of IWRM (Pahl-Wostle, 2002; Jønch-Clausen & Fugl 2001; Galaz, 2007; Grigg, 2008). The issue of water is always an interconnected one. On one hand, there are different institutions dealing with the water issues. Their integration and attempts at reaching an agreeable decision are very difficult. Another issue was that the

water resources cannot be considered separately. When we intended to manage water, we should take account of agriculture, land use, and forests among other uses of water.

On the other hand, water flows regardless of political boundaries. This creates the issue of trans-boundary water among nations and countries. With regard to this issue, some authors say that there are no need to establish a new institution to implement the IWRM; instead, they encourages the coordination and collaboration of the existing one (Biswas, 2004; Jeffrey & Gearey, 2006; Grigg, 2008; Medema *et al*., 2008). Van der Zaag (2005) believes that even the new institutions that have been established, it must enforced a consultant role rather than an executive one. Therefore, unless we overcome these two institutional barriers, it will be very difficult for IWRM to be practiced successfully.

(c) The political will, which can be thought of as a form of support from the political leaders by placing water issues within their priorities of policy. In this regard, Van der Zaag (2005) states the reason that most of the rural population in South Africa Development Community (SADC) still lacks water and sanitation was because of the absence of a political will. The lack of a political will was considered as the main reason that impedes the IWRM implementation (Allan, 2003; Swatuk, 2005; Van der Zaag, 2005). Allan thinks that if we took the political will into consideration, the implementation processes surely will succeed.

(d) The lack of human capacity in water resource's institutions, since it's not only one of IWRM framework; rather, it is allocated in the heart of its elements and is considered as the most important prerequisite for institutional development (Swatuk, 2005).

(e) The financial problems, or poor financial resources of the management aspects, for example, many institutions faces limited financial resources to build capacity for human

resources through training programs and skills development, which highlighted by many authors (Swatuk, 2005).

(f) Data availability, including the methodology and analysis of data, which are crucial in the early stage of the implementation process until the last decisions. In other words, the water resources assessment consists mainly of figures and statistics on water quantity, quality, and of population size (Biswas, 2004; Jonker, 2007).

(g) The infrastructure for basic services may be incomplete. This is a common situation in almost all of the under-developing countries. Biswas and Merrey raised the issue of the adoption of water prices as a tool for demand management. Since, it was difficult to be implemented without volumetric system to control water consumption (Biswas, 2004; Merrey, 2008).

(h) Lacks of awareness among users and officials. Water users are unaware of the other users' needs, the conservation aspects and their roles in water management processes, while officials need awareness regarding the public participation and the governance aspects.

(i) The complication of water regulations and the poor enforcement of sanctions. This issue was dominant in African countries. The water regulations are the cornerstones in IWRM implementation processes as all management aspects rely on water legislation such as water quality parameters and the role of water institutions.

(j) The lack of planning tools and management strategies, are considered as the most vital factors.

2.2 IWRM in the context of least developing countries in Africa

Section two focuses on the IWRM implementation in the least developing countries. First, it will highlights the progress of IWRM in some Arab and African countries, some challenges for African countries. It also points out some success and failure stories of implementation, which includes factors of success and failure implementation efforts. The section then shows the present status of water management and IWRM progress in Sudan.

Africa has an abundant water resource, with 50 significant water basins located in most of its countries, including large inland water bodies such as Lake Victoria, Chad, and Kariba. Furthermore, one-third of the world's rivers are allocated within the Sub-Saharan Africa (SSA) continent, which includes 11 river basins occupying about 30,000-100,000 km2. Van der Zaag (2005) was of the opinion that the concept of IWRM was a perspective, a way of looking to solve the problems through an effective decision-making process; he believes that IWRM was relevant to South Africa because it encourages new water managers to do well regarding water management issues. And it helps in achieving the MDGs mainly poverty reduction and ensures the coordination among the southern Africa water professionals.

2.2.1 Progress of IWRM in some Afro-Arab countries

Sudan has mixed characteristics as it was an African country, with a mostly Arab population. Its progress has to be viewed through the context of both Arab and African countries. In order to address the progress of the IWRM implementation process, GWP carried out a survey in 108 respondent countries in 2005, the survey showed that 10% had made good progress towards the IWRM efficiency plan. Another 50% had taken some steps and 40% were still in the initial stage, as the date for natural strategies neared (Bennett, n.d.).

UN-Water issued a report aimed to illustrate progress made on meeting the target to develop integrated water resources management and water efficiency plans by 2005. This was endorsed at the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002 through the Johannesburg Plan of Implementation (JPoI). It was based on a survey covering 104 countries of which 77 are developing or countries in transition and 27 are developed (the OECD and EU member states). The survey shows also the results of questionnaires by UN-DESA, UNEP in 2007, and some of the GWP survey reports in some African countries (UN-Water, 2008), which was depicted in **Figure 2.3**, this figure grouped some of the African countries with varied developmental status. Three countries are already adopting the IWRM approach, while others are preparing plans for implementation; three have taken only initial steps towards implementation. So, this may indicates, despite the differentiation between different countries, but there are many factors affecting the progress of the implementation processes.

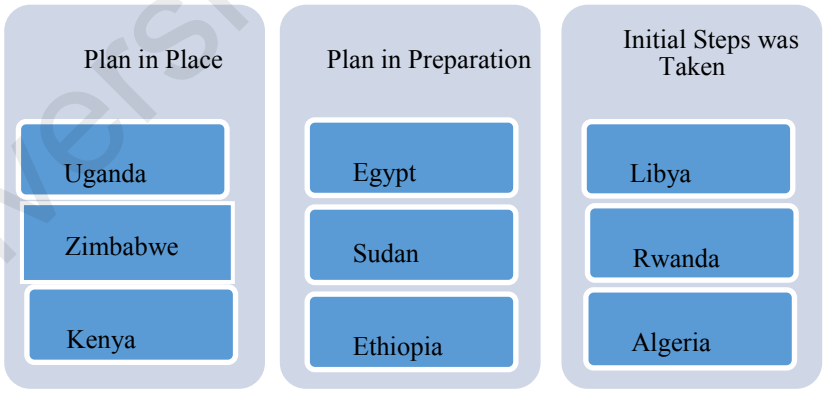

Figure 2.3: IWRM progress in some Africans countries.
(UN-Water, 2008)

According to, CEDARE in the year 2003 they conducted a survey for Egypt, Libya, Tunisia, Algeria, Morocco, and Sudan, the 2005 target was likely to be met in all countries, and the progress status, plans, strategies, and policies were on track to

achieve IWRM. CEDARE survey showed some positive indicators by some Arab countries, based on the establishment of national water committees and boards (Tunisia and Libya), water use association formulated in Egypt and the development of integrated basin management authorities in Algeria. So, there is some progress towards IWRM application, but still there are many Arab countries lagging behind (Wagdy & AbuZied, 2006). Recently, the UN conducted a survey of 134 countries prior to the Rio plus conference, 2012 the survey results showed that 82% of these countries starts to reforms in order to enhance the enabling environment, as a most important step towards the IWRM implementation, the IWRM plan was applied in 65% of these countries, (Kadi, 2014; Al-Saidi, 2017). 79% updated their water policies and 71% of these countries expedite the water management at the basin level (Al-Saidi, 2017). While, 34% achieved high progress in the IWRM application (Kadi, 2014).

2.2.2 Successful stories for IWRM implementation in some Afro-Arab countries

Successful IWRM implementation is highly linked with the water resources availability, stage of development, institutional structure and socio-economic situation of the particular country. This section represents successful stories of IWRM adoption in some African countries. For example, South Africa as one of the first African countries that successfully adopts the IWRM approaches for its water resources management. In 1996, water laws and policies were adopted, and the new Water Act was formulated in 1998. South Africa reduced water management to domestic and municipal users only by 2006 (Jonker, 2007), which contributed to the situation of South Africa in IWRM conceptualization. Application of IWRM in South Africa led to a new generation of creative water management, and better coordination among water specialists. Although, IWRM are usually considered a buzzword, this was not the case in South Africa (Van der Zaag, 2005). Despite, the numerous challenges facing the IWRM implementation, there are still some countries that successfully implemented the

IWRM. South Africa was an example of an African country that adopted the IWRM as an approach to manage its water resources. It can be seen as an example of recently adopting IWRM as a central water resources management approach. Since the 1990s, South Africa implemented many strategies in order to eradicate the poverty as well as to increase social and economic development. The policy and legislation have been improved for different sectors including the water sector, this clear from its achievements of the MDGs for water service in 2002, which was initially targeted to be achieved in the year 2015 the Department of Water Affairs and Forestry (DWAF) is the government department responsible for the formulation and implementation of policies governing South Africa's water and forestry sector. It has a significant role in supporting the water sector through local authorities' improvement in terms of Water Service Act (No. 108 of 1998). It also established the Infrastructure Assessment Management (IAM) strategies in order to develop municipal infrastructure. South Africa has many policies and legislation concerning water supply management such as the Water Supply and Sanitation Policy approved in the year 1994 followed by the Water Service Act (No.108, 1997). Regarding water resources management the first National Water Resources Strategy (NWRS) was approved in 2004, thus fulfilling the requirements of the National Water Policy and the National Water Act (No.36 of 1998).

In Burkina Faso, they are also facing many water issues and challenges that constrained its development. It was decided to implement IWRM through three steps: assessment of the situation, rearrangement of the legal framework in accordance with IWRM principles and investigation of the major water resources management issues, in order to develop an action plan. The process ensured the representation of different stakeholders and the mainstreaming of the action plan framework within the law, including its details and implementation supported by consultation. The main issues of water have been considered through numerous stakeholder participation processes. A

permanent secretariat has been established, with a mission and a role to implement the committee decision of the action plan (Jønch-Clausen, 2004). In Algeria where most of the water resources are shared with the neighboring countries, it focuses on water governance within the IWRM implementation. They formulated five agencies and committees as water parliament for national water resources.

The previous examples of IWRM implementation are mainly tried to achieve the four Dublin principles and the three pillars of IWRM as suggested by the GWP. That consists of the enabling of environment by preparing an adequate legal framework. Similarly, the institutional role, by means of establishing instructional framework, raises the capacity for both human and institution to enable them to deal with IWRM. And management instruments such as monitoring and assessment of water resources, and the environmental impact assessment of different development projects.

2.2.3 IWRM implementation challenges in some Afro-Arab countries

Most of the world's countries attempted to implement IWRM as an approach for their water resources management. The fact is that it wasn't easy to successfully adopt a plan for IWRM implementation, particularly in developing countries. This study lists some examples of failure implementation stories including the factors that led to the failure.

Cameroon was a country with large water resources, which are poorly managed because of increasing population and unplanned urbanization. It attempts to use IWRM in order to achieve sustainable water management. There are some issues that hampered IWRM implementation such as a lack of institutional framework. Water is managed through fragmented institutions and the poor public involvement in the water management processes. Water is provided with low prices because of subsidies; furthermore, providing water for its entire population is considered as a challenge.

Water are failed to be recognized as a social goods; consequently, the government was unable to provide water in sufficient quality and quantity to meet basic needs as a human right. IWRM are not considered in livelihood perspectives; there was a need to develop a mathematical model that facilitates IWRM implementation (Ako *et al*., 2010). Similarly, in Egypt, there are many factors that impede the IWRM implementation. They are composed of four factors. Firstly, water should be considered in a holistic way, but in Egypt water quality issues in urban as well as rural areas are worsened daily; secondly, the decentralization of water management was one of the most important IWRM principles. Which encourages that water management tasks shared between the public and private sector, however, the Egyptian government was still dominant in providing water service; thirdly, effective stakeholder participation are crucial, in contributing to IWRM success, yet legal constraints create low levels of stakeholder participation in Egypt (Abdelgawad *et al*., 2010; Hoffet *et al*., 2012). Lastly, water should be regarded as economic goods through numerous economic instruments such as full cost recovery, but in Egypt, water suffers from low-cost recovery (GWP, n.d.).

There is no blueprint for IWRM planning and implementation process. It is not possible to enact a similar IWRM model for all countries or even for all regions within a single country. As these entities differs in natural resources, population distribution and lifestyle, economy, as well as political, institutional and legal structures (Goodman & Edwards, 1992). The same factors could lead to success or failure of IWRM adoption, as is clear in **Table 2.4** below:

Table 2.4: Factors of Failure IWRM process

IWRM aspect	Factors of successful IWRM	Factors of failure IWRM
Holistic approach	Consider a holistic approach for water, decentralized water management.	The water managed in fragmented manner, and water institutions, lack of an institutional framework.
Stakeholders participation	Adoption of stakeholder participation approach, which ensure public awareness and create some procedures to facilitate their participation at all water management stages.	Public and stakeholders are rarely to be involved in water management system.
Decentralization		Water management is centralized by the government; water services are provided by the government.
Political will	IWRM has been supported adequately from the highest political levels.	
Management instruments including information	The availability of water data and information, the data on water quality and quantity.	
Institutional role	Water institution differed from the previous one; it is well established and it has a framework for water management.	
Water as an economic and social good	Treat water as an economic good and as a social good as well.	Fail to treat water as economic goods, in other words, water subsidies from the government, provide water at a low price in large
Dublin principle recognizes the importance of woman involvement in water management process.		The importance of women empowerment and involvement, moreover, to address their role in water management through water law and legislation.

So, it was difficult to translate the IWRM concept to practice. Merrey and Biswas asserted that it was unfeasible to implement IWRM in developing countries, where there is no infrastructure (Mazvimavi, *et al*., 2008). Biswas (2004) also maintains that the IWRM concepts are vague and lacks guidance, which makes it very difficult if not impossible to be implemented. Lankford *et al*. (2007) countered Biswa's claim by stating that IWRM implementation are possibly right for developing countries. However, in developed countries such as; the European Water Framework Directive, USA, and Australia where infrastructure and policies exist. The main cause of IWRM

implementation difficulties are not only due to the lack of infrastructure and policies, as it's in the least developing African countries. However, evidence shows that even in developed countries such as European WFD, U.S., New Zealand, and Canada, the full implementation of IWRM are doubtful (Agyenim & Gupta, 2012). Furthermore, Rahaman *et al*. (2004) when compared the European WFD with IWRM principles, they found that there are seven mismatches in European WFD. Failure cases of IWRM implementation mainly attributed to the lack of clear and agreed definition of IWRM and inability to provide a specific method for implementation. Some of the countries attempted to frame their IWRM strategy around the four Dublin principles. While other countries tried to adopt the three pillars of IWRM implementation framework as proposed by GWP. Furthermore, there were different guidelines used in IWRM application. So the issues of success and failure of IWRM application could be assessed relatively.

There was recognition that the water resources in many African countries have a significant role in the social and economic development (UN, 2007). Many countries have struggled to convert IWRM principles into practice because their strategies often used a blueprint that failed to take into account local resources and problems. In some countries, the national IWRM policy was formulated, but not adopted. While other countries had partial elements of strategy, including model experiments and water resources management blueprint, but also faced socio-political conditions, which hampered its implementation (Bennett, n.d.).

For instance, Jonker (2007) argues that, despite extensive publication on IWRM as well as the establishment of the necessary enabling environment, implementation remains elusive. Through an analysis of documents DWAF in South Africa (policies, legislation, reports, media release and the 2007 Budget Vote) and the literature on

IWRM, it is concluded that DWAF has moved from broadly IWRM to primarily domestic supply and sanitation. This is due to a lack of conceptual clarity of IWRM.

In Mozambique, the IWRM is constrained by low human resource and capacity building in the water sector institutions, non-existence of water management plans at river basin level and weak financial structures. Gallego and Juizo (2011) emphasized the importance of community participation in the process of IWRM, while Dungumaro and Madulu (2003) conclude that the community participation is crucial to successful and sustainable water resources management. They emphasized that natural resources management related policies including water requires the use of knowledge, experience, and opinions of local communities who are the key stakeholders in resource conservation; through public participation.

Unlike the previous authors, Merrey (2008) goes into more detail on IWRM implementation feasibility in developing countries. Merrey states the implementation IWRM concept requires the existence of water infrastructure, which are lacking in most developing countries. In other words, for IWRM to be implemented, we should use demand management and cost recovery aspect, polluter pay principle, and effective stakeholders involvement. These aspects are unfeasible in the context of developing countries where there is no infrastructure for water delivery and measurement. In addition, to the lack of physical, institutional infrastructure and the poor involvement of stakeholders in water decision-making. IWRM definition by GWP was concerned with second generation issues while ignoring the first one. For example, the provision of water, livelihood, and the poverty reduction. This compelled many authors to looking for a new definition that took into consideration the critical issues that faced by humans. Merrey asserts that IWRM marginalizes the basic issues and the most important issues for people such as water accessibility, livelihood and poverty reduction. Merrey

suggests discarding IWRM and adopting the adaptive water management approach; she also proposed the expedient water management as a water management approach.

According to Donkor and Wolde (2000), IWRM's challenges in African countries are due to population growth; in Africa, the rate of population growth are estimated to be around 3%, which adds more pressure on the water resources because of the increasing population needs for agriculture, industry, and domestic water. Consequently, the available water resources are reduced; water resource data, despite being necessary for the water resources planning and development, is still not collected in many African countries; water scarcity in many parts of Africa is due to water demand exceeding the water availability, e.g. in some North African countries it is associated with the dry season. While in other regions suffers from the scarcity of water resources per se, for example, Ethiopia, which experience water scarcity as a result of the re-occurrence of drought. Moreover, the Population Action International Study expected that by 2025, fifteen African countries will suffer water scarcity, while eleven will face water stress and institutional aspects. There are many institutional issues affecting the IWRM implementation such as the coordination of the responsibilities of water resources planning and management, which is fragmented among different sectoral ministries. This results in the overlapping of activities and wastes limited resources. Other issues include the lack of a comprehensive water policy and legislation, which, is most important factor in IWRM application. Further, IWRM is strongly related to the coordination of the water sector activities such as water pricing; in general, the government is responsible for water resources planning and development. However, it always lacks financial resource and the capacity to install, operate and maintain them. These issues constrain the development of water resources, as well as their operation and maintenance. In many African countries, several projects of water supply and irrigation are not operating as designed. This is due to poor operation and

maintenance. For example, many systems lose considerable amounts of water through leakages, which causes not only water losses but also costs money and worsen the system. This situation considered a major problem especially in remote areas of rural Africa. Poor human resource development, the lack of human skills and experience, in many aspects of water management contribute to the ineffective performance of most of the water institutions. A lack of regional cooperation on trans-boundary basin; despite Africa's 57 trans-boundary rivers, lakes, and groundwater, most of them lack cooperative arrangement and integrated land and water management. The fragmented management of these sectors leads to ineffective management.

2.2.4 Present status of water management and IWRM progress in Sudan

Sudan is a semi-arid country where water is precious; in order to avoid water resources conflicts water resources should be manage adequately. Regarding this issue Abbas *et al*. (2013) in their report they aimed to address the level of IWRM implementation in Sudan as a part of a regional assessment. They asserted that the policies and legislation were scattered over different water institutions without coordination between them. Moreover, the fragmented structure of the institutional framework results in overlapping of the responsibilities. They also introduced IWRM opportunities, implementation challenges, as well as the regional and international issues of water.

Ibrahim *et al*. (2009), UNESCO-CWR conducted a research study to assess drinking water sources in Khartoum state. The results showed that surface and groundwater were at risk of contamination by wastewater disposal because of improper practices. Poor maintenance of water network distribution threatens the drinking water quality; furthermore they concluded that all drinking water supplies were unsafe due to contamination.

The governmental water supply in Khartoum state lacks behind the increasing demand, particularly during the end of 1980. Greater Khartoum was facing rapid increases in demand for water due to the civil war in the South and western part of the country. In addition, to the drought, this increased migration towards Khartoum city. Despites the government's efforts to improve water supply (such as the new network extensions and construction of new water stations), still, it was failed to catch up with the rising demand for water (Beckedrof, 2012).

United Nations Environmental Program (2007) discusses many issues of water resources in Sudan such as different water resources, and water consumption, which were mainly dominated by the agricultural sector. They also discussed the Environmental Impact Assessment (EIA) issues of water sectors; moreover they asserted the poor EIA for large dam projects in Sudan such as Merwe dam. The author confirmed that all water sources are in bad condition due the biological water pollution from sewage; consequently, waterborne diseases as the main threat to human health in Khartoum state.

While, the Nile Basin Initiative (2005) describes the water resources availability in Sudan, its usage, the legal and institutional framework of water, some observation on the current legal status; the author also discusses the international water issues. He argues the lacks of water policy, overlap of regulations and lacks of coordination between concerned agencies were the main constraints of proper water resources management. For instance, groundwater resources of Khartoum are vulnerable to contamination due to the liquid waste disposal through injection Wells and surface ponds, which were prohibited in many water laws and regulations. However, the law could be violated by charging some money. The development of water resources policy

and clear mandates on water resources management along with the enactment of the water policies are the key solution (Elmadani, 2012).

In 2007, the Sudanese government invited the United Nations for Development Program (UNDP) to support the IWRM implementation program, along with the Ministry of Irrigation and Water Resources (MIWR) and other non-governmental organizations. UNDP was successfully implemented IWRM in Darfur, which included two study tours to South Africa to benefit from the South African's implementation experiences, which came from the development of a shared vision on IWRM with stakeholders from Khartoum and Darfur (Sudan, 2012). The UNEP targeted the expansion of the IWRM program to comprise the whole country. The main objectives are to support MIWR in formulating policy and strategy for IWRM focusing on non-Nile water resources; to implement participatory catchment management in a number of degraded Wadis basins in Sudanese IWRM principles and to support institutions; and strengthening of IWRM stakeholders with a particular focus on groundwater and Wadis department.

IWRM program was shared between the Ministry of Water Resources Irrigation and Electricity and Ground Water and Wadis Directorate. The third party UNEP, however, their program contract ending by the end of 2014. They mainly aimed to promote the adoption of the IWRM principles in water resource planning and management in the federal government of Sudan, through targeted support to policy and strategy formulation, organizational development and staff capacity building through the national program.

2.3 IWRM from an Islamic perspective

This section discusses IWRM from the Islamic perspective by introducing the importance of water in Islam, and it argues Islam and water rights, then it discusses the

water conservation in Islam, lastly, the section highlights the Islamic principle of water consumption.

First, it provides interpretations for some words that are used repeatedly within this section. Firstly, the meaning of Islam, the root of the word Islam is *Salam* in Arabic, which means "peace and harmony". The Islamic way of life teaches about living in peace and harmony. According to the Arabic dictionary, Islam means "a binding obligation and to avoid the forbidden without objection" (Amery, 2001a). Islam is the second largest religion in the world, with the current Muslim population estimated to be at 2.18 billion, or 28%, or more than one-fifth of the world's population according to the website of Muslim population data (National Public Radio, 2015).

Al-Quran is the exact word of Allah, as received by Prophet Muhammad (PBUH) through the Angel Gabriel; *Sunnah* is the description of Prophet Muhammad's (PBUH) life, which can be found in the *hadith*. And it's consists of documented narrations of prophetic deeds and sayings. It also gives more specifics about the Quran (Faruqui & Al-Jayyousi, 2001).

Water management is highly affected by a society's customs, traditions, cultures, and religions (Amery, 2001a). A Muslim is a person who declares the shahada - which means 'there is no God but God (Allah) and Muhammad is the last messenger of God'. Most Muslim countries are facing the issue of water scarcity (Amery, 2001a). Islam highly encourages water conservation and it agrees with IWRM principles. Islam can inspire Muslims to support IWRM implementation particularly in Sudan, where 97% of Sudan's population is Muslims, with reference to Muslim population.com

In Islam, there are two sources: First is the Quran, which is the records of God's words to the Prophet Muhammad (PBUH), it is also defined as guidance for Muslims. Second, is the *Sunnah*, which provides more details about the Islamic way of life and

Prophet Muhammad's (PBUH) traditions (Faruqui & Al-Jayyousi, 2001). Moreover, Allah (S.W) ordered the Muslims to obey the Prophet by following the *Sunnah*: "O you who have believed, obey Allah and obey the Messenger and those in authority among you. And if you disagree over anything, refer it to Allah and the Messenger, if you should believe in Allah and the Last Day. That is the best [way] and best in result" (4:59). From the Quranic verse, obedience to the Prophet is equal to the obedience of Allah for believers.

2.3.1 The importance of water in Islam

Water was mentioned in the Quran repeatedly - about 63 times (Amery, 2001b; Faruqi, 2001; Gilli & Arabic, 2004; Wickström, 2010; Jah, 2013; Absar, 2013); this indicates the importance of water in Islam. Water was referenced in the Quran in many ways, for example, as the origin of all living beings, Allah said: "Have those who disbelieved not considered that the heavens and the earth were a joined entity, and We separated them and made from water every living thing? Then will they not believe?" (21:30) (Faruqi, 2001; Gilli & Arabic, 2004; Ahmad, 2011; Jah, 2013; Absar, 2013). This means water is life-giving. It's the origin of all living things and a sustaining element. Also, it's used to giving life and it is evidence of the resurrection. Therefore, Muslims must appreciate water because if there is no water there is no life.

In the description of the thorn of God, Allah said: "And it is He who created the heavens and the earth in six days - and His throne had been upon water - which He might test you as to which of you is best indeed. But if you say, "Indeed, you are resurrected after death,' those who disbelieve will surely say, this is not but obvious magic." (11:7).It is also used to describe God's throne as lying on water, meaning that the water was created before the heavens and the earth (Absar, 2013).

Paradise was described as a garden that has rivers flowing beneath it: "Allah hath promised to Believers, men, and women, gardens under which rivers flow, to dwell therein, and beautiful mansions in gardens of everlasting bliss. But the greatest bliss is the good pleasure of Allah. That is the supreme felicity" (9:72). So, water in the paradise provides coolness, greenery and is useful to quench thirst (Gilli & Arabic, 2004). This gift of paradise reflects the uniqueness of Allah.

The Quran states that: "More precisely, is He [not best] who created the heavens and the earth and sent down for you rain from the sky, causing to grow thereby gardens of joyful beauty which you could not [otherwise] have grown the trees thereof? Is there a deity with Allah? [No], but they are a people who ascribe equals [to Him]". (27:60) (Gilli & Arabic, 2004). The verse indicates that water was needed by all aspects of life. Humans cannot create anything, but Allah is the creator of everything and this can be used as a sign of His uniqueness.

Water is also a resurrection sign, as shown Allah proclaims "And Allah has sent down rain from the sky and given life thereby to the earth after its lifelessness. Indeed in that is a sign for a people who listen" (16:65) (Faruqi, 2001; Gilli & Arabic, 2004; Attallah *et al*., 2001; Jah, 2013; Absar, 2013).Water is the primary element of life for plants, humans, and animals survive.

Purification is a vital need, especially for Muslims, because the purification is the basic requirements for worship such as prayers, which have to be preceded by ablution (*Wudu*) (Faruqi, 2001; Absar, 2013). Regarding purification's aspects, Allah said in the Quran:"[Remember] when He overwhelmed you with drowsiness [giving] security from Him and sent down upon you from the sky, rain by which to purify you and remove from you the evil [suggestions] of Satan and to make steadfast your hearts and plant firmly thereby your feet." (8:11) (Gilli & Arabic, 2004).Water is essential for Muslim purity. It is clear from the water usage in *Wudu* or ablution. It can be defined as a ritual

cleansing of the face, hands, and feet with water. Furthermore, one of the five pillars of Islam is prayer, which is always preceded by *Wudu* as commanded by Allah in the Quran: "O you who have believed, when you rise to [perform] prayer, wash your faces and your forearms to the elbows and wipe over your heads and wash your feet to the ankles" (Absar, 2013). The description of *Wudu* makes it crucial for Muslims to perform it before the five daily prayers. It is stated by the Prophet (PBUH) that, there is no prayer without *Wudu*. Allah said: "And if you are in a state of janabah, then purify yourselves. But if you are ill or on a journey or one of you comes from the place of relieving himself or you have contacted women and do not find water, then seek clean earth and wipe over your faces and hands with it. Allah does not intend to make difficulty for you, but He intends to purify you and complete His favor upon you that you may be grateful" (5:6) (Gilli & Arabic, 2004).

Moreover, Al-Sheikh (1996) claims that during *Wudu* we wash away most of the uncovered parts of the body, which are subjects to pollutants and odors due to secretions. They also considered a good environment for the breeding of the bacteria and parasites. There are many benefits from body cleansing or even a part of it such as invigorating to the blood circulation and the nervous system. Also, it activates the whole body. Originating from Prophet Muhammad's (PBUH) traditions, ablution is recommended not only before the five daily prayers but also before a Muslim goes to bed. In addition, when he is in a state of ceremonial impurity (such as anger) and also when he wants to read the Quran or enter a mosque as well. Another type of purification is bathing or *Ghusl*. It means to immerse the whole body in water. This is compulsory for Muslims who are in the state of ceremonial impurity. Moreover, it is recommended on numerous occasions, such as weekly Fridays and 'Eid prayers (Al-Sheikh, 1996). So, water has a special importance for the Muslim practices of *Wudu* and ghusl which are shown to have more health benefits besides the preparation of worship. Thus, Muslims

should protect water from pollution and wastage. By that, he follows the Quran and *Sunnah* traditions because Muslims are ordered to obey Allah and the Prophet.

2.3.2 Islam and water rights

Many conventions and declarations worldwide recognized water as a human right, such as Mar del Plata conference in Argentina, 1977, where for the first time, human rights to water was defined. The main outcome of this conference was launching the drinking water supply and sanitation decade (1980-1990). Similarly, water was declared as a human right in 1977. The Rio conference in chapter 18 of Agenda 21, repeated that: "all people, whatever their stage of development of social and economic conditions, have the right to have access to drinking water in quantities and of quality equal to their basic need" (Gleick, 1998). In 1992, the Dublin conference described water as economic goods (Rahaman & Varis, 2005; Eslamian *et al*., 2017; Henkel, 2017). The intent was water priced at a certain level, making people use it sparingly. In other words, imposing water charges will conserve water; actually, about 1400 years ago, Islam had secured the fundamental human rights to access water. First, the water right of human and animal , based on Islamic teachings, humanity has the first right to water resources as God has provided for his creation, as evidenced by the water rights stated by many authors: "The right of thirst or *Haq al-shafa'* or *shirb*, the right for the humans and animals to access water to quench their thirst and the right of irrigation" (Izzi Din, 2000; Faruqi, 2001; Caponera, 2001; Wickström, 2010; Jah, 2013).

It's supported by two primary Islamic sources, the Quran and the Prophet's tradition, which considered the basis for *Sharia* or Islamic law. Regarding the first and second priority, water was considered as a gift from Allah and it's also a social good, in this light, water was considered a common property. Further, it can't be privately owned in its natural state. As evident from *hadith* Prophet Muhammad (PBUH) said: "Muslim

has common share of three things: grass (pasture), water, and fire (fuel)" (Izzi Din, 2000; Faruqi, 2001; Kadouri *et al*., 2001; Gilli & Arabic, 2004; Wickström, 2010).

Moreover, Islam encourages Muslims to give water to the needy for free, this correlates with the report that the Prophet (PBUH) said: "he who purchases the Ruma Well and offers its water to Muslims for free of charge will be granted paradise" (Kadouri *et al*., 2001; Caponera, 2001), as Allah will reward whoever offers water, not only for the people but also for serving any animals. It is evident by the Prophet's (PBUH) traditions when he said: "A prostitute was forgiven by Allah because when passing by a panting dog near a well and seeing that the dog was about to die of thirst, she took off her shoe, and tying it with her head-cover she drew out some water for it. So, Allah forgave her because of that" (Amery, 2001a). In other narrations, the Prophet's (PBUH) companions asked him whether there were a reward for serving animals; he confirmed that there was a reward in serving any living being. Jah (2013) claims that providing water for thirst was considered a *Sadaqa* not only in the Muslim's life but also after he dies. Faruqui (2001) quotes the *hadith* describing Prophet Muhammad's (PBUH) saying that: "when a person dies, his legacy is served except from three: a following good feat (*Sadaqa jareeyah*), knowledge from which other (will) benefit, or a good offspring that supplicate (to God) for him or her". He also argues that S*adaqa jareeyah* included a source of flowing water. Since, in Islam the work always linked with reward and penalty, humans will be rewarded for giving free water to needy humans and animals.

Conversely, there was a penalty for whoever denies any human or animal access to water. This was clear from *hadith* Prophet Muhammad (PBUH) when he asserts that: "among the three people Allah will ignore on the day of the resurrection is: a man who possessed superfluous water and withheld it from the travelers" (Faruqui, 2003; Jah,

2013). It is also mentioned in *hadith* that "Allah's messenger forbade the sale of excess water" (Caponera, 2001).

Second, the priority rights of irrigation, Caponera (2001) claims that priority rights for irrigation are given to those who are nearest to the water source. If water in scarce, the plots near the river will irrigate first, by taking a quantity of water equal to ankle height. Then, pass water through to the next plot, until all are satisfied. As water flows without recognition of political borders, this creates mutual water resources (such as rivers, lakes, and springs) between two countries or more. Priority use of water must be given to the upstream nations before the downstream nations. If there were a dispute, the riparian countries should decide on priority according to the population size, needs of water for domestic, agriculture and industry. Furthermore, Hussein and Al-Jayyousi (2001) stated that the international law for mutual water aims to equalize utilization for all who share the water resource and to ensure no harm towards any party. This is totally sanctioned by Islam through the equitable and reasonable utilization of water resource. Through determining the priority rights of water, which were discussed earlier, as well as through *Sharia* principle of 'no injury', however, the most important issues in water rights in Islam could be categories as:

(a) Water right property and selling in Islam:

Water ownership was a controversial issue because in Islam, it can't be owned because it's considered as a public goods. According to Prophet Muhammad (PBUH), as previously mentioned, Muslims are co-owners of three things water, grass, and fire.

Muslims doctrines *Shafi'i* and *Maliki* stated that the owner of the water supply may sell it, except in case of well water use for watering the animals and plants. However, *Hanafi* and *Hanbali* allowed the water selling, if the water was collected in receptacles. Then it becomes private property subsequently, it could be sold (Caponera, 2003). In Islam water was considered free goods as evidenced by the Prophet wife who was quoted as saying that she heard the Prophet prohibiting the sale of water (Haddadin, 2006). In Islamic tradition water cannot be owned by an individual; in other words, Islam does not support the notion of property rights in water. Moreover, there were no experiences in the Islamic tradition for water marketing. This issue may face strong social and political objections (Schiffer, 2014). Water cannot be owned unless it is taken into possession; water collected in jars from rivers was not allowed to be sold. However, the most comprehensive sources of codified water law inspired by the *Sharia* appear to be the Mejelle, the civil code of the Ottoman Empire, which was enacted in the 1970s. Caponera analyzes the Mejelle and he quoted Article (1234) which defined water as a non-saleable commodity to which everyone had a right. Article (216) stated that: "the sale of irrigated right is permissible as a part of the sale of land" (Schiffer, 2014)

According to Faruqui *et al*. (2001), the water resources were subdivided into three categories regarding the trading purposes:

i. Private goods: this category included water that were treated, stored and distributed through the distribution system, in this case, it belongs to its owner and was permitted to be sold.

ii. Restricted Public goods: when water bodies like streams, springs, and lakes were located on private land. This type of water doesn't belong to the landowner. However, he has special rights over it, therefore, he can sell it. For example, the others can use this water for drinking purposes, but for irrigation, they should ask him for permission.

iii. Public goods: water considered a public goods when the water in its natural states such as rivers, lakes, glaciers, aquifers, and Seas. It also includes the water from snow and rainfall, water in this category cannot be sold and traded.

Most Muslims scholars' opinions are that in Islam, water was allowed to be sold. Based on the *hadith* by Prophet Muhammad (PBUH) about the Ruma well, it is indicated that the well and its water can be sold. Perhaps we can say that Prophet Muhammad (PBUH) wants to emphasize the *Waqf* approach in order to ensure equity among the community strata. He stated that: "it is better for anyone of you to take a rope and cut the wood (from the forest) and carry it over his back and sell it (as a means of earning his life) rather than to ask the person for something and that person may give him or not." From the Prophet's (PBUH) saying we conclude that water was like a tree or wood. Thus, they considered his saying as permissiveness for water selling (Kadouri *et al*., 2001). Islamic scholars interpreted this to mean that water cannot be sold unless someone delivers it to the public, then he can charge for the service (Haddadin, 2006). So, water selling in Islam was permissible, when some value was added to the water or if it's located within the private lands.

(b) Water prices:

Water price was used as an economic instrument for water demand management. In order to preserve water and to guarantee that, all individuals have access to the basic requirements of water. Further, we must ensure the sustainability of water through the water prices or treat water as economic goods. Citizens should pay for water services in

order to consume water wisely and not freely. This may achieve water preservation. In addition, it enables the development of water institution, sustains the water supply and allows for an adequate water management. Water prices are paid by the users for the capital and operating costs of the water supply infrastructure. The economist recognizes that the increases in commodity prices were resulted in a lower demand for this good. So, the economic approach for water was considered a key for conservation and sustainability too. From an Islamic perspective, most Muslims scholars believed that Islam does not encourage the governments to fix prices for goods, water was not an exception. The market should determine the prices based on accessibility, fairness and social justice. The evidence was that some people complained to the prophet about the high prices. When they asked him to adjust it, he refused to do so. Further, he said that "Allah is the one Who fixed prices, Who withholds, gives lavishly and provides, and I hope that when I meet Allah, none of you will have any claim on me for an injustice regarding blood or property" (Kadouri *et al*., 2001). Water pricing is always used as a means for demand management to reduce the volume of withdrawal water without affecting the consumer satisfaction (Kadouri *et al*., 2001). Therefore, water price was permissible in Islam, as long as it ensures the human rights and social equity.

(c) The opinion of Islam on water rights:

Regarding thirst rights, the Sunnite school of thought considers thirst right to be applied to water everywhere, which was treated as a public utility. On the other hand, Shi'ites say that the thirst right was limited to the public water, and in the case of privately owned water was not entitled.

The right of irrigation, which depends on the water source, it can be presented as follows:

i. Large water bodies: according to Sunnites, those considered large bodies of water should be treated as public property so that all the community members can benefit from them.

ii. Rainwater: this falls on land, which wasn't owned by anyone, it's also considered a public property. The nearest cultivated plot has the first priority. If there are several plots, the owner, whose crops are most urgently in need of water must consider a priority to irrigation. When the water falls on occupied land, the owner has the first priority to use this water.

iii. Small rivers: where water is scarce, up-river lands should be irrigated first, but the level of water should not reach above the ankles. The Shafi'i school of law considers that only surplus water (that remains to stand in his field after the ground was saturated) should be returned. Maliki School of law sought that the upstream owner should let the water flow after his land was irrigated, to the low-lying areas without waiting for saturation.

iv. Irrigation canals: which requires building or have some value added, it becomes a private property, whereby the owner has rights to decide on the irrigated water right. If there were more than one owner, they can determine the right to irrigation through agreement of all parties (Caponera, 2001).

v. Digging of well: the person who digs a well he has rights to its water if the well was located on his land or was on unoccupied land; he was not obligated to supply water to irrigate to other lands. The gift of surplus water to an owner whose well has caved in depends on the cause of the incident. If it was not the owner's fault, the Maliki stresses that it's obligatory to give the owner free irrigated water. When the caving in is due to the owner's negligence, he has to buy the water. The Shafi'i considers that it

is always obligatory to give one's surplus water for the irrigation of the field of others. However, the Hanafi says there's never any obligation to the water owner (Caponera, 2001).

vi. Spring water: If the spring is allocated on unoccupied land, the irrigation's right should give to the person who digs or improves it (Caponera, 2001).

2.3.3 Water conservation in Islam

In water demand management, water conservation used as a non-economic instrument. Muslims are encouraged to use water to perform many aspects of purification, although it is Islamic compulsory practice using water, it was not entitled to wastage. Water conservation practice is one of the non-economic instruments used in the water demand management. The Quran reveals two philosophies that contribute to preserving the water resources. First, the amount of water is fixed. Second, it should be used wisely (Faruqi, 2001; Wickström, 2010). The Prophet Muhammad (PBUH) prohibits water wastage, even if it's in an abandoned state. Despites being used for holy purposes, it still does not entitle water wastage. When Prophet Muhammad (PBUH) witnessed Sa'd performed *Wudu*, he said: "what is this, you are wasting water." Sa'd replied, "can there be wastefulness while performing ablution?" The Prophet replied, "Yes, even if you perform it in the flowing river" (Izzi Din, 2000; Faruqi, 2001; Gilli & Arabic, 2004; Wickström, 2010; Jah, 2013). Furthermore, according to Al-Bukhari: "Prophet used to perform ablution with one *Mudd* (approximately two thirds of a liter) and he used to take baths with one *Sa',* which is equal to two to three and a half liter" (Faruqi, 2001; Shah *et al*., 2001; Gilli & Arabic, 2004; Wickström, 2010; Jah, 2013). Abu Dawud narrated that the Prophetic traditions involved water irrigation when Prophet Muhammad (PBUH) stated that not more than an ankle's depth of water could be taken for this purpose. This was sufficient for one season (Caponera, 2001; Wickström, 2010). Therefore, the Islamic values and ethics teach Muslims not only to

be thrifty concerning water usages but also to avoid water pollution. The evidence that Prophet (PBUH) established a buffer zone (*Harim*) around the water resource where human activities are prohibited to avoid corruption of this particular water body (Izzi Din, 2000; Caponera, 2001; Gilli & Arabic, 2004; Wickström, 2010). One of the prophetic traditions concerns the prohibition of defecation and urination in stagnant water (Al-Sheikh, 1996; Gilli & Arabic, 2004; Wickström, 2010). *Hadith* Prophet Muhammad: "Guard against three practices" When he was asked: "What were these practices were?" he said: "Evacuating one's bowels near water sources, by the roadside, and in shade". As we have learned, stagnant water is the best environment for the breeding of parasites. The prohibition of evacuating in the shady places was very important because shady places don't receive enough sunshine to kill the germs. The evacuation was proven as preventive measures that aim to protect other people against infectious diseases (Al-Sheikh, 1996). According to Izzi Dien (2000), he asserts that industrial waste and agriculture runoff are considered a true impurities, *Najasah haqiqyah*; since the Prophetic tradition prohibits any urination and defecation, it also extends to include the industrial and agricultural pollutants (Faruqui, 2003). Islam, through the Prophetic traditions, encourages prevention measures. Thus, from these Islamic traditions, we can achieve water conservation in terms of water quality and quantity.

2.3.4 Islamic principle of water consumption

The Quran and *Sunnah* highlighted some Islamic principles that are relevant to guiding Muslims in consuming water to ensure its sustainability. These principles are different according to different Muslims scholars. For example, Wickström (2010) argues that it consists of *Tawhid, Mizan*, and *Khalifah*. Amery (2001a) cites Tawhid, *Khalifah* and *Fassad*, among others. This guiding principle can be used by the Muslim

countries to address all the water problems they face. In this research, *Tawhid*, *Mizan, Khalifah*, *Itqan* and *Ihsan*, similarly *Fassad* and *Waqf* have been selected from the other Islamic principle.

Tawhid means the unity of the creator, the sole creator of the universe, to whom the Muslims ought to submit themselves and their actions to (Amery, 2001a; Kamla *et al*., 2006; Wickström, 2010). The Quran says: "Allah there is no deity except Him, the Ever-Living, the Sustainer of [all] existence. Neither drowsiness overtakes Him nor sleep. To Him belongs whatever is in the heavens and whatever is on the earth. Who is it that can intercede with Him except by His permission? He knows what is [presently] before them and what will be after them, and they encompass not a thing of His knowledge except for what He wills. His Kursi extends over the heavens and the earth, and their preservation tires Him not. And He is the Highest, the Most Great". (2:255), "And have you seen the water that you drink? If We willed, We could make it bitter, so why are you not grateful?" (56:68-70), "[More precisely], is He [not best] who created the heavens and the earth and sent down for you rain from the sky, causing to grow thereby gardens of joyful beauty which you could not [otherwise] have grown the trees thereof? Is there a deity with Allah? [No], but they are a people who ascribe equals [to Him]". (27:60)

These verses emphasized that Muslims or humans should understand the unity of this universe and how it reflects the unity of its Creator. Therefore, it's used as a sign of one God, also recognizing a holistic approach by means of the inter-dependency and inter-connectivity of all creatures. Which entail Muslims to share benefits with others and maintain the natural resources from the corruption, moreover it is inspired by Islamic morality and responsibility (Kamla *et al*., 2006). In other words, there was one earth in which all beings lived and shared the natural resources. Namely, water which is one of the most important of these natural resources. So, it is a duty for all Muslims to

respect the nature and to care about the environment. Furthermore, in all previous verses, it not only indicates the unity of the Creator, but it also emphasizes that He is the Lord and Master of all creatures. Moreover, all beings were created and possessed by Allah, therefore, the human is just a trustee for this environment.

Mizan means balance, or it may include the equilibrium of the environment. This principle also means that all aspects of the creation are held together as a balance (Al Jayyousi, 2001; Kamla *et al*., 2006; Wickström 2010). Humans are expected to share the available resources equally in order to reflect the equilibrium of the environment; moreover, this equilibrium enables human beings' sustenance in the earth. If it was corrupted, there will be environmental disasters. Besides, they must remember that there are future generations and they also need water as well. *Mizan* principle was mentioned in the Quran: "And the heaven He raised and imposed the balance that you do not transgress within the balance, and establish weight in justice and do not make deficient the balance" (55: 7-9). "Indeed, all things We created with predestination" (54:49). The previous Quranic verses indicated that balance is fundamental to the environment and humans should not damage the balance of nature, which was attained through the reasonable usage and conservation of the resources.

Khalifah means vice-regent of Allah, also referring to stewardship, trust, and *Amanah*. Regarding this principle, Allah proclaimed in the Quran: "And [mention, O Muhammad], when your Lord said to the angels, "Indeed, I will make upon the earth a successive authority". They said: "Will You place upon it one who causes corruption therein and sheds blood, while we declare Your praise and sanctify You?" Allah said: "Indeed, I know that which you do not know." (2:30), from this verse, we understand that Allah created humans for a specific purpose that is to conserve the natural resources. In addition, to ensure their equitable utilization among the human and non-

human species. So, the people as *Khalifah* have a responsibility to conserve and sustain the natural resources of the earth and all resources that belong to Allah, the Creator of everything. In this sense, human beings are trustees of the earth and they are not independent of God. He is entitled to use and benefit from the environment, but he mustn't corrupt it (Amery, 2001a; Faruqi, 2001; Hussein & Al-Jayyousi, 2001; Gilli & Arabic, 2004; Wickström 2010; Jah, 2013). The *Khalifah* concept in Islam is considered a guide for the interaction between the human and the environment (Faruqi, 2001). Many authors believe that the *Khalifah* is a guardian and friend of the environment. Therefore, human beings as *Khalifah*, must ensure that the property was passed on to the next generation in the purest form possible. As in the hereafter, Muslims will accordingly be held accountable for any acts of destruction committed against the earth, Allah said in the holy Quran: "So whoever does an atom's weight of goodwill see it, and whoever does an atom's weight of evil will see it" (99:7-8). These verses showed that Muslims will be accounted for his / her actions. This makes Muslims attempt to avoid the forbidden and to obey the obligation (Amery, 2001; Absar, 2013). *Khalifah* concept reflects a good human who understands very well that Allah created him to act as His victor on earth. Furthermore, He created for him all things, for his use and benefits. Thus, Allah honored human beings and preferred them more than any other creations. At the same time, He gives them the responsibility of being the earth's custodian. If they fail to do so, Allah will replace them with other people, who will, in turn, obey Him and act as a *Khalifah* in the earth.

Ihsan, from *hadith* Prophet Muhammed: "to worship Allah as though you are seeing him, and while you see him not yet truly He sees you" (Amery, 2001a). This verse means that Allah monitor all Muslims perform. Therefore, he should care about his deed and says.

However*, Itqan* used to determine the level of work quality, by means that to do work in a systematic and methodological way, and from *Sunnah* its evidence by *hadith* Prophet Muhammad (PBUH) that: "Allah loves when you perform deed to execute it with excellence". (Shuriye, 2014)

Mubazir means when humans use something wastefully, referring to careless usage, consumption, and expenditure. Allah said in the Quran: "O children of Adam, take your adornment at every masjid, and eat and drink, but be not excessive. Indeed, He likes not those who commit excess." (7: 31). This Quranic verse states that the human can use the natural resources for his benefit and sustenance, but there are conditions in using this natural resource: namely, to avoid excesses. Despites the importance of water for Muslim for his purification practices, but he commanded by the Quran and *Sunnah* to use it wisely, as it mentioned above. The message from Prophet Muhammad about water usage concerning the practice of *Wudu* indicates that, water should be used wisely. Even when we use water for religious purposes, or when water was abundant. This can be seen as an invitation for water conservation through the economic use of water.

Fassad or mischief -means taking something unjustly, unfairly, or spoiling or degrading the natural resources (Amery, 2001a) and (Amery, 2001b). *Fasad* was translated as corruption, which was mentioned in the Quran: "Corruption has appeared throughout the land and sea by [reason of] what the hands of people have earned so He may let them taste part of [the consequence of] what they have done that perhaps they will return [to righteousness]" (30:41).

It could mean changing the original status. Allah says in the Quran: "And to [the people of] Madyan [We sent] their brother Shu'ayb. He said, "O my people, worship Allah; you have no deity other than Him. There has come to you clear evidence from

your Lord. So fulfill the measure and weight and do not deprive people of their due and cause not corruption upon the earth after its reformation. That is better for you if you should be believers". (7:85)

"But seek, through that which Allah has given you, the home of the Hereafter; and [yet], do not forget your share of the world. And do well as Allah has done well to you. And desire not corruption in the land. Indeed, Allah does not like corrupters" (28:77), from the previous verses, the key message was that it is an obligation for Muslims to avoid mischief or corruption. Another meaning for *Fasad* is mischief, which means corruption of all kinds, including pollution, environmental damage, reckless exploitation, and mismanagement of natural resource including water (Amery, 2001a) and (Amery, 2001b). Water pollution is harmful; it can lead to human injuries and diseases. Therefore, when Muslims pledge to not commit mischief, consequently they will ensure an adequate provision of water in terms of quality and quantity, a healthy environment and good health for the public.

Waqf in general means charity, which was evident from Quran verses: "Who believe in the unseen, establish prayer, and spend out of what We have provided for them." (2:3), the verse shows that all wealth belongs to Allah and He gave humans a part of it. Then He commanded them to spend some of it. The human obligated to spend from what Allah has already provided; this also reflects the importance of charity in Islam. Therefore, it was mentioned in the Quran after the performing of prayer and was stated here as a description for those conscious of Allah. Narrated in *Sunnah* that, Prophet (PBUH) encouraged Muslims to dig a well and described it as an act of great merit. It's evidence by Prophet Muhammad (PBUH) when He promised His companions that, who buy Ruma well (a settlement in Arabia) and make its water as free for Muslim, he will be rewarded by Allah with paradise (Faruqi, 2001). In the Prophet's times, the first *Waqf* in Islam was applied by Uthman Ibin Affaan (who later became the third Muslim

caliph) when he bought the Ruma well in Medina and made it as a *Waqf* for the Medina citizens (Faruqi, 2001). Sabil water is another type of water charity or *Waqf*, which was donated by rich citizens, free for all; furthermore, in an Islamic state, water affairs such as construction and maintenance of waterworks was financed by religious endowments *Waqf* (Izzi Dien, 2000). Thus, Prophet Muhammad (PBUH) was considered as a leader in water management, by ensuring an equal access to all community levels including the poor and rich people. This equals to the international concept of water as a social good. So, these were the basic principles that can guide and regulate water consumption.

It was clear from the previous argues that the Islamic principles were interrelated to each other. For example, when argued the meaning of the *Tawhid* principle. Several Quranic verses highlighted signs of the uniqueness of the Creator, at the same time; it stated that humans cannot act as the Lord and Master of this earth. This specifically gives the meaning of vice-regent or *Khalifah*. *Mizan* principle, if the balance was not maintained, it will result in mischief or *Fassad*. Mischief also means the overconsumption of the resources, which can be used to describe those who use the resources in excess as *Mubazir*. Thus, we can say that the Muslim role as *Khalifah* is to ensure that all creatures have access to water resources including humans. This task can be accomplished through the *Waqf* principle. So, we should ensure all of them in order to guarantee the water conservation.

The level of water consumption in Muslim daily life based on the above principles concerning water value; it can be concluded that the daily basic needs of Muslims in consuming water was only to fulfill these purposes for drinking, ablution *Wudu* and bathing *Ghusl*, in Islamic teachings, water is needed for human daily life. Twenty liter is enough for sanitation purposes according to Gleick (1996). The basic human need for water varies according to different authors. Gleick suggests that basic human needs are listed in four categories: drinking, bathing, cooking, and sanitation. For Muslims, their

daily need for water includes needs of ablution and bathing. These are basic needs that enable them to perform their daily worships, like the daily five prayers. In some countries, other needs can exceed the basic needs, but Muslims are obligated to use water sparingly. The Islamic guide for water consumption was that Muslims or humanity must recognize that the true owner of the universe and all natural resources are the Creators. All creations have their right to inhabit the earth. Humanity are the most precious of these created beings in this universe since the Creator made him His vice-regent. He asked to respect the rights of other humans, as well as all species of living organisms. In addition, to treat the natural world with full respect in order to ensure the survival of our coming generation and the sustainability of water resources.

2.4 Concluding remarks

This chapter concluded in three points first, it is clear that IWRM is an aged concept; however, it re-occurred in the 1990s through the Earth summit and Dublin conference. IWRM is an agreed approach calling for a shift from fragmented supply management towards a holistic, interdisciplinary approach.

It has many definitions, however, the most quoted is the GWP definition, despite the strong criticisms by different authors, and duly they proposed alternative definitions.

And it also has many indicators used to determine the IWRM adoption. However, they are not properly formulated for example the existence of water policies and legislation, which is not enough in order to implement IWRM successfully. Evidence by many countries has water policy and legislation, but they are not adequately formulated or they are not enforced.

The IWRM adoption was hampered by many factors including its vague definition. These facts indicate that IWRM is a relative concept and is highly reflects the implementer's specification and needs. In order to harness the IWRM adoption it should be adaptive more than normative and theory of IWRM approach. Therefore, it should be

applied as a framework, which could be adopted by different countries with different situations. In this research, the GWP framework, which was authorized by Agarwal *et al*. (2000) was adopted as a theoretical framework that was very comprehensive one it consists of (78) items.

The second point, the IWRM approach is highly relevant for African developing countries, enabling them to achieve the SDGs. However, there are many factors need to be considered such as legal framework, institutional capacity including the poor human resources development. In addition, to the lack of skilled and experience, poor financial resources and political will.

The third point is the similarity between Islamic principles and tradition with the IWRM principles and guidelines. Which indicate the opportunity of the Muslim community, especially in North Africa to promote IWRM implementation within their religious traditions.

CHAPTER 3: METHODOLOGY

This research has used the mode of qualitative research because it's mainly about the description of the human problem. Creswell states that: "qualitative research begins with assumption and the use of interpretative theoretical frameworks that inform the study of research problems addressing the meaning of the individual or group ascribed to the social or human problem to study this problem, qualitative researchers use an emerging qualitative approach to inquiry, the collection of data in a natural setting sensitive to the people and place under study, and data analysis that is both inductive and deductive and establishes patterns or theme. The final written report or presentation includes the voices of participants, the reflexivity of the research, a complex description and interpretation of the problem, and its contribution to the literature or call for change" (Creswell, 2017).

This chapter is mainly concerned with the research methodology and it consists of five sections. The first section (3.1) represents the framework of research including the conceptual, theoretical and analytical framework. Section (3.2) lays out the research design of the in-depth single case study, and then section (3.3) gives a background about the case study. The interviews, documentation and exploratory public survey were grouped under sources of data in section (3.4) and the last section is (3.5) which shows the procedures of data analysis, which is mainly thematic analysis, SWOT analysis, and simple statistical analysis.

3.1 Research framework

The research framework consists of conceptual framework, which indicates the definition of IWRM that used in this research. However, the theoretical framework is

the GWP framework for IWRM implementation, which modified to be used as analytical framework.

3.1.1 Conceptual framework

Definition of IWRM in the research context, as shown in the literature that IWRM is a problematic concept. In terms of its meaning, definition, the items that should be integrated, and its implementation. IWRM was an approach used for water management and it mainly calls for good governance. Through the involvement of different actors, institutions, and stakeholders to manage their water resources in a coordinated and cooperative manner. GWP formulates a definition for IWRM, which considered a formal definition, and it has been cited in many articles. However, it has been criticized by many authors because it contains many issues such as lack of measurement and implementation guidance (Biswas 2004, 2008; Gallego & Juizo 2011). Some authors states that: its meaning is differ means that it depends on many factors that were not same in many regions or countries. (Jønch Clausen & Fugl 2001). Twelve definitions have been presented by different authors, perhaps it influenced by the economic, political and social situation of each country or nation. Taking previous definitions into account, the definition of IWRM used in this thesis follows the Merrey, *et al* (2005) definition because they prioritize the welfare of people and poverty reduction as the main objective of the IWRM, moreover, the author address the lack of domestic water as one of the poverty characteristics. Sudan is one of the under-developing countries that aimed to alleviate the poverty, and the first step was to meet household water needs in order to achieve MDGs and SDGs through the adoption of IWRM approach. Merrey's definition as follows:

"IWRM is involving the promotion of human welfare, especially the reduction of poverty, encouragement of better livelihoods and balanced economic growth through

effective democratic development and management of water and other natural resources in an integrated multilevel framework that is as equitable, sustainable, and transparent as possible, and conserves vital ecosystems" (Merrey *et al*., 2005).

3.1.2 Theoretical framework

The literature contains numerous theoretical frameworks for IWRM, and most are based on the reformulation of the original GWP framework which, suggested by Agarwal *et al*. (2000) it's considered as a toolbox formulated to facilitate the IWRM application. The framework is comprehensive and it is mainly composed of three categories: enabling environment, institutional role and management instruments, these categories consist of multiple sub-categories, which are used selectively by many authors including (Jønch-Clausen, 2004;; Xie, 2006; Assaf, 2010; Eslamian *et al*., 2017) For example the first category enabling environment consist of five sub-categories namely: the role of government (six subcategories), water legislation (four subcategories), cross-sectoral upstream downstream dialogue (two subcategories), financial structure and investment allocation for water resources infrastructure (six subcategories) and cooperation within international river basin (five subcategories). Assaf (2010) proposes all sub-categories in the enabling environment, while Xie (2006) selects two sub-categories.

The second category is the institutional role, which consists of two sub-categories: role and function of the organization included at different levels (eight subcategories) and institutional capacity building (three sub-categories). Xie (2006) advocates two subcategories.

The third category is the management instrument; this category has four sub-categories: water resources assessment (nine subcategories) including the

Environmental Impact Assessment (EIA), communication and information (five subcategories), water allocation, conflict resolution (seven subcategories) and regulatory instruments. The regulatory instruments sub-category composed of three sub-categories: direct control (six sub-categories), economic instruments (six sub-categories) including water prices, and encouraged self-regulation (five subcategories). Assaf (2010) chooses four sub-categories as management instrument, while Xie (2006) prefers eight sub-categories.

3.1.3 Analytical framework

Feasibility study was used to identify the potential of application of a particular project or management approach. In order to recognize the different factors that could enhance or impede its application process. Furthermore, feasibility has different meanings according to the field that uses the term; for example, in the private sector it is defined as an exercise in cost-benefit balancing (Sunstein, 2002); in network construction, feasible means that all technical, legal and structural conditions are satisfied (El-sharkawy, 2005). In the environmental management, it means to identify the current constraints and opportunities (Gain *et al*., 2017). However, this research feasibility has been used to assess the factors that support or hinder the IWRM implementation process. The GWP framework has been modified by many authors including Xie (2006) who selects four sub-categories under the enabling environment, divides the institutional role into two sub-categories and management instruments consist of seven sub-categories. While Assaf (2010) proposes five subcategories to be under the enabling environment and he divides the management instruments into two subcategories, he divides one of them into three sub-categories, and the second one, which contains three categories he chooses one, that includes two sub-categories. The researcher selects three sub-categories from the main three categories to be used as an

analytical framework in as most critical issue in the case of Khartoum, Sudan. In order to evaluate the feasibility of IWRM implementation as well as the potential of socio-cultural aspect, which includes religions, this research focuses on Islam. Since, it's a religion of more than one-fifth of the world's population; furthermore, it's a prevailing religion in Sudan. As it mentioned in chapter two section three, culture including religions have an influences on natural resources. Moreover, Islamic teaching contains a fertile ground for developing water management principles (Amery, 2001b). The analytical framework was depicted in **Figure 3.1.** For instance, the first category is the enabling environment consists of water legislation, good governance, and cooperation within the national river basin. The second category is institutional role pertaining to institutional development, building institutional capacity and the community participation. The managerial instrument is the last category, which involves water resources assessment, water prices and the environmental impact assessment (EIA).

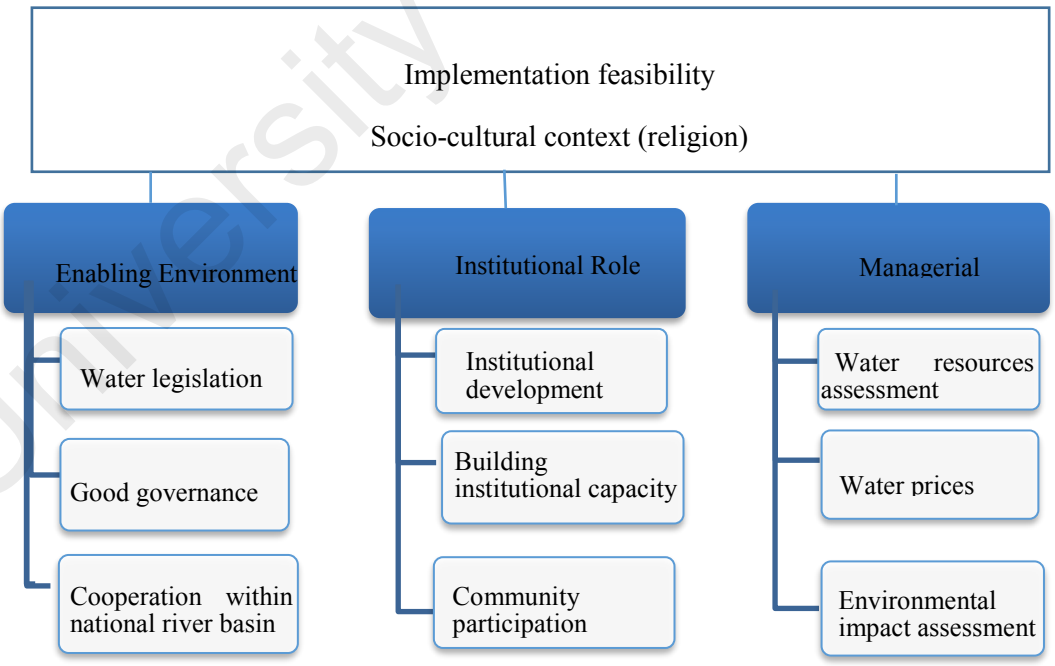

Figure 3.1: Analytical framework of IWRM

(Adopted from Agarwal *et al*., 2000)

3.2 Single case study as research design: IWRM in Khartoum, Sudan

The rationale for using a single case study was because the case was descriptive information that was produced from different sources of data in this research, using a single group of people (Khartoum residents).

According to Yin (2014), a single case study is used when the researcher has access to a situation previously inaccessible to empirical study. The descriptive information will consider as revelatory, and it investigates a single group of people in the same city or neighborhood. The case study enables the researcher to get comprehensive information on real-life events such as the individual cycle, organizational and managerial processes, neighborhood change, international relationships, etc.

It can be defined as an empirical inquiry that investigates a contemporary phenomenon in-depth and within its real-world context, when the boundaries between the phenomenon and context are not clear, and it deals with many variables, relies on multiple sources of evidence, and benefits from the prior development of theoretical frameworks to guide the data collection and analysis (Yin, 2014). It also means that the researcher investigates a small number of cases (sometimes one case) in order to obtain detailed information about the phenomena (Gomm *et al*., 2000). And it used when the researcher aims to get more information about the specific case.

In this research the case study was selected from five research methods because of three reasons; first: the research question is in the form of who and why; second: it doesn't require control of behavioral events; third: it focuses on contemporary phenomena, according to Yin (2014). These are the three reasons used as a rationale for the case study (See **Table 3.1**). In this research, the in-depth case study design was used because the research topic addresses questions that focus on describing a group of

individuals, who the researcher aimed to get an in-depth understanding of their situation (Algozzine & Hancock, 2016).

Table 3.1: Relevant situation for different methods
(Source: Yin, 2014)

Method	Form of research question	Required control of behavioral event	Focus on contemporary event
Experiment	Who, why?	Yes	Yes
Survey	Who, why, where, how many, how much?	No	Yes
Archival study	Who, why, where, how many, how much?	No	Yes/no
History	Who, why?	No	No
Case study	Who, why?	No	Yes

The rationale for choosing Khartoum as case study that Khartoum considered a major urban area. Secondly, the availability of water resources in Khartoum such as Niles water and underground water indicates that the water issue was not water scarcity; it is rather a mismanagement issue. Lastly, Khartoum is currently in the preparation stage of IWRM implementation. Therefore, the findings of this study could be used as a guide to identify the most important factors that need to be improved. In addition, fostering the other factors, which have the potential to enhance the IWRM implementation processes.

Sudan is a North-Eastern African country; its location's coordinates are 1500 N-30000, with an area of 1,861,484 sq. km (Central Intelligence Agency, 2017). Sudan is located in North Africa bordering the Red Sea and seven other African countries (MWRE). The land use is the 100 % agricultural land, and the irrigated land is about 18,900 sq. Km. Sudan dominated by the Nile and its tributaries, the climate is hot and dry; arid desert; rainy season varies by region (April-November) (Central Intelligence Agency, 2017). Sudan share surface and groundwater with the neighboring countries, its share the Nile water with ten riparian countries and the under groundwater with four

neighboring countries, water availability about 30 billion m^3, the per capita water availability is less than 1000m^3. The area of arable land was estimated at 200 million feddan (84 million ha) cultivated area per year is about 40 million feddan (17million ha) 20% (Irrigated land: 11 million fed, rain-fed land: 29 million feddan). The rural population is mostly engaged in the Agriculture as it considered the backbone of Sudanese economy, with an estimated contribution of 45.6% of GDP, 55% of employment and 80% of export earnings. (Sudan, n.d). The population is about 36,729, 501 million inhabitants with a growth rate of 2.4% (world population review, 2017). Consisting of many ethnic groups such as Sudanese Arab (approximately 70%), Fur, Beja, Nuba, Fallata, they speaks Arabic, English, Nubian, Ta Bedawie and Fur languages. Sudan has a majority Muslim population with a small Christian minority, with half of the population at or below the poverty line. Sudan has experienced social conflicts, civil war, and in July 2011, it lost three-quarters of its oil production due to the secession of South Sudan.

Major urban area is Khartoum (capital), which has an area of 28,000 km^2 with a population of approximately six million inhabitants (Awad *et al*., 2005) Khartoum is located in the heart of Sudan on the confluence of the two Niles blue and white Nile (See **Figure 3.2**), and it has a semi-arid climate with summer rains average 100-300 mm, the hottest month is May with average temperatures of 41.2°C, while the coolest month is January about 31.5°C (El Sayed *et al*., 2000).

Figure 3.2 Map of Sudan, Khartoum
(Source: https://www.cia.gov)

3.3 Sources of data

In this research the in-depth single case study research design uses three sources of data, the interviews, which considered a main source of data, through conducting face-to-face interviews, by using semi-structured interview questions with four groups, policymakers (which means the personnel who have influence over the water decisions in different water institutions), water managers and experts, academician and Muslim scholars. It was conducted from July to November 2015 (See **Table 3.2**).

Documentation has been used as secondary data sources, which includes government documents, reports, journal articles, newspaper articles; online articles, books, and publication of NGOs (See the list of documents in **Appendix F**). The rationale of triangulation of data sources was that the researcher, aimed to address the issue of water in Khartoum from different dimensions. It's important to use multiple sources of data about these issues to produce an accurate result about the case study. Secondary data

were also collected from the exploratory public survey, which was conducted at the beginning of the study, in order to understand the current water problems faced by the Khartoum residents. A total of 210 samples were randomly collected and it was conducted from September 2012 to January 2013 in Khartoum, Sudan. Then, the data were analyzed by applying thematic analysis of the interview data, SWOT analysis of data from documentation and simple statistical analysis for the exploratory public survey data.

3.3.1 The interviews

The in-depth interview was adopted as one of data collection methods, the interview can be defined as "a conversational practice where knowledge is produced through the interaction between an interviewer and an interviewee or group of interviewees" (Brinkmann, 2014). The justification for adopting the interview as one of the research methods: The interview is the most applied technique in qualitative research. Furthermore, it allows the researcher to access the motives, meanings, actions, and reactions of people in the context of their daily life. In order to understand the significance of their experiences, which described based on their own perspective (Minichiello *et al*., 1995). According to King and Horrocks (2010) "If you want to know how people understand their world and their life why not talk to them?". The researcher targeted some issues of water management in Khartoum that could be gained from specific groups of individuals. Moreover, the interview as a data collection method has been used in previous studies such as Gallego and Juizo (2011), Chidammodzi and Muhandiki (2017)

The interview respondents have been chosen by using purposive sampling procedure. As it means that the researcher used purposive sampling to intentionally select

individuals and sites to learn about or understand the central phenomenon (Creswell, 2014).

In this research, face-to-face interview was conducted with four groups of the respondent, who were selected based on their in-depth knowledge of the water resources management in Khartoum, professional experience, their individual reputation in the water sector, and their willingness to share their experiences. Based on the above criteria, a total of 12 interviewees from four main groups (3 from each four-group) was selected. The first group is the policy makers who are able to alter the water management practice such as the director of the Groundwater and Wadis Directorate (GWWD), Khartoum State Water Corporation (KSWC) consultant, and the head of judicial authority office in MIWR now becomes Ministry of Water Resources, Irrigation, and Electricity (MWRE).

Semi-structured interview questions were designed first to gain an understanding of the existence of cooperation between different sectors. Second, to get some information about the institutional capacity. Third, to know more about the laws formulation processes, updating and enforcement. Lastly, to understand the awareness of policy makers regarding the public participation as well as the IWRM approach. The interviews questions are included in **Appendix A**.

The second group composed of water managers and experts. Namely, senior water expert UNDP Khartoum office, Al Mohgran water treatment plant employee, coordinator water experts from the Ministry of Irrigation and Water Resources.

Semi-structured interview was used, first to get detailed information about managerial instruments that used in the water institutions. For example, water purification techniques and the water pricing principles. Second, to understand the role

of KSWC as a water service provider. Finally, to know their awareness of the current water issues and the IWRM approach as well. See **Appendix B**.

Third group; consist of the academics, including the university lecturers. The interview questions for this group were designed mainly to determine their awareness level about water issues in Khartoum. The IWRM as a water management approach and their potential role in raising awareness among the universities students and the public, see **Appendix C** for more details.

Fourth group, are the Islamic scholars from the Islamic Universities and department of Islamic studies in another universities. They were interviewed in order to know their ideas about the water management from the Islamic point of view and the current water issues in Khartoum. In addition, to their potential role to improve the water resources situation and their awareness about the consistency between IWRM and Islamic principles. Refer to **Appendix D**.

The researcher conducted a face-to-face interview with four groups of experts as mentioned above, and it's considered one of the major data collection approaches in this study. All the members of four groups were served with consent letters a few days before the commencement of the interviews (The consent letter is attached in **Appendix F**). Although, the four groups had tight schedules, the researcher was able to interview each of the respondents two to three times from July to November 2015. To give the researcher an opportunity to explore more about water management practice in Khartoum state.

All interviews were mostly conducted in the Arabic language, and the duration of the interviews lasted for about 35 to 80 minutes according to different groups. The responses generated during the course of the interview with the four groups of interviewees. Further, they gave a better insight into the water management issues and

practices in Khartoum, in addition, to invaluable data and documents. The researcher used a semi-structured interview, to cover all the water management issues in the interview. The semi-structured interviews were found significantly useful because the questions set could assist in guiding the researcher or it serves as a check-list to make sure that all matters concerning water management issues and challenges were covered. The interview sessions composed of twelve interviewees; **Table 3.2** shows the full description of the interviewee together with the coding, this coding will be used as a reference in the analysis chapter.

Table 3.2: List of interviewees

No.	Interviewees	Interviewee affiliation	Date	Code
1	Policy makers	Director of Groundwater and Wadis Directorate	16.9.15	P1
2	Policy makers	The consultant of Khartoum state water corporation.	4.10.15	P2
3	Policy makers	The manager of the judicial authority office, Ministry of Water Resources.	3.8.15	P3
4	Water manager & experts	Senior water expert UNDP Khartoum office.	8.9.15	W1
5	Water manager & experts	Al Mohgran water treatment plant Employee	19.10.15	W2
6	Water manager & experts	Ministry of irrigation and water resources, coordinator water experts.	20.8.15	W3
7	Muslims scholars	Lecturer at Omdurman Islamic University	1.10.15	M1
8	Muslims scholars	Lecturer at Sudan University, Khartoum, Sudan.	23.7.15	M2
9	Muslims scholars	Lecturer at Sudan University, Khartoum, Sudan.	2.10.15	M3
10	Academics	Al-Neleen University associated professor, lecturer.	5.9.15	A1
11	Academics	Ahliya University lecturer.	9.10.15	A2
12	Academics	Senior lecturer at Khartoum University, Khartoum, Sudan.	15.9.15	A3

3.3.2 Exploratory survey

The exploratory survey was conducted at the beginning of the study and was used mainly to allow the researcher to get more information about the issues of water (i.e., water pollution, water shortage, water prices, water leakages … etc.). And it was conducted in Khartoum state from September to January 2013. However, it used when

it is relevant within the analysis for different elements of the analytical framework, furthermore, it's provided valuable supporting information to the general perception of the issues of water supply in Sudan.

a) Structure of survey question

The survey questions were written in Arabic language, it consists of yes/no and open-ended questions, and are divided into three main sections, section one was about the interviewee's personal information, while section two explores main water issues (for example water leakages, shortages and water prices). The last section examines the public awareness about water quality, storage tanks types and hygiene, relationships between the water quality and health, and their role towards the water conservation.

The survey questionnaire was conducted through the house-to-house visits and the researcher guides, explains and assists some respondents who couldn't read or write to fill the questionnaire, despites it been written in Arabic language (Survey questions are provided in **Appendix E**).

b) Survey sampling

Random sampling was used to select samples from large populations, as there was no city population list that could be used for sampling purposes. However, Khartoum state consists of three cities: Khartoum, North Khartoum (Bahary) and Omdurman. Khartoum state as a whole was divided to seven localities each one consists of a number of administrative units, which consists of areas and districts. In order to cover all the study areas the researcher used all Khartoum state localities to select 30 samples from each locality randomly, that means the total sample of survey was 210 samples. The survey results were analyzed using an Excel spreadsheet to produce diagrams. These results used when it relevant in the analytical framework. **Table 3.3** below provides more details:

Table 3.3: Sampling procedures

Locality	Number of sample
Khartoum	30
North Khartoum	30
Omdurman	30
Karari	30
Um-baddah	30
Eastern Nile	30
Gabal Awlya	30
Total	210

3.3.3 Documentation

A wide spectrum of documents was reviewed, which consists of national documents (governmental institutions reports, relevant policies acts, and official letters), articles, published and un-published documents, newspaper articles, online articles, books, and publication of NGOs. (The list of documents is listed in **Appendix F**).

3.4 Data analysis

Data analysis in this research employs a combination of three types of analytical techniques to meet the three main research objectives. First, the thematic analysis, was used to investigate the feasibility of IWRM implementation in Sudan, especially in the context of Khartoum state. It is also used to explore the socio-religious aspects of the Sudanese people that can enhance the implementation of IWRM. Second, SWOT analysis was used to identify critical factors that both drives and impedes the implementation of IWRM in Sudan. Finally, simple statistical analysis was used where it is relevant throughout the thematic analysis.

3.4.1 Thematic analysis

Thematic analysis emerged in the 1970s. However, it's well recognized through Boyatzis's book entitled Thematic Analysis and Theme Developments. Despite its wide application in psychology, it is used in other different disciplines (Braun & Clark, 2016) and it also used in water and environmental management (Smith & Ferguson, 2013;

Dunn *et al*., 2014; Omar *et al*., 2017). Thematic analysis can be defined as: "A set of techniques used to analyze textual data and elucidate themes. Its key characteristic is the systematic process of coding, examination of meaning and provision of a description of social reality through the creation of theme" (Vaismoradi *et al*., 2016). According to Braun and Clark (2006): "Thematic analysis is a method of identifying, analyzing and reporting patterns (themes) within data. It minimally organizes and describes your data sets in rich detail. However, it also often goes further than this, and interprets various aspects of the research topic."

It is also defined by Fereday and Muir-Cochrane (2006) as: "A search for themes that emerged as being important to the description of the phenomenon".

The process involves the identification of themes through the careful reading and re-reading of data. It is a form of pattern recognition within the data, where the emerging themes become the categories for analysis. Thematic analysis was adopted for the interview data through reading and rereading the interview data, in order to identify specific patterns of meaning. In this research deductive themes were used based on selected elements of GWP framework. As it was sometimes difficult to find each or the exact element in the interview transcript, therefore the researcher formulates a definition for each element (See **Table 3.4**). The justifications for adopting the thematic analysis was that it allows the researcher to provide detailed descriptions of the case study. In addition, to interpret various aspects of the research topic and it could be used to answer second and third research questions. For example, the framework element of water legislation, if well formulated and implemented properly it will provide a positive/ adequate results. Where water legislation exists, but it is partially implemented or is not enforced then, it provides positive in-adequate results. While, negative in-adequate were used to show the lack of water legislation per se.

Table 3.4: Interpretation of framework elements

Framework elements	Interpretation
Water legislation	Enforced, holistic and updated and approved water legislation with regard to the economic, social and culture of Sudan.
Good governance	Limit government role to regulate, enable and control the role of other parties such as, private sectors, civil society and other stakeholders.
Cooperation between international river basin countries	To cooperate effectively and assist equitable utilization of the shared water resources, conservation and the international cooperation.
Institutional development	Institution with a clear role and responsibility and it has an adequate framework as well as qualified staff.
Building institutional capacity	For both institution and human resources to be strong in its framework and for human resources to be qualified, trained and have a skill in water management approaches.

Table 3.4, continued

Framework elements	Interpretation
Community participation	Empower community through raising awareness and formulate clear procedure for effective participation; it should be supported by the legal framework.
Water resources assessment	Evaluation of water quality and quantity.
Water prices	Fair water prices that trade-off between human rights and economic i.e. to provide water for human basic needs for free or in lower price as charge prices according to the consumption after a certain threshold.
Environmental impact assessment	Environmental impact assessment is the expected impact from human actions on environment as well as on the human society, including the effects of water development projects which can affect water quality and quantity.

3.4.2 SWOT analysis

The Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was founded by Andrews (1965) (Yazdani *et al.*, 2012). It has been used by decision-makers for strategic planning to identify the external and internal factors that affect the project (Gallego & Juizo, 2011). It can be defined as: "A tool designed to be used in the initial stage of decision-making on the one hand and as a tool for strategic planning" (Zorpas *et al.,* 2017).

SWOT analysis has been applied in different areas including water resources and the environmental management area, for example, Gallego and Juizo (2011) used SWOT analysis to identify and to establish a priority ranking for the main factors that affect IWRM implementation in Mozambique.

Podimata and Yannopoulos (2013) used SWOT analysis to evaluate the priorities and the challenges of a trans-regional river basin in Greece. While, Chidammodzi and Muhandiki (2017) used SWOT analysis as a means to investigate Lake Basin management issues and how these issues could be solved by the IWRM framework. In order to attain sustainable management and utilization in Malawi and to improve the Lake Basin management.

From the previous research it was clear that SWOT analysis used by Podimata and Yannopoulos (2013) and Chidammodzi and Muhandiki (2017) to identify and priorities the challenges and issues of water management. However, Gallego and Juizo (2011) used SWOT analysis to identify relevant factors to IWRM strategic planning in Mozambique, furthermore, they combined it with the Analytic Hierarchy Process (AHP) technique, used for the prioritization of SWOT factors by assigning them for corresponding weights to establish a priority ranking for the main factors that affect IWRM implementation in Mozambique. Interestingly, Mozambique was very different compared to Sudan in terms of water institutions and the status of IWRM implementation.

In this research SWOT analysis use for each one of the nine elements of the analytical framework, that was incorporated within all framework elements. In order to determine and prioritize the weaknesses, threats strengths and opportunities of the IWRM implementation in Sudan. As Khartoum state currently prepares for IWRM implementation. So, it will contribute as a guide for decision-makers to address the weaknesses and threats benefiting strengths and opportunities in the case of Khartoum. As it is also useful to identify the significant external and internal factors, and enable the decision-makers to use the opportunities and strengths to overcome weaknesses and threats. So, SWOT analysis useful at any stage of IWRM adoption.

3.4.3 Simple statistical analysis

Simple statistical analysis was applied by using the exploratory public survey's data. Then, it was analyzed by using Excel sheet to produce diagrams and pie chart for some survey questions in order to explain the water problems in Khartoum. These results have been used within the analytical framework where relevant.

3.5 Concluding remarks

Chapter three describes the procedures that were adopted in order to answer the research questions. The researcher formulated an analytical framework based on the theoretical framework by selecting some sub-categories. In this research the in-depth single case study was adopted as a research design, the data obtained through the triangulation of data sources namely, the experts' interview, documentation and the exploratory public survey. And the data was analyzed by using thematic analysis, SWOT analysis, and simple statistical analysis.

CHAPTER 4: ANALYSIS

This chapter represents the analysis of data. As section 4.1 contains thematic analysis including three sub-sections, enabling environment, institutional role, and the managerial instrument each one of these elements splits into subsections; while section 4.2 SWOT analysis that was applied on each sub-categories of GWP framework.

4.1 Thematic analysis

Thematic analysis based on the analytical framework was used to evaluate the feasibility of IWRM implementation. In addition, to assess the potential of the Islamic principles in each element of the analytical framework. In this research, thematic analysis basically used to investigate the analytical elements regarding the reality in Khartoum and the potential of Islamic principles as well, using different sources of data. The researcher used some terms, e.g. 'positive adequate' to indicate that the particular element was in place or fully adopted; 'positive in-adequate' where the framework element exists, but it is partially adopted, for example, when the water legislation is not fully implemented, or it is available but not enforced; 'negative in-adequate' is used where the framework element was not adopted at all. Thematic analysis was applied also to the potential of Islamic principles, to examine its relevancy with the framework elements, i.e. good governance as one of framework elements was advocated by Islam as it's evident from Quran and *Sunnah.*

4.1.1 Enabling environment

Enabling environment is important in IWRM for the preparation of suitable policies, laws, and regulations at all levels to enable all stakeholders through determining their rights and roles. There are two main features of the enabling environment; the first one is to move away from a top-down approach towards both top-down and bottom-up

approaches involving full stakeholder participation. The second one is to shift from a company domain to the involvement of civil society. This element was divided into three sub-elements: water legislation, good governance, and co-operation within the national river basin.

4.1.1.1 Water legislations

The formulation and enactment of water laws considered a cornerstone for water resources management. It provides a framework for action, rights and liabilities for the government, the private sector and civil society. Therefore, the adequate formulation and enforcement are prerequisites for effective water legislation. In many countries the lack of water laws enforcement can be attributed to the political will in particular countries. And could be defined according to the Oxford dictionary as: "Political intention or desire (in early use not as a fixed collocation); (later) specifically the firm intention or commitment on the part of a government to carry through a policy, especially one, which is not immediately successful or popular" (Agarwal *et al*., 2000).

a) Reality in Sudan

Water policies and legislation development in Sudan were featured in the comprehensive policies and legislation of 1992. Since that time, the institutional and legal framework of water resources development, utilization, and management in Sudan was reviewed and revised, through the introduction of a number of instruments such as The National Comprehensive Strategy (NCS) of 1992. Accordingly, the water policies and legislation spilled into two groups: before 1992 when the water laws and legislation were fragmented mainly focused on pumping licenses and the drainage of Nile water for cultivation purposes. The main water regulations in Sudan are based on the 1951 Regulations, which are licensing regulations for pumping water from the Nile according

to the Nile Pumps Control Act of 1939; recent instruments have modified the 1951 regulations, e.g. Water Resources Act of 1995. This also asserted by the interview respondent who states that:

> "Water legislation is the main cause of water problem, these legislation are mainly based on the regulation of 1951 (more than six decades) this may reflects the need for updating of water legislation to be suitable for the current population needs and socio-economic situations. The other issue was that water resources in Sudan [are] governed by three legal regimes with many gaps and overlaps, i.e. that there are some water laws [that] give the responsibility of one task for more than one institution, which result in conflicting responsibility and degrading the overall performance of the water institutions." (A3, personal communication, September 15, 2015).

The second group of water legislation approved after 1992 is the National Water Policy (NWP) 1992, which were based on NCS issued during the same year. According to the NWP 1992, the Ministry of Irrigation and Water Resources becomes responsible for most of the subsections namely policy-making, legislation, planning, and coordination of all water resources. This era was more comprehensive and it's clear from its application to water resources; it has defined "water resources" to mean surface and groundwater resources whether crossing the national borders or not. It covers the use of water resources for all purposes (unlike the two previous legal regimes) such as consumptive use, hydro-power generation, and drainage. Its institutions entrusted with the implementation of the 1995 Act are the National Council for Water Resources chaired by the Minister of Irrigation and Water Resources (MIWR), the MIWR (and the entities falling under its supervision) and the state organs, which acts under the powers delegated to the MIWR. (NBI, 2005; Sudan, 2007a; Sudan, 2010)

The Sudan NWP in the various sub-sectors was based on the internationally adopted guiding principles for water resources management and development, which included within the context of the freshwater chapter within the Agenda 21 of the Rio de Janeiro U. N. Conference on the Environment and Development of June 1992. It is mainly

concerned with raising awareness about the water cycle unity, water conservation regarding quality and quantity, holistic approach and decentralization of the authority. Through strengthening the role of private sector, local community and effective coordination of different related sectors. And to integrate sustainable development advocating the integration of water and land uses management. In addition, to the capacity building and the institutional development through designing appropriate training program. And it also concerns with the formulation of environmental policy for all sectors. Including water sector and enhancing cooperation with all the Nile basin countries and other countries sharing other water resources.

Despite the compatibility of the NWP of 1992 with the international discourse and its adequate objective and strategies, its formulation and implementation are not based on a comprehensive approach that entailed full stakeholder's involvement. As a result, a multi-disciplinary multi-sectoral committee was formed in 1999 to review, integrate and update the existing 1992 Water Policy. The committee composed of highly qualified and experienced members representing all water-related institutions, including participation of private sector and NGOs. It is worth mentioning that the Committee has received support from the FAO and the UNDP in the form of consultancy services and financial support.

The Sudan National Water Policy (SNWP) draft of 2000 produced for the first time many aspects of water resources management, utilization, and protection in a single integrated policy document. The objectives of the SNWP are depicted as follows: to bring together and clarify existing policy; to review and adapt water policy to meet changing circumstances within the country and to ensure that the water resources of Sudan are properly managed, protected and efficiently used for the benefit of all. Similarly, to provide the basis for the ongoing development of water-related regulations

and legislation and to strengthen and rationalize water-related institutions in both the public and private sectors in Sudan. However, the SNWP remains as a draft without approval.

Based on the sound of water assessments, the effective regulatory framework was established with the capacity for enforcement of approved legislation. In addition, to promote the role of women, in a move toward market-oriented solutions and incentives for the sustainable use of water resources. The integrated water policy of 2007 National Plan for Environmental Management (NPEM) has been formulated based on the transitional constitution of Sudan, as well as its water policies of 1977, 1992 and year 2000.

The objectives of NPEM are to: recognize water as scarce vulnerable resource with high social and economic value, which has to be equitably, economically, and efficiently managed, used, sustained and developed for the benefit of the people, on strategic planning basis with long term visions. Similarly, to provide an equitable distribution of water for the different states and users in the country based on comprehensive and integrated plans and optimum allocation principles that incorporate efficiency of use, equity of access, and sustainability of the resource. And to promote national unity through the reasonable and balanced utilization of water resources and the entire natural resources, as well as to establish a financing mechanism for the funding of the water resources management functions. In addition to develop human resources and capacity building to meet the professional and technical skills needs of the country in water resources management; to increase investment in essential water resources infrastructure. Furthermore, to promote demand management, conservation and protection of water resources and the overall aquatic environment in a sustainable basis in conjunction with essential infrastructure development. And to promote

environmentally sustainable water resources development and management, and to promote the participation and engagement of the private sector and other stakeholders in service delivery to improve efficiency and effectiveness and enhance sustainability of the services including water resources management. In addition, to recognize the linkages between water resources management and the economy and ensure food security, water security, control immigration and water-related conflicts, poverty alleviation, and security and attain settlement and peace, and to secure and maintain the country rights in the shared water resources and lastly, to promote water as an element for fostering strategic relations and integration (Sudan, 2007a; Sudan, 2010). Despites the availability of water legislation in Sudan, it suffers from two issues; the first being the inadequacy of the formulation and the overlaps in some water legislations, which was made clear by the interview respondent's argument:

> "Sudan has very short experience with water resources policy; however, with support from the FOA and the UNDP first draft of national water policy was formulated in 2000, and updated later in 2007 in response to several variables, especially the decentralization system adopted in Sudan. All these drafts provided general guidelines for management of resources. That, included protection of water resources from pollution through preparation of the policy. Which, based on the consultations at state and national level, the final version of the policy has been endorsed by the relevant authority. Therefore, Sudan lacks water policy or legal document governing management and utilization of water resources. However, there were different existing water-related legislation dealing with management of water resources in Sudan. The main gab was the lacks of approved water resources policy, which is still a draft. In addition to the lacks of coordination among various agencies at different levels; these reasons contributed to poor management of water resources and contamination of groundwater in Khartoum city and elsewhere in Sudan" (P1, personal communication, September 16, 2015).

The documentation also indicates that the 1990 Act neglected to make certain key legal amendments. For example, the concerned Authority under the Nile Pumps Control Act of 1939 was a Board chaired by the Minister of the People's Local Government, which no longer exists. Also, it does not defined the waters to which it should be applied. The gap in some water legislation was evidenced by the lacks of water selling

and full cost recovery for all water users. For example, the policy regarding the water pricing and charges collection in the Agricultural Corporations (AC) was not clearly defined. Although, the policy of the MIWR warrants the cost recovery for the water, the farmers were obliged to pay flat rates system. However, the price depends mostly on what they irrigate during the season, regardless of the quantity of water that was used, therefore, the water prices system didn't encourage the water conservation. Similarly, the lacks of adequate and comprehensive principles for groundwater protection, and the absence of unconventional water sources such as the reuse of drainage water from agriculture, industry, and domestic effluent after adequate treatment, as well as the desalinization of sea water especially in Port Sudan city, which allocated on the Red Sea.

The Water Resources Act 1995 covers the generic issues pertaining to the development and management of groundwater and surface water (Wadis). However, it neglects the Red Sea and its valuable marine resources. In 1997, the regulations governing the utilization of these waters were drafted, but unfortunately, it wasn't ratified. In spites, the fact that 1995 Act wasn't mentioned clearly the economic value of water, but implicitly addressed the issue in the different efficiency and conservation terms. The Act was specified the type of water use and the location, but neglected the timing of water delivery and the period of use. The water sector was governed by three overlapping legal regimes; the first one was established by the Nile Pumps Control Act of 1939 and the 1951 regulations.

The second legal regime, which was established by the Irrigation and Drainage Act of 1990, complements the first legal regime and, therefore, the Nile Pumps Control Act of 1939 was not repealed. The two major advantages of the second legal regime were

that it broadened the scope of the existing legal regime to include drainage activities, and it has made the Minister of Irrigation and Water Resources the concerned authority. Moreover, jurisdiction and responsibilities between the Ministry of Irrigation and Water Resources and the Agricultural Corporations have to be evaluated and promoted. For example, in the large national irrigation schemes, the MIWR used to assume full responsibility for operation and maintenance of the schemes from the main supply canal down to the head of minor canals. In 1995, responsibilities of MIWR were extended to cover the minor canals to the Field Outlet Pipes (FOP). This has eliminated the confusion that existed for joint responsibility of the minor canals by MIWR and AC.

In the year 2000, the policy was again changed and the responsibility of the minor canals was given back to the AC. Unfortunately, this was created a great confusion and an organizational gap in the operation and maintenance of the irrigation systems of the AC. With the ratification of the new Gezira Scheme Act of 2005, the Water Users Association (WUA) was to hold the management of the minor canals down to the field. The last legal regime which was currently in force was the regime established by the Water Resources Act of 1995. It was repealed the Nile Pumps Control Act of 1939 while keeping the 1951 Regulations. Also, it was not repealed the Irrigation and Drainage Act of 1990. Therefore, there was an overlap between the three legal regimes. Other contradictions were the MIWR has given the power to license water pumping for irrigation under both the Irrigation and Drainage Act of 1990 and the Water Resources Act of 1995, and licensing power was given both the local authorities under the 1951 Regulations and to the MIWR under the Water Resources Act of 1995. (NBI, 2005)

The second issue is the lack of enforcement and approval of water legislation and policies, as evidenced by the interview excerpts below:

> "Legislations concerning groundwater resources and its protection in Sudan were the responsibility of the federal government and also the national regulations are overarching for all state regulations and for each state should review the national laws and regulation before formulating new ones. Anyhow, this is not always the case in Sudan, For instance the Khartoum state, despites the fact that, the Ministry of Water Resources and Electricity is the national body responsible for water resources management according to the government regulation, KSWC has issued a law prohibiting drilling of injection tube wells, withstanding drilling of hand dug wells tapping the same aquifer (upper aquifer) against some fees equivalent to about USD 200." (W1, personal communication, September 8, 2015).

Water pollution was the main evidence for the lacks of water legislation enforcement from the exploratory public survey, which indicates that Khartoum population consumes water from different sources; however, the results showed that more than 90% of the population suffered from water pollution.

This is clear from the interview respondent:

> "Disposing of sludge on the ground surface in ponds was not prohibited, and it's one of the main hazards, not only to groundwater but also to human health especially it was located in an Alazhari residential area in the Southern part of the city. The state government was managing this 'business' because of revenues that were collected from private tankers disposing of the sludge in these pools. The limited capacity of the government to construct a sewage system along with treatment plants was contributed to contamination of groundwater in Khartoum State at least in Alreyad, Burri and Imtidad Nasir residential areas." (W1, personal communication, September 8, 2015).

However, the documentation indicates that despites, the availability of laws and legislation concerning drinking water quality such as: Ministry of Health Act (1975), which prevented the drainage or throwing any substances (solid or liquid) harmful or likely to be harmful to human and animal's health into any drainage water sources, criminal Act (1991). According to Article 70 (1&2), people who cause pollution to any source of water shall be punished with imprisonment for a term not exceed 3 years, Sudan constitution (2005), which advocated a right to safe and hygiene environment, environmental protection Act (2001) Article 20 (b) pollution of water resources such as rivers, seas, lakes, ponds, canals and natural and artificial storage and reservoirs and otherwise wherein water is kept for man and animal use, Article 21 (1) whoever,

contravenes the provision of section 20 shall be punished with imprisonment for term not exceeding 3 years or with fine not exceeding one million or both and the environmental health act 1997. Similar to the Ministry of Health Act (1975) however, it mentioned that the health authority give a permission for disposal of treated sewage water and industrial effluent, in three conditions first: the Chemical Oxygen Demand (COD) shall be less than 20 parts in million parts of water weight, second: suspended particles shall be less than 30 parts in million parts of water weight, third: no concentrated chemicals in treated water. Khartoum State/ Province Water Corporation (KSWC) Act for 2009, article 29, item (3) prohibits drilling of wells for water supply or injection well/siphon or conducting any activity that may cause pollution of ground or surface water that will be used for drinking purpose, without a prior permission from KSWC (Sudan, 2007b).

Lacks of enforcement of water legislation evident from documentations showed that the regulations concerned with water resources management, pollution control, and land use rights related to water, watershed development, environmental quality and pollution control standards, are not effective or enacted because of relaxation of the administrative enforcement machinery.

Evidence form the interview respondent:

> "There is a common phrase regarding this issue is the laws and legislation are violated by those who formulate it, by means they did not apply the laws and legislation for themselves" (P3, personal communication, August 3, 2015).

Other respondent states that:

> "From my point of view the main urgent issue of water pollution which need enforced water legislation is uncontrolled disposal of the untreated effluent (Molase the byproduct from sugar cane in the Blue Nile, which was directly linked with the eutrophication phenomenon (excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen industries) from sugar factories" interview with the consultant of Khartoum state water corporation. (W2, personal communication, October 4, 2015).

The enforcement of water legislation and policies depends on the relevance of the regulations and on the administrative machinery required to implement or to ensure compliance. In Sudan, more effective mechanism to ensure the enforcement of regulations is required, e.g. pollution control regulations are not applied, citing restrictions of pumps are poorly or no longer enforced, aquifer monitoring to alert decision makers about the drawdown levels is mostly or often absent.

The issue of biological water pollution attracts many scholars, as a result there are many studies concerning the water quality in Khartoum city. Magid *et al.* (1984) asserted the existence of microbial contamination with faecal coliform is high in surface wells and the Nile's water. The infectious agent as one of the consequences of the biological or sewage contamination, and the waterborne infectious agent is a serious threat to human health in Sudan. Although the monitoring point of water in Sudan is limited, it has so far confirmed biological contamination of the Nile and groundwater in Khartoum state (UNDP, 2007). Tap water was unsafe due to the isolation of pathogenic and potential organisms (Yagoub & Ahmed, 2009). According to Alraheem, (2000) she asserts that the aquifers in Khartoum state are not safe from pollution. Moreover, she claims that the pollution was mainly from sewage and siphon wells (which are the main means of sewage disposal in Khartoum city). The lower aquifer present in the sandy layers of the Nubian Sandstone at a depth of 100 m below ground level is the main source for the municipal water supply to Khartoum. However, as there were no impermeable geological boundaries between the two horizons, the sewage can reach the lower aquifer and pollute the water pumped into the city. She also observes that most of the boreholes have a bad casing that leads to an increase in the inorganic metals such as Iron, Copper as well as microbial contamination as a result of the bad hygiene of the borehole surroundings. According to the British classification of rivers, the Nile at

Khartoum was classified as doubtful to bad quality. In some area of Khartoum, state groundwater was contaminated by the wastewater disposal due to the extensive use of one-sided sewage and excreta disposal system (e.g. pit latrines, septic tanks). Haffirs supply (artificial bonds for rainwater storage) was also considered as poor quality because of the non-hygienic situation with no fencing to protect them from animals (Ibrahim *et al*., 2009). Many Khartoum residents consume contaminated water, which causes the water-related diseases and worsens the state of public health (USAID, 2010). The majority of industrial factories has no dedicated water treatment facilities and releases their wastewater into the domestic system (where one exists) or directly into Nile watercourses or onto land. Industrial waste considered as a major fish kill in the Blue Nile in March 2006, following an accidental spill of molasses from the northwest Sennar Sugar factory (UNDP, 2007). Uncontrolled industrial disposal causes chemical pollution by raising the concentration of some parameters which threatens both surface and groundwater (Ibrahim *et al*., 2009).

Taha and Ibrahim (2002) claimed that the Nile River and its tributaries suffer from three problems; the discharge of untreated wastewater and sewage from some industries into the River Nile; wastewater from the refinery (containing polymers and other chemicals); and agricultural chemical waste, which was mainly the pesticides and chemical fertilizers.

b) Analysis of the feasibility

Water legislation was the cornerstone for IWRM and it should be adequately formulated and enforced strictly because it acts as a guide for all stakeholders by determining their roles and responsibility as well as protect, control and organizes the water resources. Moreover, unenforced and poor formulation of water legislation will adversely affect the enabling environment, the role of institutions as well as the

managerial instruments; for example, if the water legislation is improperly formulated, without clearly determining the role and responsibility of government, NGOs, civil society and different stakeholders, the result would be poor water governance. Khartoum, despite the existence of many laws and legislation concerning water, still suffers from water shortage and water pollution in all sources of water due to the lacks of enforcement of water legislation. Gaps and absences of important principles of water management such as water rights, water prices, responsibilities overlapping and the finalizing and approval of the latest policies are factors that should be considered as they underpin the IWRM implementation process.

c) The potential role of Islamic principles

In Islam water consider as public good by means that all people are entailed to use it, as it's clear that the human has a right to quench their thirst from water according to the right of thirst for human and his animals *Haq al-shafa'* the right for the human, and *Haq al-shirb* for cattle and domestic animals to access water to quench their thirst. In Quran 'This is a she-camel; she shall drink and you shall drink on known days" (26:155).

Therefore, water is appreciated in Islam, in the tradition of Islam Prophet Muhammad (PBUH) emphasizes the human right to water, evident from *hadith*: "Muslim has common share three things grass (pasture), water, and fire (fuel)", and he encourage providing water for free moreover he guarantee the paradise for Othman the third caliph when he bought Roma well and he gave its water for Muslims free of charge, as Islamic principle of *Waqf*. Islam appreciated providing water not only for human but for all living beings, as its clear from the *hadith* Prophet Muhammad that when Muslims offer water for living being the human and animals, Allah will reward them.

4.1.1.2 Good governance

Water governance is a focal point in IWRM; however, numerous authors attribute the water crisis to the governance of water. Water governance refers to the range of political, social, economic and administrative systems that are in place. In order to develop and manage water resources and the delivery of water services to different levels of society (Roger & Hall, 2003). Good water governance principles include predictability (rule of law); ethics (control of corruption); and open, transparent and broad participation (UNDP, 2013).

Water resources management has a wide spectrum of stakeholders such as government, the private sector, NGOs and civil society; each one has a task. For example, the role of government within the IWRM context is to shift its role from a provider of water services. Towards a facilitator, enabler, regulator, and controller for all stakeholders. Enabling them to conduct their task properly, through the formulation of a holistic framework. (Agarwal *et al*., 2000). Water governance is a focal point in IWRM; therefore numbers of authors attribute the water crisis to the water governance.

a) Reality in Sudan

According to the water governance definition, water should be managed by three entities. First, the government, whose responsibility was mainly to formulate the water policies and legislations. And to facilitate the process of water management through clear demarcation of roles and responsibilities for all stakeholders, enabling them to participate effectively. In addition to regulate the private sector preventing the monopolization, to protect the consumer from over-pricing. And to ensure good quality of water services. Second, the private sector involvement through water management to perform a different task. However, the provision of water services becomes government challenge in most of the world's countries. Therefore, they resort to the private sector to

achieve adequate water provision services based on the government framework. Similarly, the documentation sources advocate the role of civil society according to Kobail and Elfeel (2012) local communities should be involved throughout the whole processes of water management, as the involvement of local people in policy formulation was still weak. The private sector was involved in water management process. However, good water governance entails integrated roles of all parties, in the case of Sudan the government still practice the top-down approach, which affects the private sector as well as civil society. One of the interview respondent states that:

> "The community was totally ignored in water management because the participation of the local community needs for democracy and transparency don't exist in Sudan. Regarding the private sector, there are many private companies involved in water management as water fee collectors. I can say that the water service were provided by the government, but it was not satisfactory in terms of quality and quantity. Therefore, we are compelled to buy mineral water from the private company, which are not affordable for all segments of the community". (A2, personal communication, October 9, 2015).

There are more than ten million people without drinking water. And doubled lacks access to sanitation (Omer, 2010). This fact indicates the disability of the governments to deliver adequate water and sanitation services. The interview respondent emphases the gap of water supply service as he said:

> "We need to be aware of the role of government in water pollution. Water supply services are very bad now. We receive water from a public supplier, which is [frequently] discontinued and its water [is] always in bad quality. The last time we encountered water turbidity in the autumn season, despites the existence of water treatment plants, but now we suffers an additional biological pollution. We didn't have any voice, the government wants to charge for water services, [yet] we also have a right to evaluate their services if it is satisfactory or not". (A1, personal communication, September 5, 2015).

The disability of the governments to deliver adequate water and sanitation services entailed the private sector involvement. In order to ensure appropriate water and sanitation services as well as good management of available water resources. In accordance with the framework of a global neoliberal agenda, which assumed that "less

government is good government". Water sector privatization can be defined as "transfer of ownership of water supply systems to private companies" (Beckedrof, 2012). In 1990s, Sudan first attempted to introduce privatization to KSWC, but the real transformation of KSWC took place in 2001, whereby the private companies were involved in water fee collection, water network construction and water treatment plant operation. Water sector privatization has positive and negative impact on the water management. And it also leads to an increase in corrupt practices such as bad or poor water supply management and water supply. The privatization of the Khartoum governmental water management was 'governmentalized' and led to what might be called 'governmental-private-continuum' (Beckedrof, 2012). According to Omer (2010), the government lacks an appropriate mechanism to regulate and control the private sector.

b) Analysis of feasibility

The governmental water supply dominated the water supply services in Khartoum. Its struggle to enhance the access of water for Khartoum population through the investment of water infrastructure and increasing the water well production. However, it fails to overcome the water supply gaps because of the financial problems and the needs for new equipment. Therefore, Khartoum state starts to introduce privatization in the 1990s. However, the involvement of the private sector is limited to the fees collection and the construction of water infrastructure. Although, they do not participate in water supply services; the government fails to control their tasks. So, water sector in Sudan are privatized without adequate provision of water and sanitation services. This mainly due to the politics of the ruling party, lack of transparency, and absence of government as an enabler, organizer and controller of the private sector. That leads to the administrative corruption and poor water governance. The situation needs some improvement through the adoption of water governance principles. For example, the public-private partnership, which was fruitful in Morocco. It was applied for several cities, and it results in network expansions connection by 270,000 connections and it covers the wide range of population estimated to 1.3 million, furthermore, it is benefits in reduction of the non-revenue water (UNDP, 2013).

c) Potential of Islamic principles

The concept of governance based on four principles: the existence of effective law; ethics values to control corruption; open and transparent roles and responsibility of all stakeholders and broad participation for all water stakeholders at different levels in water decision and management. All these principles were emphasized by Islam; for example, the first principle regarding rules and law: Muslims rely on rules and laws embodied in the Quran and the Prophetic tradition in addition to *Sharia* or Islamic law.

The ethic value was the most encouraged by Islam. Prophet Muhammad (PBUH) summarizes the religion in two words: 'good ethics'. And from the principle of *Ihsan*, which means that Muslims in all their deeds must be mindful of Allah (SWT), they must perform good deeds and avoid bad ones; this will lead them away from corruption. The transparency and broad participation is equivalent to the consultation principle *Shura*, which was highly encouraged in Islam and Prophet Muhammad's (PBUH) life is the best example. In addition to what was mentioned above, Islam encourages the collective responsibility as evident in the Quran. Most of the Quranic verses are in the plural form; Islam encourages Muslims to perform their tasks as a group: "Say, work. God will see your work, and so will his messenger, and the believers. Then, you will be returned to the knower of secrets and declarations, and he will inform you of what you used to do."(8:105).

In *hadith*, Abdullah bin Umar said: "I heard Allah's Apostle saying, all of you are guardians and responsible for your wards and the things under your care…." (Abderrahman, 2000) in this *hadith* ibn Umar indicates the responsibility of all community member; moreover, they will be accounted by Allah for their responsibilities.

Good governance emphasizes the separation of the provision of service and monitoring of its quality. This could be achieved through *Hisba* institution, which could be defined as an Islamic institution. That guided by the Quranic attitude of "Al Amr bil ma'aruf wannahyi anil munkar" (enjoining what is good and forbidding what is bad)" and *Sharia* principle "no injury" or harm. *Muhtasib* is the officer in charge; one of his duties was to ensure fair and just water management applications (Amery 2001a; Kamla *et al*., 2006; Attahiru *et al*., 2016).

4.1.1.3 Co-operation within national river basin

Water resources pass from source to estuary ignoring the political boundaries, forming basins, which consist of at least two countries, which are known as up and downstream riparian countries. The up-stream riparian are the countries where the source of water begins, or are located closer to the source of water relative to the downstream riparian countries. Therefore, downstream riparian countries are vulnerable because their water originates from outside their territory. That calls for cooperation between riparian countries in order to reap sustainable benefits from the shared water resource. Water basins cover about 45.3% of the land surface, which equivalent to 60% of the global flow of the river affecting 40% of the world population, however, sixty-three of international river basins are in Africa, occupied 64% of the total area, such as Congo and Niger share within eleven countries, Nile: ten countries and Lake Chad: eight countries (Wolf *et al*., 2015).

a) Reality in Sudan

Sudan has a lot of water resources, despite the all its water resources (except the rainfall) are shared with its neighboring countries, according to (FAO, 2008). Sudan's surface water, which comprises from Nile River, this is shared among 11 countries including Sudan. Non-Nilotic streams: which are four; all are shared with neighboring countries and Nubian sandstone system: was the largest aquifer, also shared with Chad, Libya, and Egypt.

Eleven countries share the Nile water, which is arguably the world's longest river: Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda, and the Democratic Republic of the Congo. Three million square kilometers, that equivalent to 1/10 of the African area was occupied by Nile basin. With a population of about 250 million lives in 11 of the Nile basin countries (Salman, 2013). The demand of the Nile

water was likely to be exacerbated by the population growth, which is expected to be doubled within the coming 25 years, concomitant with the agricultural and industrial growth (Kameri-Mbote, 2007). According to Swain (2002), there are two main sources of the Nile's water: Lake Victoria and some of the equatorial lakes, which are located in Rwanda, Burundi, Congo, Tanzania, Kenya, and Uganda. Water from these lakes contributes to the White Nile formation. The second one is Lake Tana and some tributaries within Eritrea territories, which are the main source of the Blue Nile. Both the White and Blue Nile are joined in Khartoum, Sudan, creating the River Nile, which flows toward the Mediterranean Sea through Egypt (Swain, 2002). Interview respondent argues that:

> "Sudan has many shared water resources; however, the Nile waters gained more concern. When we discuss the cooperation, we need first to recognize the fair share of Sudan from Nile water. An effective cooperation can't be achieved unless; both Egypt and Sudan recognize the rights of the other riparian countries. Furthermore, by now South Sudan becomes an independent country; they can claim their allocation from the Nile water. This issue will aggravate the water sharing issues" (P3, personal communication, August 3, 2015).

The years 1929, 1959 and 1999 represents key tipping points in the hydro-political relations between riparian countries in the Nile basin. In 1929 the first Nile Water Agreement was signed between Egypt and Great Britain on behalf of Sudan and other British colonies in the basin (Uganda, Kenya, and Tanzania) water quantity of 48 $\times 10^9$ m^3/yr. was allocated to Egypt and 4×10^9 m^3 /yr. was allocated to Sudan. After the independence of Uganda, Tanzania, and Kenya in the 1960s, questions about the validity of the colonial treaties arose. The 1929 Agreement was replaced by the 1959 Agreement for the full utilization of the Nile waters. After the independence of Sudan in 1956, Egypt's plans to build the High Aswan Dam and the needs to renegotiate existing water allocations under the 1929 Agreement prompted the two countries to come up with new volumetric water allocations 55.5×10^9 m^3/yr. to Egypt and 18.5 $\times 10^9$ m^3/ /yr.

to Sudan under a new agreement. This bilateral agreement allocated the Nile's waters to only two riparian's countries, thus marginalizing the other nine co-riparian, bearing in mind that some of these countries are sources of the Nile water such as Ethiopia, from which the Blue Nile originates, thus contributing more than 80% of the Nile water. The 1959 agreement divided the Nile basin countries into two contradictory groups; Egypt and Sudan, which wanted to ensure their existing historical rights and uses, whilst the remaining co-riparian, which wanted to repeal it. In 1999, the Nile Basin Initiative was signed by ministers of water of the nine countries with a collective vision: "To achieve sustainable socio-economic development through equitable utilization of and benefit from the common Nile basin water resource" (Hamada, 2017).

One decade after NBI in 2009, the discussion about the Cooperative Framework Agreement took place and was signed in 2010 by six riparian countries (Burundi, Ethiopia, Kenya, Rwanda, Tanzania, and Uganda). The core of the discussion was article 14 (b) "Nile Basin States, therefore, agree, in a spirit of cooperation: ….Not to significantly affect the water security of any other Nile Basin State." Egypt and Sudan suggested an amendment for article 14 (b) to include "Nile Basin States, therefore, agree, in a spirit of cooperation: ….Not to significantly affect the water security and current uses and rights of any other Nile Basin State." This amendment was rejected by the upstream riparian countries because this amendment consequently will continue the colonial-era veto rights for Egypt and Sudan. Accordingly, Egypt and Sudan rejected the CFA (Kimenyi & Mbaku, 2015).

In 2011, the government of Ethiopia started the construction of the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile. Egypt did not welcome this project and thought that Ethiopia was attempting to threaten Egyptian water security. The Egyptian president, Mohamed Morsi, angrily stated that while he was not "calling for war" with

Ethiopia, "Egypt's water security cannot be violated at all." In 2013, Sudan declare their full support to GERD (Kimenyi & Mabaku, 2015). A detailed presentation on the GERD, was presented by the Ethiopian government about the benefits of GERD for Egypt and Sudan. After that, the three countries proclaimed their Agreement on Declaration of Principles on the GERD (DoP) in March 2015. This consists of different principles, one being the principle of cooperation: as stated in sub-article (2) "To cooperate in understanding upstream and downstream water needs in its various aspects." The principle of equitable and reasonable utilization means the three countries need to take into consideration certain guiding factors. a) Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character; b) The populations dependent on the water resources in each basin state; c) Existing and potential uses of the water resources; d) The availability of alternatives, of comparable value, to a particular planned or existing use. On principles of sovereignty and territorial integrity, the three countries shall cooperate on the basis of sovereign equality, territorial integrity, mutual benefit and good faith in order to attain optimal utilization and adequate protection of the River (Bayeh, 2016). DoP was clearly annulled the sovereignty of Egypt and Sudan over the other co-riparian countries. In favor of more development and poverty reduction for all river basin countries. Through the equitable utilization of the common Nile water, which could be sustained through an effective cooperation and commitment to the public interest.

b) Analysis of feasibility

The ignorance of the ten other co-riparian countries in terms of water allocation prompts the Nile basin countries to formulate a legal framework. In order to ensure the equitable utilization of the Nile water among all riparian countries such as the Nile basin initiative. However, it failed to deal with the main issue, i.e. the redistribution of the

Nile water among all riparian countries. The more serious issue was the state-centric principle of water utilization, which emerged within the northern part of the Nile basin. Namely between Ethiopia, Sudan and Egypt, which shares the Blue Nile water. This principle was adopted by Egypt since the colonial era, however, the adoption of the DoP in 2015 was the starting point for equitable utilization of the Nile waters towards poverty alleviation and development for all Nile Basin countries as long as they conserve the coordination efforts. By the end of 2017, Ethiopia's GRD (on the Blue Nile) will begin filling up (Lemma, 2001, Swain 2002; Assaf, 2010).

c) Potential of Islamic principles

Muslim countries were divided into six zones. However, we will discuss two zones (Sudan falls within these zones): the socio-economic and hydrological zone and the tension-driven zone, which consists of countries that share the river and/or groundwater aquifers with their neighboring countries Up-stream riparian has a right to water, but this was contradicted by the existence of unilateral Egypt and Sudan. This may threaten the sovereignty of some countries due to the inequitable sharing of the water basin. This situation could be improved by adopting the basic Islamic principles and concepts such as *Maslaha m'tabara*, (means)the existence of this concept indicates that the public interest are recognized in Islam (Izzi Din, 2000). And also the concept of *Haqq al-majra*, which means the right of flowing water (Wickström, 2010)

Tawhid principle can contributes to enhance the equitable utilization and *Khalifah* principle assists to remind Muslims about their responsibility and the accountability in the hereafter (Absar, 2013).

Islam's concerns with the equitable utilization among groups that share the same resource, in this case, the right to water, in keeping with the words of Prophet Muhammad (PBUH), that Muslims are co-owners in three things - water, grass, and fire. Islam encourages the cooperation; there are many Quranic verses referring to Muslims as a group and encourage Muslims to cooperate. Allah (SWT) said in the Quran, "and cooperates in righteousness and piety, but do not cooperate in sin and aggression. And fear Allah; indeed, Allah is severe in the penalty" (5:2). The protection and preservation of the international river are supported by the *hadith* on the authority of Abu Sa'eed Al-Khudree (may Allah be pleased with him), the messenger of Allah (PBUH) said: "There should be neither harming (darar) nor reciprocating harm (dirar). Prophet Muhammad (PBUH) describes the Muslims as one body, thus indicating the Islamic basis for cooperation. The public interest was emphasized in Islam; moreover, it has higher priority than private interest. In Islamic tradition, it is clear that Islam encourages equitable and reasonable utilization of shared resources.

Interview respondent states that:

> "Islam is very clear about this issue hence in Islam all Muslims are brothers Allah said: (and cooperate in righteousness and piety, but do not cooperate in sin and aggression) Muslim shouldn't do anything that may harm other people, and also from *Sunnah* we can show that from *hadith* Prophet Mohamed (PBUH) which means that you should like something to your brother as you like it for yourself" (M3, personal communication, October 2, 2015).

The Islamic principle of unity *Tawhid,* which means the ones of the God and His creations include water as one of the natural resources. However, Muslims are God's guardians on this earth (the principle of *Khalifah*) and their task is to ensure the wise use of natural resources and avoidance of corruption. The *Fasad* principle seeks to conserve the balance of the environment. *Mizan* principle is signified by Allah's (SWT) the statement in Quran, "And the earth We have spread out (like a carpet); set thereon

mountains firm and immovable; and produced therein all kinds of things in due balance" (15:19).

4.1.2 Institutional role

The institutional role, which could be at different levels, was to formulate and implement IWRM policies and programs through appropriate institutions. Water institutions vary according to a given context of country or region. They differ in the stage of development, financial and human resources, and traditions and norms. All these factors determine which are appropriate for specific situations.

4.1.2.1 Institutional development

Institutional development was mainly about solving the institutional issues that are considered barriers for IWRM adoption. For example, clarify responsibilities between different actors, adequate coordination between different institutions, jurisdictional issues, authority and capacity for action.

a) Reality in Sudan

One of the most important water institution's responsibilities was to improve the water supply services. However, according to the public survey results, more than 90% of Khartoum state experience bad water supply services. And 95% experience leakages in water distribution system, which were only repaired after more than two days. Ninety three percent of the public survey respondents suffer from water pollution from the public water supply; the booster pumps were used by 87% of public survey respondent and 90% of public survey respondent are suffering from the non-continuous public water supply.

The documentation shows the evolution of water institutions in Sudan, it is undergoing instability in terms of their administrative, ministerial structure and names.

This issue was pointed out by many authors such as Elraheem and Abdou (2012), Beckedrof (2012), Elmadani (2012). Elraheem and Abdou (2012) attributed this instability to the lack of strategic planning in water resources management.

Omer (2008) states that the institutional changes since independence have shifted ten times. It underwent many combinations and division, with different names, under the responsibility of different ministries and institutions. Starting from the Ministry of Work, and lastly the Ministry of Water Resources and Electricity (MWRE). Each of these ministries has its own policies and regulations with specific role and responsibilities (For more details see **Table 4.1**).

In addition, the issue of overlapping of responsibilities between federal and state governments, which leads to conflicting responsibility, duplicating of tasks and deteriorating the overall performance of water institutions. This was depicted within **Figure 4.1**.

Omer (2008) claims that uncounted water losses in the distribution system are up to 40%. According to USAID (2010), the inadequacy of water system operation and maintenance leads to high non-revenue water losses, which are always considered a challenge. This leakages are not only the cause for water loss, but it also acts as contamination sources, as reported in many previous studies such as Ibrahim *et al.* (2009). They also argued that most of the distribution network has dead ends, which may cause bacterial growth (Al Arabi, 2003; Omer, 2008). There are frequent network damages, due to overage and the increasing use of booster pumping (Sami *et al*., 2002). According to the Malaria Centre, Khartoum state (2013), only 19.1% of damaged pipes were repaired. Water institutions in Khartoum are still fragmented with weak demarcation responsibilities. They also lack strategic planning and appropriate

framework. There are many institutions that deal with water management in Khartoum, but they are poorly coordinated, this issue was pointed out by many authors like NBI, (2005), Omer (2008), Elraheem and Abdou (2012), Beckedrof (2012), Elmadani (2012) and AfDB (2015).

Table 4.1: History of water sector development

Date	Name of Water Supply Institution	
1957-1965	Sudanese Light and Power Company	
1966-1986	Central Electricity and Water Authority(CEWA)	Rural Water and Development corporation
	(Ministry of Works; since 1979 Ministry of Energy)	(Ministry of Agriculture; since 1974 Ministry of Local Governance; since 1979 Ministry of Energy)
1980-1986	National Electricity	Regional Water corporations
	Corporation (NEC)	Federal corporation For Rural and Urban Water Supply.
1986-1989	National Urban Water Corporation	National Rural Water Corporation
1994	26 State Water Corporations	Public Water Corporation (under Ministry of Irrigation and Water resources)
2010	Ministry of Water Resources	
2012	Ministry of Water Resources Ministry of Dams and Electricity	Ministry of Water Resources, Irrigation and Electricity

The interview respondent states that:

> "We suffer from many institutional problems; for example the collapse of the development projects as consequence of personnel shift. Then, we have to start different development projects with different objectives according to the new head of the department or whatever. The lack of accurate software that is critical in networks planning projects; for example, now we use GIS software for mapping when we go to the field. [Sometimes] the map does not match the reality. And the miscommunication with the community [whose cooperation] is necessary to facilitate the use of new technologies, i.e. when the KSWC attempted to fix a new volumetric devices for the household, the communities contradict the worker, I think [this is] because they are not aware of the water management system" (Consultant of Khartoum State Water Corporation P2, personal communication, October 4, 2015).

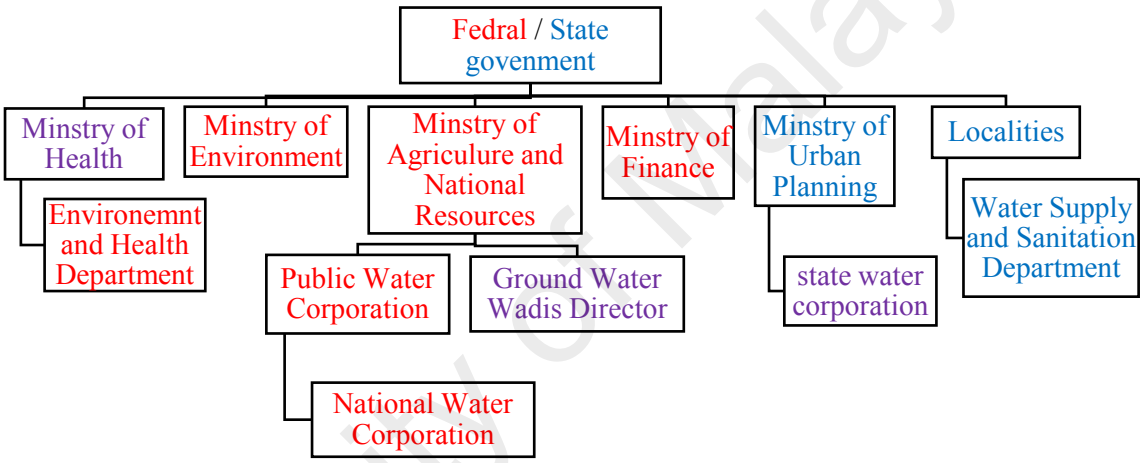

Figure 4.1: Federal and state responsibilities
(Modified from Elraheem and Abdou (2012), Elmadani (2012))

- Red: under federal responsibility. Blue: under state responsibility. Purple: overlapping responsiplity

The African Development Bank Group (AfDB) (2015) emphasizes that poor coordination among different water sector institution and its fragmented structure as one of the main challenges for the water sector in Sudan. This also emphasized by the interview respondent:

> "Khartoum state has a number of institutions dealing with water resources management with a very weak coordination. Except when there are issues that require the coordination among them, they also lack of a certain body to facilitate such cooperation. However, now the MIWR, through its program of IWRM, which

mainly considers the institutional capacity including the coordination between different water institutions to ensure effective water management" (P1, personal communication, September 16, 2015).

b) Analysis of feasibility

It is clear that fragmentation of water institutions, weak cooperation between different water institutions, and instability of water institutions and frequent changing of personnel directly impact the institutional development program, resulting in poor water management such as water supply shortage and lacks of maintenance causing water leakages. These issues are attributable to the lacks of strategic planning, as well as confusion in roles and responsibilities. It is worth to mention that the 1992 water policy addressed the institutional development and capacity building issues well, which only indicates the poor planning for policy implementation.

c) Potential of Islamic principles

Islam considers the work or job as a responsibility, which entails doing well because the Muslims will be accountable in the hereafter for all their deeds. Its evidence that Islam always link the work, with the goodness (salih) (Those who have faith and do righteous deeds) is mentioned frequently in Quran. This may indicates that the work should be done in aright and perfect manner, the job here was to provide water for human, which was appreciated in Islam in life and afterlife. *Itqan* used to determine the level of work quality, by means that to do work in a systematic and methodological way. Muslims were encouraged to do their work properly (*Itqan),* as it is clear from *hadith* Prophet Muhammad: "Allah loves when you perform deeds to execute it with excellence" (Shuriye, 2014).

4.1.2.2 Building institutional capacity

Building capacity could be defined as a sum of efforts to nature, enhance and utilized skills and capabilities of people and institutions at all levels, locally, nationally, regionally and internationally. The capacity building, for both human resource and institutions those, involve empowering people and the organization with appropriate tools and sustainable resources not only to solve their problems but also to provide better services.

a) Reality in Sudan

The institutional capacity refers to both the institution and human resources and they are strongly linked together. As the institutional performance indicates the performance of the human resources work there, and they highly affected by the context of that institution. However, each one has a specific responsibility. Most of the literature indicates that institutional capacity in the water sector in Sudan consider a constraint for effective water resources management (NBI, 2005) for example, Elraheem and Abdou (2012) advocated institutional capacity in water sector hindering the MDGs achievement. Interview respondent states:

> "Water institutions lack the planning or the strategic framework that ensure the development of the institutions. In addition, it lacks the critical description of the job and specific qualification for the employee. This worse by the nepotism in the employment and after employment, for example when the manager has some relatives and friend he tries to favor them in the training course. Even though, it was not matching their academic background. As a result the institutions becomes undeveloped and the absence of regularity. For example, in attendance and departure in addition to the monitoring and accounting. Another thing that was very critical is the presence of the representative of the director or head of the department in case of absence to facilitate the service for citizens". (A3, personal communication, September 15, 2015).

Sudan has negative in-adequate institutional capacity in water sector evidence from its classification as one of ten bottom countries, its ranked 140 out of 146 countries according to the Environmental Sustainability Index (ESI) in the year 2005, based on

five factors included the institutional capacity that factors used to evaluate the environmental performance (Elasha, 2014). Institutional capacity of the water sector remains very weak, despite many commitments of strategies and plan (AfBD, 2015), the brain drain phenomena considered a one of the main causes of deteriorating the institutional capacity. However, the losses of professional and skillful employees in Sudan lead to severe shortages in many technical professional skills, which adversely affect the resources (El Imam &Yusuf, 2013).

Based on the interview respondent:

> "The water sector suffers from the lack of trained and skilled human resources. Due to the lack of financial resources to ensure training courses and other capacity building program. In addition to, the migration of qualified and well trained human resources. They migrate to the Gulf oil country and other countries because the salary in Sudan was not satisfactory" (W2, personal communication, October 19, 2015).

All these factors lead to inadequate institutional performance and its fail to achieve its responsibilities for example to improve the water supply services. Omer (2008) claims uncounted water losses in the distribution system are up to 40%. According to USAID (2010) the inadequacy of water system operation and maintenance, lead to high non-revenue water, which always considers as a challenge. This leakage is not only considered as a cause for water loss but it also as contamination sources, as it reported in many previous studies such as Ibrahim *et al.* (2009). They also argued that most of the distribution network has dead ends, which may cause bacterial growth. (Al Arabi, 2003; Omer, 2008), There are frequent network damages, due to overage and the increasing of pumping (Sami *et al.*, 2002). According to Sudan, Malaria Centre, Khartoum state (2012), 19.1% of the total of damaged pipes has repaired;

These issues were also advocated by the interview:

> "Drinking water has many issues such as water pollution today become a real problem and it covers all the water resources. Furthermore, the pollution of drinking water evidence from the turbidity in autumn and with the bad odor in summer. In

> many areas they notice bad smell in their drinking water, if it is available because there is a frequent cut off. The bad situation of water distribution network evidence that in each block of Khartoum state you can see it and it becomes main sources of the mosquito breeding. I think that consuming this water may cause many diseases. I think, this issue under the responsibility of water institutions." (W3, personal communication, August 20, 2015).

However, according to the results of the public survey more than 90% of Khartoum state has bad water supply services, 95% of the leakage in the water distribution system repaired after more than two days, 93% of the public survey respondent suffers from water pollution from the public water supply, the booster pumps has been used by 87% of public survey respondent, and 90% of public survey respondents are suffering from discontinued public water supply.

b) Analysis of feasibility

The reality of water institutions in Khartoum indicates fragmentation structure, weak cooperation between different water institutions, and instability of water institutions. By means the changing of personnel, have directly impact on the institutional development program. This result in poor water management such as water supply shortage and lack of proper water leakages maintenance, these issues attributable to the lacks of strategic planning, confusion in roles and responsibilities. It is worth to mention that 1992 water policy are well addressed the institutional development and capacity building issues, but it still suffers from in poor human resources and weak institutional structure that led deteriorated the performance of water sector institutions, this may attribute to poor planning for policy implementation.

c) Potential of Islamic principles

Water institution capacity in Islam could be explained from *hadith* Prophet Muhamad when He was asked about the last day the messenger of Allah (PBUH) replied, "when the practice of honoring a trust is lost, expect the last day." he asked:

"how could it be lost?" he replied, "when the responsibility is entrusted to the undeserving people, then wait for the last day.". The employees should be qualified, responsible and trustee in performing their work, in the Islamic theory of administration the employment should be based on the qualifications of the employee as its clear from Quran: "Allah commands you to entrust authority into the hands of those who are best fitted to discharge it" (4:59). The main purpose of the capacity building was to enable the staff to perform their work in perfection way. However, *Ihsan* and *Itqan* concepts consider the main pillar of professionalism in Islam. As Muslims worker must mind Allah in his daily life and in his workplace as well, according to *hadith* Prophet Muhammad when he asked about *Ihsan* He replied: "To worship Allah as though you are seeing him, and while you see him not yet truly He sees you" this verse means that Allah watching all Muslims performs. In addition to what was mentioned above *Itqan* also means to achieve excellently, this evident from *Sunnah* in *hadith* Prophet Muhammad: "Allah loves when you perform deeds to execute it with excellence". (Shuriye, 2014)

Training and incentive are two concepts that have a strong link with the capacity building, as it stated by Adham (2001) training consider as one of the conditions for leadership in Islam, as well Prophet Muhammad (PBUH) send some of his companions to Yemen to learn some things about of weapon usage and manufacturing.

4.1.2.3 Community participation

The community is one of the important stakeholders that have poor involvement in the water resources management. In the IWRM context, when the community was involved they become more empowered to participate in water management in better and sustainable manner.

a) Reality in Sudan

The community participation is highly recognized within the Sudanese culture there are many aspects indicated the existence of collective work manner. For example, Faz'a, Nafir, it means that the local communities willingly participate for the benefit of all. Furthermore, since centuries they have developed great knowledge and systems of local organizations to manage their local affairs and to take responsibilities of resource management. This organization is named as Community Based Natural Resource Management Institutions (CBNRM). For example, traditional institutions, an ethnic and tribal institution where the traditional resource manager facilitate the participation process. Through provision of a structure that enables the community to meet their needs. And it was linked to tribal structures and function according to traditions and customs under the supervision of the tribal leaders. These ethnic institutions are not part of the hierarchy of the Native Administration, but linked to it through the office of the tribal leader. According to (Mohammed, n.d) tribal and ethnic institutions are highly contribute in controlling and conserving the natural resources, through their roles in mobilizing communities in resource management, i.e. organization of nomadic routes, control of bush fires and conflict resolution in general and conflicts over the land. In addition to organize digging water ponds and all forms of community mobilization for any public activity. As the result of changes of policies and governments the traditional institution have been abolished and replaced by a large number of local (modern) institutions that aimed to mobilize and managing local resources and development, these institutions include Village Councils, Village Development Committee or Popular Committee changes. Unfortunately, the performance of these institutions revealed that they failed to fill the gap created by the abolition of native administration particularly, with respect to resource management (Mohammed, n.d).

The Jonglei canal project is an example of the negative impact of local community marginalization. Actually, the river Nile has two main tributaries, blue and White Nile, they join in Khartoum to form the river Nile. Then, it flows towards Egypt before it reaches the Mediterranean Sea. The Blue Nile contributes 80% of the Nile flow, while the White Nile contributes, only 20%. This because of the water losses in the swamp area since it loses 50% of its water flow through the Sudd wetlands area in South Sudan. It's considered a one of the world's largest wetland, its size was highly variable, about over 30×10^3 000 km^2, while over the rainy season, it becomes over 130×10^3 km^2, or an area the size of England (Kaushik, 2012). In early 1900, Egyptian and British proposed establishing of the canal to bypass the Sudd wetlands area. The project was accepted and supported by Khartoum and Egypt government as well as France. Despite, the project was incomplete because of the civil war in South Sudan, yet there are two issues that led to the project failure. The first defect is that the governments ignored the local communities. Whose, mainly depend on the wetland area as a livelihood in terms of fishing sites grazing the land and so on. Second, they don't consider the environment, in other words, the losses of the biodiversity by (UNDP, 2007). So, the local communities as stakeholders are a very important segment, to be considered and involved in the project development. In order to share the benefits of the proposed project and ensure their support, which is crucial for the project success. This issue was discussed by the interview respondents:

> "The community needs awareness rising about water management to enable them to participate. In addition to that they did not involve in the water resource management and decisions-making. Since, there are no particular mechanisms through which they can participate. Furthermore, the community participation basically depends on democratic and transparency which are both lacked in Sudan" (A2, personal communication, October 9, 2015).

Another interview respondent argues:

> "The role of the universities is firstly to raise the awareness of the student. Enabling them participate in raising the community awareness. In order to contribute in effective community participation in the process of water resources management through the workshops and public awareness campaigns" (A3, personal communication, September 15, 2015).

b) Analysis of feasibility

Its evidence from the above-mentioned, that community participation has a vital role in water resources management. Moreover, the lack of community participation could adversely affect the process of water management through the deterioration of natural resources. The approach of top-down in resources management, leads to the alienation of people from their resources. So, they start uncontrolled usage of the resources, which affect them adversely. For example, the spread of deforestation and land degradation as well. Not only this, but the removal of tribal leaders and the undermining of the ethnic institutions have contributed to the spread of resource-based conflicts particularly in Darfur (Mohammed, n.d).

Another issue is the developmental projects, which does not consider the interest of the local community. For example, Jonglei canal project, which failed because it lacks local support. When, the Government of Egypt and Sudan were ignored to involve the local community. Moreover, they did not acknowledge them with the mutual benefit from the project (UNDP, 2007). The dam implementation in Sudan such as Merowe dam, which required to forced resettlement of up to 78,000 people. Furthermore, they strongly opposed the government for building the dam, for being resettled in the desert with little compensation, and for the handling of their cultural heritage.

The Involvement of all water users and stakeholders through the consultation process means that the decision is already accepted by them. The acceptance and sustainability of water resources management system has a strong link with the public involvement

and awareness. The involvement of the local community is a long-term process which entails democratic and transparency along with the awareness of local communities and clear procedures for the involvement will result in effective participation. This element is likely to be achieved according to the MIWR program of IWRM.

c) Potential of Islamic principles

Islamic tradition, the Quran as well as *Sunnah* are emphasizing the consultative approach, or Shura principle as a part of concerning human dignity. In the Quran, Muslims described as those who conduct their affairs in consultation. Moreover, Prophet Muhammad (PBUH) formulates a consultant committee consists of fourteen captain. He consults them about their affairs because the decision about these matters should be by the consensus of the community this may reflect the transparency of the governing system. Best example when Prophet Muhammad (PBUH) decided where to camp for Bader (Islamic fighting) based upon the suggestion of one of his companion, Hbbab Ibn Al-Munther (Al-Jayyousi, 2001).

Interview respondent states that:

> "Now we are very far from Islam, but if we consider the Prophetic tradition we could realize that community should participate in everything in Islam. Prophet Muhammad (PBUH) consults his follower and even he consults his wives in Muslims current affairs and he appreciates their advice" (M1, personal communication, October 1, 2015).

Other respondent states:

> "Our role as Muslims is to conserve the environment to cooperate in raising awareness through Friday prayer speech and by the classes, which performed in *Zawya* (small mosque). In order to enable the public community to harness the political will. Furthermore, this issue is a religious obligation, and Allah will reward us" (M2, personal communication, July 23, 2015).

4.1.3 Managerial instruments

Management instruments in IWRM context mean the tools and methods that assist the policymakers to take and appropriate decisions. That based on specific policies, social environmental and economic variability of the particular nation or country.

4.1.3.1 Water resource assessment

The assessment of water resources is to evaluate the water resources in term of quantity and quality, which are crucial in planning as well as in water management decision; this evaluation depends on many factors, for example, water availability such as rivers, lakes, groundwater and rainwater; the climatic variables; the population density; their cultural aspect and the stage of development, all these factors affect the availability of water resources. Water assessment is important as it could be used as means to explore the problems. And to determine the gaps that need to be bridge through more detailed investigation. As water supply availability considers one of the most important goals of water resources management.

a) Reality in Sudan

Water resources assessment encompasses water quality and quantity, regarding water quality, WHO reports that 90% of major epidemics in Sudan are water-related (Omer, 2008). Niles' water and groundwater are the main sources of domestic use, with doubtful to bad quality, emerged from the point and non-point pollution sources, according to the British classification of rivers. Groundwater has been influenced by the wastewater disposal in microbial content and the network system has been proved bad situation suffering from chemical, physical and microbiological contaminants (Ibrahim *et al*., 2009). Magid *et al.* (1984) asserted the presence of coliform and faecal coliform as an indicator for microbial contamination of surface well and Niles' water. Yagoub

and Ahmed, (2009) claimed that there was a problem with the tab water distributed in Khartoum state, due to inadequate treatment of water. This clear from the interview excerpts below:

> "We as an academic institution we can facilitate the water resources assessment through the specialist studies of water quality. In addition, the usage of different software such as Geographic Information System (GIS) as means to investigate water pollution. When, we discuss water management we should consider water supply and demand. This issue is the task of professional who can design a model and formulate mathematical equations with regard to the water availability" (A1, personal communication, September 5, 2015).

Despites, the public survey result showed that almost 70% of Khartoum population suffers from the water-related disease, but the water still consumed with no action regarding this issue. This result could be justified by that most of Khartoum communities depending on the water supply that limited in quality and quantity.

One of water quantity issues in Khartoum was the Water shortage in Khartoum:

Khartoum state has a total of ten water treatment plants and two pump stations that responsible for water supply to the Khartoum inhabitants. Their daily production is 503×10^3 m^3/d. Which becomes 713×10^3 m^3/d after the new Bahari was extended to product 3×10^3 m^3/d in the year 2013, Gebel Aulia water treatment plant, productivity reduced by more than 50%, and Al Manara treatment plant produce 25% of its real capacity. Due to the lacks of distribution networks, as well as north Bahari, that is less by more than 50% in the same year, due to intake problem. There are many treatment plant extensions, which indicate the continual demand for water as a result of growing population. So most of the water treatment plant suffering from technical problems, which could be considered an inadequate management issue. Water shortage is a situation when, the demand for water supply, become more than available water supply, the actual water that's available for consumption is to be $713\times10^3 mm^3$. While demanding for water is one million (Laure, 2011), it is also confirmed that there was a

critical shortage of potable water in greater Khartoum, 2/3 of the population lacks water supply, they need for an estimated one million m3/d. (USAID, 2010) Most of the people in the poor settlement buy water from small-scale water vendors (Soman, 2005). Elraheem and Abdou (2012) attributed the water shortage, cut off and leaks, to the random expansion, power supply shortage, inadequate funds, and untrained workers. Further, the lack of infrastructure for abstraction and purification is considered the main constraint of drinking water accessibility in Khartoum (Waterwiki, n.d). The interview respondent asserts that:

> "Water sector made a substantial effort to increase the availability of water for all Khartoum citizens. However, there are many constraints such as the financial resources. In addition to the increases of urban population compared to available water situation of infrastructure and the poor awareness of the public regarding water conservation" (P2, personal communication, October 4, 2015).

Other respondent states that:

> "Water quantity becomes less than previously this issue indicate population increases. I think this problem was faced by many regions of the world, but the issue is the wise water management system. That consider different water uses, formulate an adequate laws and legislation for the priority of each users determined by the quality and quantity. Furthermore, to focus on the agriculture uses of water, that consumes the most of available water. In order to regulate, this we should emphasize the water prices principle, and the usage of water technique that uses less water in the irrigation purposes" (A3, personal communication, September 15, 2015).

b) Analysis of feasibility

Despite the existence of different sources of water in Khartoum such as Nilotic and non-Nilotic water, rainwater, and groundwater. However, it experienced critical water shortage and unfortunately, all its sources are polluted, according to the previous studies, those consider a major cause of water-related diseases.

The UNDP (2007) argues that data about water resource were not available, and also regarding water quality, there are few stations along the Nile for water qualities monitoring. From the reality in Sudan the main problems of water resources assessment are the lack of enforcement to define all types of water resources. In addition, to that the information system was improper; duly the management system becomes inefficient. Furthermore, the relaxation of water law regarding the issue of surface and groundwater protection from the over-consumption and pollution. And the improper water pricing system for different sectors, agricultural sector in particular, as it is the dominant user of water resources in Sudan. In Morocco, the agriculture water demand management focuses on introducing the efficient technology for irrigation purposes, such as the drip irrigation, which useful for economists, society and environment, i.e. economic: they return 30% of the capital cost, society: increase the farmer's income and environment: reduce the water abstraction.

c) Potential of Islamic principles

Water resources assessment is mainly about water quality and quantity both aspects are advocated in Islam, as water was highly connected with the purification ablution *Wudu* and bath *Ghusl*. Water quality is important because it may restrict the usage for Muslim to do his worships and religious rituals. For example, water is split into three categories according to Muslim scholar's first, *Tahur* means pure and purifying water, it

can be used for religious purposes. Second, *Tahir* means pure and purifying water, but not recommended for use *Makruh*. Third, *Najas* means polluted and cannot be used for religious purposes (Mokhtar *et al*., 2015). Moreover, Prophet Muhammad (PBUH) established a buffer zone *Harim* around water resource where human activities were prohibited to avoid corruption of this water body (Izzi Din, 2000). And he (PBUH) forbade urinate into stagnant water in many *hadith*.

From the interview with Muslim scholar who said:

> "Water is very important in Islam because it always connected with the purification aspects as Muslim should be in a status of cleanness. For example, he needs water for *Wudu* and *Ghusl*, in good quality pure water, as the same time Muslim do use water wisely regardless its availability" (M1, personal communication, October 1, 2015).

Second issues was the water quantity: the concern of water quantity in Islam could be clear through two aspects first, the water accessibility. Insurance, evidence from the encouragement of Prophet Muhammad to buy Roma well and provide its water for Muslims for free. Second, the advocating of water conservation, in its two main sources. In the Quran: "eat and drink: but waste not by excess, for Allah loves not the wasters" (7: 21). Prophet Muhammad (PBUH) states that "... Don't waste water even if you perform ablution on the bank a fast-flowing, large river". One of the Islamic principles is *Mubazer*, which comes from the origin of *Tabzeer* by means of wastage excessive use of something. This principle is supported by the above-mentioned Quranic verses and *hadith*. *Khalifah, Fassad*, *Mubazer* and *Mizan* are complementary Islamic principles that guarantee the environmental equilibrium.

4.1.3.2 Water prices

IWRM emphasized to treat water as an economic and social good through different means. Moreover, water price was allocated under the sub-category of regulatory instruments within the IWRM framework. And it used in order to achieve efficient use

of water for different uses, except the domestic use of water. That entails special consideration to enable the household to satisfy basic human needs. In addition to ensure that the poor people have access to water with quantity and of quality that satisfies their needs as a human right.

a) Reality in Sudan

The expansion of Khartoum city includes informal settlement and refugee camps; this area is out of KSWC piped water services. However, its population estimated to be around 4 million, 95-98% of them rely on water cart, which is estimated to be about 30-40×10^3 water court in Khartoum state. The population spends an average of 9.2% of their monthly income on water, knowing that human right for waters should not exceed 3% of the household income (UN, 2010). Furthermore, the water price from small water enterprises about US$ 23.2/m3 /month, while the municipal piped water, US$ 0.6 m3/month (Mc Granahan *et al*., 2006). There is an ineffective water price system applied in Khartoum state, still they used monthly rate fee principles in charging water. The rate was calculated according to the size of house and of the pipe connection, which classify the household into three categories first, second and third class who charged 45, 25, 15 SD respectively (Laure, 2011; Beckedrof, 2012). The discontinuity of the water network distribution service, make their customer use the water cart as a supplementary source of water. So that, in order to provide water for all Khartoum state citizens was issue that challenged the Khartoum government. Moreover, it compels the poor communities to pay more for less water quality. In addition, they became more vulnerable to water-related diseases. The water cuts-off and shortage are clear signed that confirms the inability of water sector to provide an adequate water supply for Khartoum citizen, despite numerous efforts for water provision (Elraheem & Abdou, 2012; Beckedrof, 2012). Water shortage forces the citizens to consume the

contaminated water, which are the main cause of diseases and even deaths. This issue may be overcome through wise water resource management, efficient use of water, through water price. In addition to, appropriate techniques for water metering, and suggestion of new sources of water, such as rainwater harvesting and wastewater reuse. Interview respondent mentions that:

> "The prices of water based on the size of houses regardless to the real consumption of water. Even if I don't use the water should I pay the cost that un-fair. In addition to, the bad water services in quantity and quality, therefore, we are not willing to pay any cost for this deteriorated service. This situation exposes citizens to consume contaminated water either from the public supply system or to pay more for less water quality from street water vendors. The most justice solution is to enhance drinking water quality according to the international standers. And to encourage the usage of volumetric in order to determine the exact water consumption for each household then, they have to pay for their water consumption" (W1, personal communication, September 8, 2015).

b) Analysis of feasibility

To treat water as an economic good is one of Dublin principles the economic value of water used as means to achieve efficient use of water. Sudan water policies are well addressed almost all of IWRM aspects; however, it failed to treat water as an economic good. Since Sudan's water policies lacks a clear section concern with water prices and principles, which entail proper population statistics with rich details about their income. Water prices or considering water as an economic good is crucial moreover; it has been used as an indicator for IWRM implementation by some agencies.

c) Potential of Islamic principles

It's worth to mention that Islam put the human on the top of the water priority right, for drinking purposes. Moreover, it encourages Muslims to provide other Muslims by water, which needs for basic needs and even it considered in a general sense as a common property. Therefore, Islam punished those who deny thirsty living being from

water. As it's clear from *hadith* Prophet Muhammad said: "who will buy the well of Rumah and dip his bucket in it alongside the buckets of the Muslims, in return for a better one in paradise?". From this *hadith* it is clear that Prophet Muhammad encourages *Waqf* principle to ensure the equity in access water.

Water price is permissible, but it conditioned to be justice and efficient, the notion of the cost recovery of value added to the water, not for the water itself. It is clear when Prophet Muhammad said that "it's better for anyone of you to take a rope and cut the wood (from the forest) and carry it over his back and sell it, rather than to ask person for something and that person may give him or not". Islam permits the recharge for any work that done by the human even the natural resource including water if he adds a value to them, and then he can sell it. For Muslims in Sudan they should replace the flat rate principle by an effective water prices principle. That trade-offs between human rights and the water efficiency and sustainability. As it mentioned in previous sections that Prophet Muhammad preferred to give water for free for all Madena population. From the prophetic tradition conclude two principles, first, human right for water; second, equal access to water regardless per capita income. These principles could be used through the lifeline rate principle, and block rate with direct or indirect subsidies for the poor.

The interview respondent states that:

> "We as Muslims the basic principle in the work that if you work you should charge for this work and the money that you get is halal. However, the work should be done in a perfect way. In this case, if the workers in the water institution are mind Allah in their work. Then they should pay attention to water quality and ensure the continuity of service before they ask for charge, considering Muslims will be accounted for his work even its in size of atom." (M3, personal communication, October 2, 2015).

4.1.3.3 Environmental impact assessment

Environmental Impact Assessment (EIA) commenced in the 1960s as part of increasing environmental awareness. EIAs, therefore, form the basis of a technical evaluation to contribute to more objective decision making with respect to projects and the environment. EIA could be defined as a process of identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made. EIA is a formal process used to predict the environmental consequences (positive or negative) of a plan, policy, program, or project prior to the implementation of the decision (Banjoko & Eslamian, 2015). Within IWRM context EIA is crucial in the stage of project designing and in setting of development priority. Furthermore, it's evaluates both social and environmental impact of a given project. And it also reflects the integration of a wide spectrum of sectors and stakeholders involved in the development project. This point matches the cross-sectoral integration which considers as a basic principle of the IWRM.

a) Reality in Sudan

EIA study in Sudan conducted prior to the year 1950 for the Equatorial Nile project, during Anglo-Egyptian condominium. However, it's legally issued by the Environmental Protection Act of the year 2001 (Ali, 2007).

One of the interview respondent states that:

> "The environmental impact assessment is very important for any project that may have environmental and social impact. For example, the sugar factories that releases its industrial effluent directly without any treatment into the Nile, attributes to the incidence of frequent eutrophication phenomenon and the fish killing in the Nile water. Actually the EIA is not new in Sudan it has been conducted in the year 1983 based on the request of some international funds finances and the World Bank. However, the first legislation concern with it was issued in 2001" (A3, personal communication, September 15, 2015).

Most famous events related to the EIA in Sudan is Merowe dam project on the river Nile, is located 350 kilometers north from the capital, Khartoum, with a capacity of 1.250 MW, doubled Sudan's electricity generation. Despite the great benefits of Merowe dam, but it lacks a proper EIA report. Furthermore, it considered a controversial development project, due to the opposition from the different scholars who are concerned with the environment and human rights. In addition, to that they frequently confirmed the negative Impact of Merowe dam on both local communities and environment. The artificial lake of the dam submerged 174km including the residential area and farmland of the Manasir, the Shaiqiya, and the Rubatab tribes, the people affected by the Merowe dam estimated to be between 50×10^3 and 78×10^3. Poor EIA results in a conflict of interest between the present regime and, the Manasir tribes (50.000 people) then they formulate the activist group Leadership Office of the Hamadab Affected People (LOHAP) who has frequently requested the United Nations and foreign embassies in Khartoum for support for the local people against the dam project. The remaining peoples of the Manasir tribe, who are rejected the resettlement, and the government compensation of land. Now they live around the artificial lakes and the change their livelihoods from farmers to fishermen. (Hafsaas, 2011), Merwe dam project also submerged immeasurable archeological treasures in its reservoir (Salman, 2008).

In line with this debate, the interview showed that:

> "The EIA is crucial to protect the environment and the human well-being; we need more strict legislation about this issue. Considering that Sudan now experience the oil petroleum and mining industries that have a numerous impact on the environment. Unfortunately, the lack of laws and legislation enforcement and the absence of the awareness of policymaker, as well as stakeholders worsened the situation. Most of the industries are profaned for the environmental law. In addition to that more of the developing projects are not restricted by the EIA report. For example, Merwe dam, they start the preparation for the construction before they issued the EIA report" (P2, personal communication, October 4, 2015).

The critical issue was the industrial effluent, which contributes to the Nile water pollution, knowing that the majority of industrial factories have not dedicated water treatment facilities, which released their wastewater into the domestic system (where one exists) so it's released directly into the Nile water courses, or onto land in some industrial factories. However, the industrial waste considered a major fish killing in the Blue Nile in March 2006, which is following an accidental spill of molasses from the northwest Sennar sugar factory (UNDP, 2007). Uncontrolled industrial disposal causes chemical pollution by raising the concentration of some parameters, which threats both surface and groundwater (Ibrahim *et al*., 2009).

b) Analysis of feasibility

From the reality, which revealed that the EIA is prerequisites not only for large-scale development projects, but it's also highly needed for all activities that have potential to adversely impact the society and environment. For example, the Sugar factories, tanneries, hospitals, apartments, hotels, cafeterias, and resorts that allocated on the river Nile bank. Khartoum government should strictly control and oblige them to formulate or construct a treatment plant for their effluents. Then, they should produce a certificate with reference to the special standard for their effluents to get a permission to dispose it into the Nile. The relaxation in EIA report legislation will lead to many environmental and social impacts, for example, Merowe dam; the environmental impact assessment study is improperly conducted. Furthermore, project construction was started without approval by Sudan's environmental ministry, this is clearly revealed in the enforcement of law and legislation regarding the EIA.

c) Potential of Islamic principles

Environmental impact assessment mainly focuses on the environment and the society, which equivalent to the concept of *Harim* and the Islamic principles that support the environmental conservation such as *Mizan*, *Khalifah*, *and Fassad*. Furthermore, there are many traditions that could be used avoid the potential impact on the environment. For example, the prohibition of urination in the stagnant water and defecation in the shady places. One of the most important purposes of formulating *Sharia* (Islamic law) is the public interest in life and hereafter, the nothing of injury for people it's not permissible to injure the people it's clear from the Prophet's *hadith* on the authority of Abu Saeed Al-Khudree, that the messenger of Allah (PBUH) said: "there should be neither harming (Darar) nor reciprocating harm (dirar)". According to Kamla *et al* (2006) the role of *Mohtasib* in Islam to protect the community from the adverse impact of Business. Moreover, assessment, monitoring and report act of changing the environment (flora and funa), under his responsibility as well.

4.2 SWOT analysis

SWOT analysis used for each sub-category of the GWP framework then overall SWOT, which results in many factors under different items of SWOT analysis, the priority of some factors upon other is due to their frequent appearing within the analysis of different elements of framework, for example, the water legislation is one of the enabling environment categories. However, it appears as an important factor in good governance, water resources assessment, water prices, and environmental impact assessment, therefore, it has been selected and so on for the other elements, this could be arranges as follow:

4.2.1 Strengths

4.2.1.1 Availability of laws and legislation in Sudan

There are a lot of water legislations but they suffer from fragmentation, updating and enforcement issues. Moreover, the latest water law was draft without approval. The existence of water laws and legislation without enforcement will give the same result with other countries that lacks it. Furthermore, the process of IWRM implementation turned to be very difficult if it is not impossible. So, the enforcement of water legislation is crucial for IWRM adoption. Despite, existence of water legislation, but it still needs to be improved, updated and enacted.

4.2.1.2 Nile basin initiative (NBI)

Nile basin initiative (NBI) consists of nine out of ten of river Nile basin countries. Sudan ratify on the NBI to achieve sustainable socioeconomic development through the equitable utilization of and benefit from, the common Nile Basin water resources. It's considered one of the Nile riparian's efforts towards equitable utilization of the Nile. Furthermore, it was signed by nine out of ten riparian countries, it needs for an effective coordination among different riparian to ensure the achievement of NBI goals.

4.2.1.3 Water quality monitoring

Monitoring of water quality is crucial to ensure safe water consumption especially for human consumption. Although, there are few stations for water quality monitoring on the Nile riverbank, it needs to be more equipped and well distributed. In order to facilitate the water assessment that is crucial for the water management decision.

4.2.1.4 Environmental awareness

The existence of many environmental aspects and institutions that support water management such as environmental impact assessment, consumer protection court,

MWRE, Higher Council for the Environment and Natural Resource (HCENR), Institution of Environmental Studies University of Khartoum (IES) among others. These institutions could contribute to raising awareness of water management.

4.2.2 Weaknesses

4.2.2.1 Water governance

The governmental water institutions are most dominance in the water management process without an effective involvement of all stakeholders. The involvement of the private sector was restricted to the construction of some infrastructure and fee collection. Even though, Khartoum state water corporation implemented many water projects in order to satisfy the need of water for population, it fails to do so.

4.2.2.2 Water legislation

Water-related institutions are fragmented duly their legislation are scattered among them without adequate formulation, enforcement. For some water the legislation there is a need for bylaws to enable the practice of these laws. The implementation of water legislation is a comprehensive process, which includes formulation, implementation, updating and monitoring of the water legislation. Currently, water legislation lacks adequate formulation, approval, and implementation.

4.2.2.3 Institutional capacity building issue

One of the most critical weaknesses of the water in situation is the lack of institutional framework and strategic planning. Evidence by the shift of the addition and separation of the ministry of water resources emerged frequently. In addition to, the fragmented structure of different water institutions. For example, there are more than ten water-related institutions dealing with water management issues without an effective coordination among them. Furthermore, it suffers from the low human capacity, even

among the directors of some department, due to the lack of training, educational skills and incentives system. In addition to, the poor financial resources, which hinder the institutional development and capacity building. Moreover, the water institutions lack technology and information system, which could improve water management such as Geographical Information System (GIS), and other software as well as water metering technology that supports water prices system.

4.2.2.4 The brain drain

Most of the skilled and qualified personnel were migrate outside the country. For that reason, low salaries, which are insufficient to cover the basic needs such the expenses of education, health and other basic services. In addition to, the deterioration of the working environment and the absence of training course and development of skills.

4.2.3 Opportunities

4.2.3.1 Water availability in Sudan

There are many kinds of water resources such as surface water, which included two main tributaries of the Blue and White Nile and the River Nile. Sudan shares groundwater aquifers of the Nubian sandstone formation, the Gash aquifer, the Gezira and Atshan aquifers. In addition to, the alluvial aquifers, Um Ruwaba formation and the Gedaref sandstone formation. However, these resources are lacks for international agreements in order to be managed in adequate manner towards sustainable water resources management.

4.2.3.2 Majority Muslims of Khartoum population

Most of the Muslim population is living in North Africa so; they can participate in IWRM strategy through their religious obligation. Since the Islamic principles agree with all IWRM framework categories. Therefore, Muslims community in Khartoum can

practice their Islamic principle in water management. In order to enhance the IWRM implementation in Sudan. For example, they can be embodied the Islam principles that could be practiced to improve the water access for all Khartoum state resident. This could be achieved through the concept of *Waqf*, in turn; the poor people could access water for free. Furthermore, *Mizan* principle is useful to use as remedy for the industrial effluent. And *Khalifah* principle, which could contribute positively in safeguarding the process of water management. They can also be benefiting the concept of *Hisba* institution and *Mohtasib* as to monitor the quality of water services in order to improve water governance in Khartoum.

4.2.4 Threats

4.2.4.1 Climate change

Climate variability change, hence temperature and the rainfall are the most important variables that could affect water resource availability. Especially in the case of Sudan because it allocated in the rid to a semi-arid zone which characterized by a low average of rainwater.

4.2.4.2 Vulnerability of trans-boundary water issues

Most of the country surface water resources are originated outside its tertiary. However, Sudan's water share will be vulnerable of sovereignty of some countries over other. Furthermore, the absence of cooperation among different riparian countries will aggravate the issue. In addition to that Sudan lacks treaties agreements to govern the shared groundwater aquifer systems with its neighboring countries. As a result, the groundwater becomes exposes to the over-consumption and pollution.

4.3 Concluding remarks

This chapter represents the procedures of data analysis such as thematic analysis and SWOT analysis that used to show the convergence of evidence from data sources. Through a comprehensive presentation of three categories. Namely the reality in Sudan, analysis of the feasibility and the potential of Islamic principle for each one of the analytical framework sub-category. The application of SWOT analysis indicates that it could be used as an evaluation tool. In order to identify and prioritize the strengths, weaknesses, opportunities, and threats according to the IWRM situation in Khartoum.

CHAPTER 5: RESULTS AND DISCUSSION

This chapter concerns with the discussion of the study findings, which organized according to the research questions for the first question Section 5.1 show the results of feasibility of IWRM implementation in Khartoum Sudan, by showing the key findings in Section 5.1.1 the findings were discussed in Section 5.1.2, second question the drivers and barriers to IWRM implementation in Khartoum, Sudan was answered in Section 5.2, in addition to its key findings and discussion in Section 5.2.1 and 5.2.2, that last question was the potential role Islamic socio-cultural tradition in enhancing IWRM implementation in Khartoum, Sudan as well as the key findings and discussion in Section 5.3, 5.3.1 and 5.3.2 respectively.

5.1 Feasibility of IWRM implementation in Khartoum Sudan

In this research, there are three objectives first one to investigate the feasibility of IWRM implementation in Khartoum, Sudan. According to the definition of the feasibility study, it was conducted mainly to evaluate the factors, which affect the implementation of IWRM in Sudan. In order to achieve this objective, the interviews were conducted with four groups namely policy makers in different water institutions, water manager, water experts, academics and Muslim scholar. Data analyzed by using thematic analysis, in order to evaluate the factors that affect IWRM adoption, based on analytical framework elements. The results of the analysis indicated that six elements of the GWP are positive in-adequate (by means that they are not properly applied) and three elements are negative in-adequate means (not implemented at all). The flowchart of this research was depicted in **Figure 5.1**.

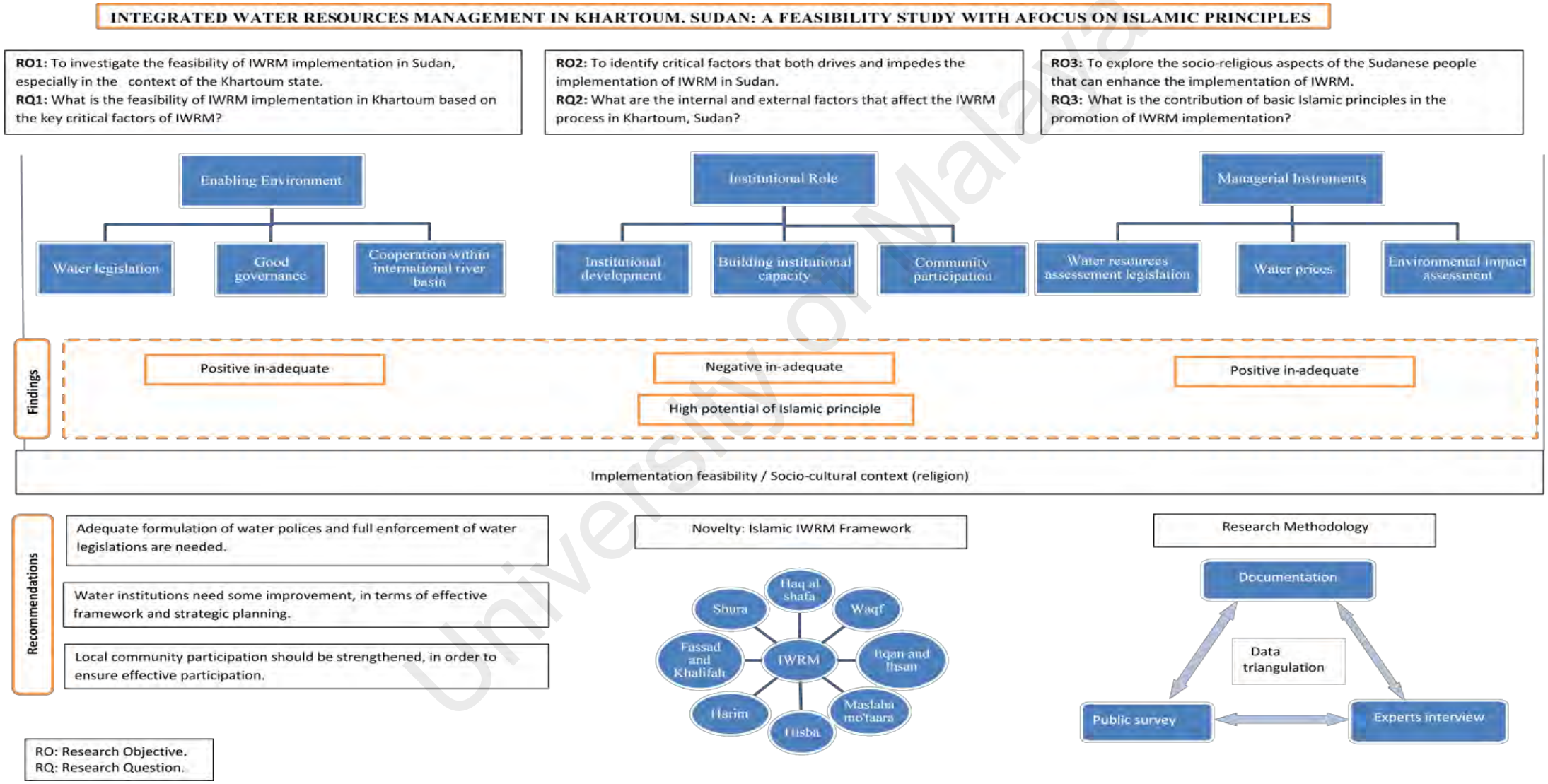

Figure 5. 1: Flowchart of Study

5.1.1 Key Findings

The results of this research showed that the enabling environment and the managerial instruments were positive in-adequate in Khartoum. Moreover, it considers as a constraint for IWRM implementation. However, the institutional role is negative in-adequate, knowing that these elements were crucial for IWRM implementation particularly in the context of Khartoum. For example, the involvement of the community will enhance the IWRM application. Since through their indigenous knowledge could facilitate, the protection and monitoring of the Nile water in terms of quality and quantity and support water decision formulation and sustainability.

Table 5.1: Summary of the result of feasibility analysis of IWRM

Elements of the analaytical fraework	**Analysis of feasibility**	**Assessment**
Institutional development	Negative in-adequate	Lack of institutional framework.
Building institutional capacity		Poor human resources and institutional capacity building .
Community participation		Absence of community voice in water management desicion.
Water legislation	Positive in-adequate	The water legislation issues - gap, overlap and the lack of enforcement, .
Good governance		Poor stakholders involvement.
Cooperation between international river basin		The international agreements are not necessary to as the remedy for cooperation between international river basin countries.
Water prices		Flat-rate approach as water price system.
Water resources assessment		Water scarcity and water pollution.
Environmental impact assessment		Merwee dam, sugar industry factories along the river Nile.

Negative inadequate = doesn't implemented before. **Positive inadequate** = not properly applied. **Positive adequate** = implemented (in place).

5.1.2 Discussion

Interestingly, the findings of this research indicated that the three elements of the institutional role were negative in-adequate in the context of Khartoum. This result may attribute to the weakness of the enabling environment, which underlines the whole IWRM process. Furthermore, the inadequate managerial tools results in the ineffective role of the institution.

The main factor that has a high impact on the IWRM adoption is the water policy and legislation. Considering that it has a great influence on the entire elements of the GWP framework. Furthermore, it should be properly formulated, updated and enacted to improve enabling the environment through clear determination of role and responsibility of government. In addition, private sector and civil society should be involved to create good water governance. The water legislation is crucial at the international level to ensure equitable and sustainable utilization of the mutual river basin among all riparian countries.

It's important for the institutional role to be performed adequately through the proper arrangement of water institution. In addition, emphasizing the coordination among different related institution and to build capacity for the institutions and human resources. The managerial instruments water resources assessment need to be underpinned by effective water legislation. In order to conserve surface and groundwater from the pollution and over-consumption, and also for water prices, the water policy and legislation should well address the water prices for all water users. Especially, the agriculture sector since it considers the main users of water resources in Sudan. The environmental impact assessment aspect should be addressed adequately within the water policy, and it required to be applied through restricted water legislation to ensure a safe environment and healthy community.

This study found the lack of community participation in the water resources management as one of the main factors that affect IWRM implementation. This finding corroborates the ideas of Ako *et al*. (2010) in paper that aims to evaluate the Cameroon efforts towards IWRM implementation, it also agrees with Dungumaro and Madulu (2003) who advocated that community participation is crucial for a successful water management, and finding was consistent with Gallego and Juizo (2011) who argued the public participation as weaknesses as the main factor for IWRM to be successes in Mozambique case.

Another important finding was the poor institutional development, which was evidenced by the frequent shifts of water institution in Khartoum. Furthermore, it indicates the lacks of strategic planning and framework. Another issue was fragmented of water-related institutions with little or no coordination among them. The provision of water considers a main goal of sustainable water management, which was mainly achieved through the water instructions. Therefore, the issue of water shortage in Khartoum could be direct attributes to the poor institutional role of the water institution. This result is consistent with (Jønch-Clausen (2001) and Agarwal *et al*. (2000) who claimed the institutional development were important in IWRM formulation as well as application. It is also similar to Adam (2011) who argues the water sector, institutional framework, and the overlap of responsibilities, financial availability as well as the lacks of political will.

The result of this study indicates that poor human resources considered an obstacle for IWRM. For example, the lacks of the skills and well-trained water manager as well as appropriate employment standers adversely affect the water management process, the findings of the current study are consistent with Jonker (2007) who founds that the lack of human capacity could hurdle the IWRM implementation.

The results of this research indicated the existence of NBI and DoP agreement could provide a suitable media for coordination between different countries of the Nile basin to formulate proper policy for equitable utilization from the Nile water. This result agrees with Ako *et al.* (2010), Najafi and Vantafada (2013) who claimed that the importance of trans-boundary water management among different riparian state for an equitable share of trans-boundary water in order to eliminate the poverty and achieve the MDGs for all riparian countries. and it's also similar to Absar (2013) who suggests the fair allocation of trans-boundary water will result positively in term of equitable and sustainable utilization of the common water resources, however Muslims should share the resources in abundant as well as in scarcity, as they are not the owner of these resources, they a guardians and they will be accountable to Allah for their actions.

Another important finding was that water policy and legislation, despites its existence, but it needs to be reviewed, updated, enacted, approved and finalized. Furthermore, there are some elements that need to be improved the findings of the current study are consistent with those of Gallego and Juizo (2011) who identified that weak policies and legislation could act as weakness in Mozambique, and Assaf (2010) argues that improper water legislation formulation, will underpin the IWRM implementation.

The study results indicated poor water governance because the water system is managed mainly by the governmental sector without involvement of the private and civil society, however, in Khartoum recently the private sector was involved in the development of water infrastructure but with minimal roles and responsibilities towards the water supply, this result consistent with those of Ako *et al.* (2010) who appreciated the water governance as decentralization aspect to be used as supportive tool for IWRM.

And Rahaman and Varis (2005) who advocated the privatization as an issue that should be solved to ensure successful IWRM.

In this research the finding showed that water resources assessment basically depends on water quality and quantity, however, both concepts are evident to be a challenge in Khartoum, that could be well controlled by striated water conservation laws and legislation and adequate data and information for example, measurement of water availability was highly affect the decision on water demand and supply strategies. This finding further supports the idea of Biswas (2004), Jonker (2007) and Agarwal *et al*. (2000) who suggested the importance of data in the water resources assessment process.

Another important finding was that the cooperation within national river basin which was vital elements to be promoted in order to ensure water resources sustainability. As Sudan depends on the Nile as the main source of water and it's one of the Nile basin countries that need for effective cooperation to ensure water security. Water resources assessment, need to improve in order to control the issue of water pollution which was becomes a reality in all the water sources, this finding agrees with similar finding of Van der Zaag (2005), Rahaman and Varis (2005) and Gallego and Juizo (2011) who proposed the international cooperation as a factor for successful implementation of IWRM.

The findings of this study indicated that water prices or to treat water as an economic good is critical problem in Khartoum that could be solved through the adoption of appropriate water prices principle to improve infrastructure as well as to ensure that all Khartoum population have access to their needs of drinking water as human right, as is evident that most of Khartoum residential area have low accessibility to water and in some areas no accessibility at all, when compared with WHO minima 25 l/c/d. this

finding was similar to Ako *et al*. (2010) who argued water as a human right for basic needs in their publication, which aimed to evaluate IWRM implementation effort in Cameroon.

This study shows that in Khartoum state the water price system was not fixed to the public in fact consumers, they charged according to the size of the residence and the type of pipe connection and neighborhood. Therefore, prices range from 15, 25 and 45 SDG, this finding indicates that water prices system was improper. This finding corroborates the ideas of Rahaman and Varis (2005), Ako *et al*. (2010) and Gallego and Juizo (2011), however Rahaman and Varis (2005) emphasized the water prices as issue to be considered to enhance and facilitate IWRM implementation. Furthermore, they recommended for special consideration to the poor, and for the domestic use of water within the water prices policy. While Gallego and Juizo identified the adoption of water prices principle as strengths in the case of Mozambique.

The current study found that the environmental impact assessment (EIA) was very important in Khartoum due to many factories especially the sugar factories, tanneries, hotels and restaurant that dump their effluent directly into the Nile without any treatments this would impact the environment as well as social wellbeing as water-related diseases vulnerable, this findings is similar to Assaf (2010) who asserts that EIA as a cornerstone for IWRM implementation process.

IWRM implementation framework could be implemented; despite Sudan is one of the developing countries. This finding corroborates the ideas of Van der Zaag (2005), who suggests that IWRM will encourage in MDGs to be achieved. And it will encourage the water manager to think about water management decision from a different angle. And it also can produce a new kind of water manager who can facilitate the IWRM implementation process.

However, the findings of the current study do not support the previously published studies Allan (2003), Merrey *et al*. (2005) and Lankoford *et al*. (2007), they produced more evident that IWRM unfeasible to be implanted in developing countries. They attributed this to that the water demand and cost recovery system needs water infrastructure for water delivery and measurement. As well as the polluter pay and marked based regulation principles, which can't adopted without physical and institutional capacities. IWRM implementation challenges were faced by many world countries regardless their development status, the evidence was that, despites general endorsements for IWRM in the U.S, full implementation of IWRM was hampered by inconsistent concept definition and basic framework for concept implementation (Cardwell *et al*., 2006). Rahaman *et al*. (2004) they represented some conferences that deal with IWRM guidelines when they do a comparison between the outcomes of these conferences with the EU Water Framework Directive (EU WFD), they recognized seven mismatching.

5.2 Drivers and barriers to IWRM implementation in Khartoum, Sudan

Second research objective used to identify the main factors that affect IWRM, which could enhance or hampered the IWRM application, this has been answered through the application of SWOT analysis, and these factors were selected based on its frequent appearance during the analysis.

5.2.1 Key Findings

The results of the SWOT analysis showed that the main drivers are: the availability of laws and legislations, which were well formulated and addressed most of the IWRM principles, unfortunately it's lacks of enforcement, which consequently results in water pollution and over-consumption. Moreover, Nile basin initiative (NBI), water resources

assessment in term of water quality monitoring and the environmental awareness were also considered as strengths for IWRM implementation. While the main barriers are: water governance, water legislation, institutional capacity building and the issue of the brain drain. See **Table 5.2** below.

Table 5.2: SWOT analysis for framework categories

Internal factors	
Strength Drivers (we have)	**Weakness** Barriers (we need to improve)
Availability of laws and legislation in Sudan.	Water governance.
Nile basin initiative (NBI).	Water legislation.
Water quality monitoring.	Institutional capacity building issues.
Environmental awareness.	Brain darin.
External factors	
Opportunities Drivers (we need to do)	**Threats** Barriers (to solve or modify with)
Water availability in Sudan.	Climate variability change.
Majority Muslims of Khartoum population.	Vulnerability of trans-boundary water issues.

5.2.2 Discussion

In this research, despites that some factors considered as drivers, however, it's also required some enhancement and improvement. For example, the availability of water policies and legislation, there are many policies concern with water management and conservation and its address many aspects of the international concern, but it's not ratified and the legislations suffers gaps and overlaps. In addition to the poor enforcement, therefore the policies and legislations consider as driver factor and barrier as well. This finding was consistent with the findings of Gallego and Juizo (2011) as weakness in Mozambique and it's also similar to Chidammozdi and Muhandiki (2017)

findings, they considered weak enforced of legislation as one of the weaknesses in Malawi.

This research found that international cooperation within the national river basin the NBI consider as driver factor because it provides an opportunity for riparian countries to coordinate to attain the sustainable utilization of the Nile water.

This study result indicates that water sources assessment is poor evidence by water monitoring points along the Nile were positively impact the quality of water and improved the water assessment task, unfortunately, it covers small part of the Nile, and therefore it was considered as a driver and barrier as well.

The environment in Sudan was highly addressed through different policies and laws and the environment has many institutions for conservation and management, in addition to a number of universities that provide different undergraduate and postgraduate courses on the environmental studies. This point could help in the raising awareness of the public about different environmental issues including water resources management.

Water governance is one of the IWRM application barriers since, the water management task was performed by government ignoring the role of the private company and civil society in water management processes. Which results in not only barrier for IWRM adoption but also, poor water governance. The institutional capacity building issues such as the poor management of institutions, as its clear from the water institutions shifting, the lacks of strategic planning and proper management, the water legislations did not clearly addressed the role of different institutions in water management processes, this results corroborate the findings of a great deal of the previous work such as Van der Zaag (2005) who states that "IWRM requires institutional capacity to integrate". Moreover, Agarwal *et al*. (2000) argued that the

coordination among different water institution as a consequent result of the integration, Gallego and Juizo (2011) who considered it as weakness in Mozambique, they asserts that the institutional framework have a role in formulating water resources data base. The research findings agree with Ako *et al.* (2010) who stated that institutional framework is important for perfect water management, because it could clearly guide different stakeholders regarding their roles and responsibilities, Jønch-Clausen and Fugl (2001), Grigg (2008) and Medema *et al*.(2008) considered the institutional issues as obstacle for IWRM implementation, however, Chidammozdi and Muhandiki (2017) founded the inadequacy of cross-sectoral coordination is one of weaknesses in Malawi, and it also agrees with Gain *et al*. (2017) who attributed the IWRM success for the institutional capacity.

This study found that the poor human resources acts as a constraint for IWRM adoption, and it needs for capacity building, which could be achieved by the training courses and incentives. In order to create and enable the water manager to perfectly perform within the process of IWRM implementation and to gain some skills that enables them to coordinate with other water institutions. This result agrees with the previous results which founded by Swatuk (2005), Gallego and Juizo (2011) who suggested it as weaknesses in Mozambique. Similarly, Chidammozdi and Muhandiki (2017) founded the in-adequate availability of human resources as weaknesses in Malawi and it also agree with Medema *et al*. (2008) who pointed out those human skills as one of IWRM challenges.

Drain brain issue has adversely impacted the water sector; hence most of the trained worker and professional technique are migrate to search for satisfaction of financial resource, good work environment and better development of skills. This finding was consistent with the findings of Gallego and Juizo (2011) as threats in Mozambique.

The findings from the exploratory public survey of this research indicate that water supplied to the citizen is of poor quality and polluted due to underdeveloped water system infrastructure which leads to loss of water through leakages in pipes and low water pressure. This force citizen to install and use water pumps in their houses, these pumps and water storage tanks contribute to further pollution. There are similarities between this result and those described by Allan (2003), Merry (2008), Donkor and Wolde (2000) they thought that this result was one of the factors that impede IWRM implementation in developing or Africans countries.

5.3 Potential role Islamic socio-cultural tradition in enhancing IWRM implementation in Khartoum, Sudan

The third research objective is to explore the socio-religious aspects of the Sudanese people that can enhance the implementation of IWRM. In order to achieve these objective Muslim scholars were interviewed, the data which obtained from the interviews have been analyzed by using thematic analysis. Sudan is one of the majority Muslim countries, as the Muslims traditions are mainly based on Quran and *Sunnah* in terms of Prophet Muhammad traditions; according to the findings, each element of IWRM framework is relevant to one or more of the Islamic principles and concepts.

5.3.1 Key Findings

The result of analysis indicates that the Islamic principles were relevant to the entire analytical framework; accordingly the potential of Islamic principles to improve water management in Khartoum will be significant. As Khartoum's population is majority Muslims, consequently they will contribute in water management practices as their religion obligations. Moreover, they will account to Allah for their actions. For example, they will enhance the concept of water governance through the concept

Khaifah and water conservation through *Tawhid, Mizan*, *Fassad*, *Mubzir* and *Khaifah.* This result in similar to Faruqui *et al.* (2001), Abdelrahman (2000), Amery (2001) and Absar (2013) who asserted great potential of water principle in water management policy especially within the Muslims majority countries. Some details were provided in **Table 5.3.**

Table 5.3: Summary of the potential of Islamic principles

Framework Elements	Equivalent Islamic Principles	Evidence
Water legislation	***Haq al shafa or shirb***: the law of thirst or the right of human to drink or quench their thirst (Izzi Din, 2000; Faruqi, 2001; Wickström, 2010; Jah, 2013).	"Muslims have a common share in three things: grass, water and fire" (Kadouri *et al*., 2001) "Islam put the human on the top of the priority of water use" (Faruqui, 2001).
Good governance	***Hisba institution***: hisbah institution is an Islamic position on the application of principles of Islam "Al amr bil ma'aruf wannahyi anil munkar" (enjoining what is good and forbidding what is bad)" (Attahiru *et al*., 2016).	"The role of muhtasib the employee of *hisba* is responsible for making sure that business is not harming the community during the Islamic rule of the 15th and 16th century " (Kamla *et al*., 2006).
Cooperation between international river basin	***Maslaha m'tabara***: the public interest recognized in Islam (Izzi Din, 2000). ***Haqq al-majra***: the right of flowing water (Wickström, 2010).	"Islam is very clear about this issue hence Muslim shouldn't do anything that may harm him or cause harm to others" interview with lecturer at Sudan University, Khartoum, Sudan. M3 (2/10/15).

Table 5.3, continued

Framework Elements	Equivalent Islamic Principles	Evidence
Institutinal development and Building institutional capacity	***Itqan***: a term employed to signify the level of quality work. And ***ihsan***: that Allah is watching over man in any task he performs (Shuriye, 2014).	"Say work soon will Allah observe your work and his messenger and the believers" (9:105). Training aspect is exist evidence from Prophet Muhammad (pbuh) when he send some of this companions to learn some of weapon manufacturing and uses.
Community participation	***Shura principle***: public consultation and involvement (Faruqui, 2001).	Quran describe Muslims "as those who conduct their affairs by mutual consultation" Prophet Muhammad (pbuh) decided where to camp for Bader (Islamic fitting) based upon the suggestion of one of his companion, Hbbab Ibn Al-Munther (Al-Jayyousi, 2001).
Water resources assessment	***Fassad*:** corruption, mischief, or spoiling of anything including water resources. ***Khalifah:*** trustee or steward of God in the earth (Faruqi, 2001).	"*Ma' Tahur*: pure and purifying water, *Tahir*: pure and purifying water and *Najas*: polluted and cannot be used for either mundane or religious purposes" (Mokhtar *et al*., 2015). "The role of *Khalifa* is to ensure equitable and sustainable use of all resources including water (Al- Jayyousi, 2001).
Water prices	***Waqf principle***: usufruct or acollective property for reliious purposes and public utility (Faruqui, 2001).	"The Prophet said "he who purchases the Ruma Well (a settlement in Arabia) and offer its water to Muslims for free of charges will be granted paradise" (Kadouri *et al*., 2001)
Environmental impact assessment	***Harim***: a buffer zone around water resource where human activities are prohibited. (Izzi Dien, 2000).	"He (pbuh) established a buffer zone (*harim*) around water resource to avoid corruption of the water body" (Izzi Dien, 2000).

5.3.2 Discussion

Some authors define Islam as a way of life by meant that everything in dial life was explained in Islam and there is no separation between the Islamic tradition and the daily life practices. Based on the findings of this research the Islamic principles and concepts will contribute to improve the water management practice in Sudan. For example, water legislation, policymakers and water managers in Khartoum should recognize the human

rights of water in Islam, hence they have a rights to quench their thirst from water according to the right of thirst for human and his animals *Haq al-Shafa'* and the rights for the human, and *Haq al-Shirb*. The reality in Sudan shows that 2/3 of Khartoum inhabitants did not access their right from water for basic human needs. That means that Khartoum resident *Haq al-Shafa'* was not being fulfilled and the equity was not being compromised.in addition to the priority of water right given to the irrigation sector, which consumed 94% of the water, 4% for human and animals, and 1% for industry (Omer, 2010). Evidence that the Prophet (PBUH) encourages providing water for free moreover, he guarantees the paradise based on the *hadith* Roma well, which was bought by Othman the third caliph. The principle of *Haq al-Shafa'* could act as a motivation for Muslim in Khartoum to improve access to drinking water for all population. Furthermore, they can benefit the *Waqf* principle for drinking water in order to ensure that all people could enjoy drinking water as human rights. This entails enforcement of water legislation to conserve water in terms of quality and quantity. Since, the policymaker when they formulate the water policies and legislation they should mind their responsibility to formulate it in adequate way, as they will be accounted to Allah. In addition to that they should act as *Khalifah* one his tasks is to ensure the fair allocation of water among Allah creation.

Good governance, Khartoum governance should advocate *Hisba* institution and the role of *Muhtasib* as responsible for making sure that business is not harming the community to overcome the main issues of water in Khartoum, i.e., water shortage, which was mentioned above and water pollution, as most of the sugar factories were allocated on the bank of the river Nile, they disposed their wastewater directly into the Nile water. *Hadith* Prophet regarding the responsibility for all community members, this *hadith* could also help the Muslim community in Khartoum to promote water

governance. Cooperation among international river basin, mainly aimed to ensure the public interest among different nations who shared that water resource. In Islam the existence of concept of *Maslaha m'tabara,* which means that conserved public interest, and the right of flowing water, that means landowner within which the water is flowing has a right to use this water as *Haq al-majra*. The Nile classified under the large public river, based on the Islamic law, they belong to the entire community and everyone can benefit from them, providing no harm was caused to others. However, the reality indicates the absence of Islamic principles and concepts, this clear from the unfair allocation of Nile water. Moreover, according to the international treaties the river Nile countries are limited or mostly prohibit from using the river Nile water except for Sudan and Egypt. Although, all these countries are up-stream countries and the sources of Nile was originated from some of these countries. Sudan government should consider *Haq al-majra* and the concept of *Maslaha m'tabara* as motivation to ensure the fair share of Nile water among the riparian countries. And to recognize the meanings of *Fassad* principle, which include taking something unfairly.

Institutional development and building institutional capacity, equivalent concepts in Islam is *Itqan*, which used to determine the level of work quality, by means that to do work in a systematic and methodological way and it's also meant to achieve excellently. These concepts considered to be an opportunity for Muslims community in Khartoum formulate a proper strategic plan for water institution development, the *Itqan* concept will contribute to solve the issue of the bad conditions of the water network distribution system that leads to water leakages and bad water quality. *Ihsan* means to mind Allah in monitoring all Muslims performs. *Ihsan* principle will enhance the overall institutional development and capacity. Similarly, it will motivate Muslims in Khartoum to concern about the job description and specific qualifications for the employee, to avoid the

nepotism and corruption. Community participation, the community participation was appreciated in Islam evident by *Shura* principle in Islam consider as introductory for effective participation, which supported by Quran and *Sunnah* in Quran, Muslims described as those who conduct their affairs in consultation. Moreover, Prophet Muhammad (PBUH) consults his companions and His wife's, in many Muslims affairs, this could inspire the Muslims community in Khartoum to participate and also motivate the government to facilitate procedures for effective stakeholder's participation. Based on the reality Khartoum government does not recognize the *Shura* principle with Muslims in Khartoum regarding the water decisions and management.

Water resources assessment, Khartoum communities should benefit from *Tawhid,* which means that all natural resources including water are belongs to Allah and the human acts as guardians*,* to ensure wise utilization of water resources. And the principles of *Mizan* and *Fassad*, to maintain the equilibrium of Niles water as through the avoidance of industrial and residential waste dumping, which pollute the Nile water. Consequently its harm the society and the environment as well. The role of *Muhtasib* and *Khalifah* principle could enhance the attitudes and behaviors of Khartoum's community to conserve the Nile water from pollution and to control the groundwater through avoidance of the construction of septic tanks, which adversely affects the ground and surface water. Furthermore, *Khalifah* principle could promote the efficient use of water, despite Muslims per capita consumption of water is more than non-Muslim because of *Wudu* and *Ghusul* as well as the cleansing after the urination and defecation but this didn't entitle him to use water freely so, he/she obligated in Quran and *Sunnah* to avoid the excessiveness and to use water wisely. Water pieces, the objective of water prices is mainly to use water efficiently and to ensure the social equity through providing of water for all community segments especially the poor, in

Islam water consider as a human right according to *hadith* Prophet Muhammad that water should be shared among people. The Prophet encourages the provision of water for free as *Waqf*, so this will contribute to cover the remaining third of the Khartoum population.

Environmental impact assessment mainly focuses on the environment and the society, the concept of *Harim* as well as the Islamic principles that support the environmental conservation such as *Mizan*, *Khalifah, Fassad*, maybe considers as some measures to avoid the impact on the environment, regarding the society the precautionary measures used to protect the public health such as the prohibition of urination in the stagnant water and defecation in shady places. policymakers could benefit from the role of *Mohtasib* in order to formulate the EIA report because the monitor, assess and report of the change that may happen as a result of the business or development is allocated at the heart of his responsibility. For example in Khartoum the government should benefit from the role of *Mohtasib* to overcome the Nile water pollution from the Sugar factories. One of the most important purposes of formulating *Sharia* (Islamic law) is the public interest in life and hereafter, the notion of injury for people it's not permissible to injured the people it's clear from the Prophet's *hadith* on the authority of Abu Sa'eed Al-Khudree, that the messenger of Allah (PBUH) said: "There should be neither harming (Darar) nor reciprocating harm (Dirar)". So, IWRM implementation process will be supported by the Muslim community of Khartoum within their role as *Khalifah*, they could ensure the water conservation through the principle of *Tawhid*, *Mizan*, and *Fassad* in order to avoid the wastage of water which is prohibited according to *Mubazer* principle, and they will foster the provision of drinking water in affordable prices or in free to achieve *Waqf* principle. As the issues of water problems in Sudan are mainly due to poor management of water resources rather than

physical availability, however, Muslims can overcome these issues by considering Quranic verses and the Prophetic *hadith* as well as the basic principle of Islam.

5.4 Concluding remarks

Chapter five focused on the results and discussion it was designed based on the three research objectives. In order to explain how it was achieved through the key findings and discussion of each research questions. First, to investigate the feasibility of IWRM implementation in Sudan, especially in the context of the Khartoum state, thematic analysis indicates that the institutional role is a critical factor that impedes the IWRM in Khartoum.

The second objective was to identify critical factors that both drive and impede the implementation of IWRM in Sudan. SWOT analysis was used in order to achieve this objective, and it showed a comprehensive view of strengths, weaknesses, opportunities, and threats. However, the most important strength is the availability of laws and legislation in Sudan. And the poor water governance considers as the main weaknesses, majority Muslims of Khartoum population provides an opportunity to enhance the application of IWRM. Lastly, the vulnerability of conflicts about trans-boundary water resources is one of the key threats to the water resource management in Khartoum.

Last objective was to explore the socio-religious aspects of the Sudanese people that can enhance the implementation of IWRM, the results of thematic analysis showed that all framework sub-categories are equivalent to Islamic principles and concepts this indicates high potential of Islamic principle in improving the IWRM implementation process, based on the fact that Muslim community is predominant in Khartoum.

CHAPTER 6: CONCLUSION

This chapter concludes the thesis. Section 6.1 summarizes the key findings of the research based on the main three research questions. Section 6.2 describes how these findings could add value to the literature particularly that reviewed in Chapter 2. Section 6.3 discusses some of the main limitations of this thesis. Section 6.4 provides suggestions for future research and Section 6.5 recommendation for policymakers.

6.1 Key findings of the research

Based on the research questions first one, what is the feasibility of IWRM implementation in Khartoum? According to the key critical factors of IWRM. Despite the results, of this research indicated that the institutional role is the key factor that impedes the IWRM adoption in Khartoum, but the policy and legislation are very important and they could affect the entire elements of the IWRM framework consequently they impede the IWRM implementation process.

Second, what are the internal and external factors that affect the IWRM process in Khartoum, Sudan? The results of SWOT analysis indicated that the most factor that supports the IWRM application is the availability of laws and legislation in Sudan, however, the monitoring of water quality is critical as well because IWRM was used as means to achieve better water management.

Water legislation is the backbone, for the water resources, however, it needs to be improved and enacted. In addition to, that water institutions in Khartoum need a strategic planning and strict qualifications standers should be adopted, monitoring and accountability should be in place to enhance the issue of capacity building.

Lastly, what is the contribution of basic Islamic principles in the promotion of IWRM implementation?

Majority Muslims of Khartoum population, consider as an opportunity they can contribute to the IWRM application through their religious principles and guidelines, which are similar to the IWRM principles, however public awareness campaign about water resources management and Islamic principles especially those are related to water conservation are needed.

6.2 Contribution of the thesis

The using of the term 'feasibility', which has a variety of meaning, in this study was used to mean how can we enhance the reality of IWRM implementation in Khartoum?

The theoretical contribution was the modification of the GWP framework by selecting three sub-elements in each category, based on the most critical issues in Khartoum.

The water management from Islamic perspective was addressed by focuses on the IWRM in Islam by Aljayyousy (2001), but it differs from this study because he investigate the similarity between IWRM and Islam based on Dublin principle unlike this research that used the GWP framework for IWRM implementation. (Refer to **Table 6.1**).

The geographical scope of the case study, as it was clear from the review of the literature that considerable literature focuses on southern Africa countries with little or no studies about North Africa especially Sudan, Khartoum. Interestingly, the case study of Khartoum indicated that the IWRM implementation was very different even within the same scope such as Kenya and Egypt.

Empirical contribution for this research was the application of in-depth case study, in North Africa Sudan, Khartoum, and the triangulation of data sources. As Sudan is one of the MENA countries, which considered as the driest region on the planet. Moreover,

Khartoum has abundant water resources however the poor water management led to the water shortage and water pollution issues.

Analytical contribution, the combination of the thematic and SWOT analysis, and the design of thematic analysis presentation, which clarifies the convergence of the data sources, considered as a main purpose of the data triangulation.

Table 6.1: Possible research contribution over the previous research

Literature themes	**IWRM concept and implementation**	**IWRM in the Africa context**	**IWRM from an Islamic perspective**
Key literature review	Biswas, 2004; Van der Zaag, 2005; Merry, 2008;Gallego and Juizo, 2011;Gordiano and Shah, 2014, ; Chidimozdi and Muhandiki, 2017	Dungmaro and Madulu, 2003; Van der Zaag, 2005; Merry 2008; Galleo and Juizo, 2011; Chidimozdi and Muhandiki, 2017	Al-Jayyousi, 2001;Biswas, 2004; Hashemi, 2010
Literature gap	No clear framework synthesized for specific group or nation in order to enhance their application of IWRM.	Intensive literature about Southern African countries, with no or a few cases about the other parts of Africa.	A comparison between Islamic water management principles and Dublin principles.
Possible contribution of research	Formulation of the IWRM analytical framework by adding socio-cultural dimension.	Case study of Khartoum Sudan as a North-East African country.	Analyze the potential of Islamic principles by using the analytical framework of IWRM application. The proposal of Islamic IWRM framework.

In addition to that, this research proposed an Islamic IWRM framework (See **Figure 6.1**) by using the Islamic principles and concept that emerged from the investigation of the potential of the Islamic principles in IWRM implementation. That it can be used as guiding elements for IWRM implementation in a Muslims majority countries in order to enhance their water management and enable them to achieve the sustainability of water resources.

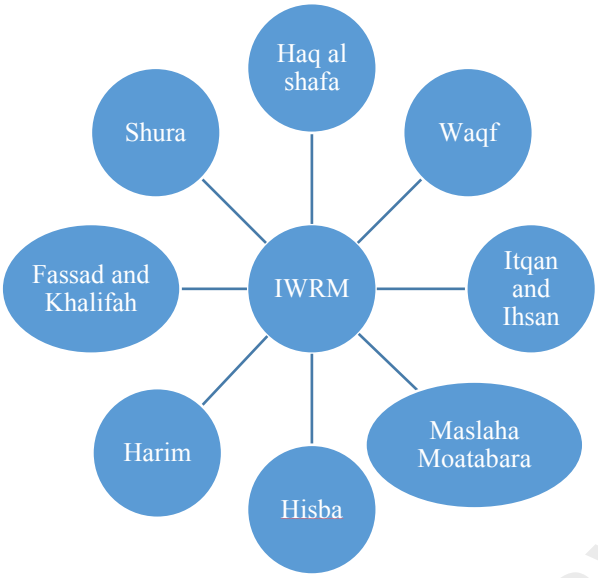

Figure 6.1: Proposed Islamic IWRM framework

6.3 Limitations of the research

The findings in this research are subject to at least three limitations. First, the time limitation: the researcher conducts the interview and public survey in Sudan, for three months during the study session.

Second, difficulties to access water resources data such as documents, maps, and figures, and also the selection of the interviewee, which is based on the issues the researcher take time to get the respondent who willing to participate in the interview sessions.

Third, as this study has been started in 2012 therefore the researcher used the GWP framework which is consist of three Pillar based on the sustainability agenda, knowing that in September 2015 the sustainability agenda was updated, with announcement of the Sustainability Development Goals (SDGs), the new sustainability framework

consists of four pillars, the previous three pillars, and the fourth one is the peace and security pillar (Al Saidi, 2017).

Finally, the time and financial limitation hindered the researcher to include and evaluate other cultural aspects of Sudanese that affects the IWRM implementations.

6.4 Avenues for future studies

Based on the limitation of this study, further research could be undertaken in the following areas:

a) A comprehensive study to evaluate the IWRM implementation challenges in Sudan by using the new sustainability framework.
b) Comparative study of IWRM drivers and barriers in Sudan.
c) A comprehensive study on the influence of ethics and cultures of Sudanese people on IWRM implementation process.

6.5 Recommendation for policy makers

From the results of this study full enforcement of laws and legislation, adequate formulation of water policy and legislations. That concern with water management, which concern with public participation, water rights, water prices, and it should contain restrict rule for the issues of standers of water quality. Water pollution and extensive abstraction of groundwater as well as EIA report for the project that impact the human and the environment. These factors are critical for better water resources management in Khartoum, Sudan.

Water institutions needed some improvement, in terms of effective framework and strategic planning, regarding the human resources should be qualified and they should in a right position of the job description, moreover they should be involved in frequent educational sessions and training programs. Critical improvement was needed for water

resources data and information system, especially the quantitative data about the water pollution in Nile water. Moreover, it should be accessible for research and other purposes.

Considerable attention was needed for the local community involvement to ensure the successfulness and sustainability of water development projects through the formulation of proper procedures to enabling them to participate effectively, in all water management phases.

Raising awareness for Muslims about the Islamic principles that related to water management is critical for effective contribution in IWRM application.

6.6 Concluding remarks

Chapter six conclude the research and it also highlights the contribution of this research as an in-depth case study for one of the North African countries utilizing the analytical framework, and it proposed an Islamic framework for IWRM implementation.

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