UNIVERSITY OF SOUTHERN QUEENSLAND

Developing and Framing Water Policy For Sustainable Water Security In Agriculture In The Jefara Region Of Libya

A dissertation submitted by:

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ABSTRACT

Water sustainability is a priority issue for Libya. The country has limited water supplies, a problem compounded by the increasing demands of population growth. This research examines the challenges faced by policymakers in formulating effective water resource management strategies in agriculture and the potential impact of these policies upon farmer viability with the purpose of ensuring sustainable water security in agriculture in the Jefara Plain region of Libya.

In response to the research problem, the research question was defined as: ***How can farmers and policymakers engage with each other to understand the key issues to facilitate more sustainable water policy?*** The research objectives were to examine current Libyan water institutional frameworks and water management policies and investigate the interrelationship and engagement of the major stakeholders. The study was aimed at exploring the potential to improve water use efficiency in agriculture in the Jefara region and provide insights into how water saving and a more efficient water policy framework could improve water sustainability.

A qualitative research design with grounded theory methodology was chosen to explore the views of the participants in relation to sustainable water security in agriculture in the Jefara region of Libya. The information gathered from interviews and observations was classified, abstracted and interpreted, and compared to secondary data and the literature to develop a model firmly grounded in the data. Face to face interviews were integral to the research methodology, using open-ended and close-ended questions in a semi-structured interview framework. Two groups of subjects were interviewed as the units of analysis: policymakers, as represented by the managers and staff of water-related authorities, and farmers from the Jefara region.

Analysis of the data revealed water use efficiency and farmer viability to be important variables in the study. The findings indicated that the ideal model for sustainable water security would take farmer viability into account in the attainment of the maximum level of water use efficiency. A key outcome of this research has been the development of a draft model, strongly supported by the research analysis and results, to effectively facilitate the development of an efficient water policy for sustainable water security in agriculture in the Jefara Region of Libya.

The research has made a significant contribution in formulating a constitutive and theoretical water policy framework to enable policymakers to develop a powerful and rational water policy. An examination of the assumptions underpinning policies and the uncertainties affecting agricultural water supplies has also established the improvement of the capacity for the management of current and future risks related to water security as a priority in the Libyan context.

CERTIFICATION OF DISSERTATION

I certify that the ideas, results, analyses and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

…………………………………………………………….	26 / 08 / 2013
Signature of Candidate	Date

ENDORSEMENT

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Signature of Principal Supervisor	Date

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Signature of Associate Supervisor	Date

DEDICATION

With my deep emotion to all who have believed in me:

The spirit of my father,

for his kindness, sacrifices and material and moral support to the last day of his life

My mother,

whose love, care and desire was to see me educated up to highest levels, for her life-long unconditional love, prayers, tireless encouragement and her deep faith in scientific research despite her own illiteracy

My wonderful sister and brothers,

for their advice, assistance and unfailing support

My wife,

for her patience, unyielding support and tireless and absolute dedication during my PhD journey

My children,

the source of so much love and joy, for their patience and understanding of my research commitments and the time spent away from the family

My relatives and friends,

for their continued encouragement

Their understanding and support made this research possible. I hope that my dedication of this thesis to them will show my gratitude and acknowledge the sacrifices they have made on my behalf during the course of this research.
May Allah bless and reward them all

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My great gratitude goes to my country, Libya, for awarding me this scholarship to undertake the doctoral degree and for everything it has given me during my life. I am very proud to be Libyan. I would like to express my thanks to the Faculty of Economics & Political Science in Alaziziyah for nominating me for a scholarship to enable me to undertake this research. In this context, I am very grateful to all those people and organisations that provided me with valuable information and data, and assisted me in data collection. I am very appreciative of the way in which the research participants freely gave up their time and contributed so positively to the research and the generosity of the water related organisations, such as the Authority for the Utilization of Jabel Hasawna - Jefara Water System and the Authority of Implementation and Management of the Great Man-made River Project, the General Water Authority and the Ministry of Agriculture, in assisting me access necessary information that I could not have accessed on my own.

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LIST OF ABBREVIATIONS

AIMG	Authority of Implementation and Management of the GMRP
AOAD	Arab Organization for Agricultural Development
AUJHJWSG	Authority for the Utilization of Jabel Hasawna - Jefara Water System of the GMRP
FAO	Food and Agriculture Organization
GCWD	General Company of Water Desalination
GMRP	Great Man-made River Project
GWA	General Water Authority
GWSSC	General Water Supply and Sewage Company
JHJWSG	Jabel Hasawna - Jefara Water System of the GMRP
JPR	Jefara Plain Region
LYD	Libyan Dinar
MEWG	Ministry of Electricity, Water and Gas
MOA	Ministry of Agriculture
NCBMM	National Consulting Bureau and Mott MacDonald
NENAR	Near East / North Africa Region
NGO	Non-Government Organizations
RQ	Research Question
UN	United Nations
UNDP	United Nations Development Programme
USQ	University of Southern Queensland
WUE	Water Use Efficiency

1.0 CHAPTER ONE: INTRODUCTION

1.1 Introduction

Water is life. Every human, animal and plant on this earth needs water (YUNGA 2013). This was the Youth and United Nations Global Alliance's (YUNGA) message to the teachers and youth leaders as the UN designated 2013 as the International Year of Water Cooperation and called for action to share the precious resource of water fairly and sustainably in the world. This study had already commenced research in this direction, as while the spectre of water scarcity looms in many areas of the world, the risk is an acute and present reality in Libya (Fedra 2004). Here the pressing problem of water scarcity is further compounded by seawater overlapping, which has led to significant environmental and groundwater pollution and the deterioration of the quality of groundwater resources all along the Libyan coastline (LG 1999). While the country's experience in the field of the providence and management of water resources is a rich one, it has been costly and not devoid of failure.

This chapter is the first stage in a journey searching for sustainable water security in Libya. It begins with an overview of the research background and the dimensions of the problem, and goes on to formulate the problem in the main research question and lays out the research objectives. Here, the researcher's motivations for conducting the research are also expressed to highlight the personal significance of the study. The scope and delimitations of the research are then determined and a summary of the methodology to be followed in conducting the research is presented. Lastly, the structured approach of the thesis is presented graphically, showing the chapter organisation.

1.2 Background to the research

The Near East/North Africa Region (NENAR) is made up of 14 countries including Libya *(See Appendix A)* (FAO 2006). The total amount of available water in NENAR is estimated at 500 m^3/yr/per person while globally the average is almost 7000 m^3/yr/per person (FAO 2006). Libya has limited water supplies and an unfavourable geographic distribution relative to human population. Water shortages are compounded by increasing demand due to population growth, and thus water sustainability is a priority issue for Libya (Fedra 2004; UNPD 1994).

Presently groundwater supplies 95% of Libya's needs (Wheida & Verhoeven 2007a). Current groundwater extraction in Libya is 130% of the recharge rate, compared to an average of 63% in the NENAR and a global average of less than 9% (FAO 2006). Over-extraction in Libya has led to a severe decline in groundwater quality and availability and is not sustainable in the long term (European Commission 2009; FAO 2006). In comparison with the NENAR and worldwide trends, water use in agricultural irrigation in Libya is inefficient and substantial improvements could be made (Lawgali 2008; Wheida & Verhoeven 2007a). Metering and water pricing mechanisms are inefficient and there is no clear future water pricing policy (Wheida & Verhoeven 2007a).

Given the large investment in the Great Manmade River Project (GMRP) [(1)] and the current inefficiencies that exist in water use in the agricultural sector, the largest user of water in Libya, measures need to be taken to improve water use efficiency (WUE) (Lawgali 2008), and thus extend the life of the GMRP as far as practical. This research explores the relationship between farmer attitudes and the perceptions of GMRP authority policymakers and examines the impact this has on policy formulation and implementation. The findings could feasibly help reform and frame water policy, ensure water flow sustainability and improve farmer performance in the Jefara Plain Region (JPR) [(2)].

1.3 Dimensions of the problem

The acute water crisis in Libya and its future evolution threatens all aspects of life (GPC 2003). The arrival of GMRP water to northern areas of Libya, without an integrated and overarching water policy for the agricultural sector, has led to irresponsible and unwise use of huge quantities of water (Wheida & Verhoeven 2007a; Zidan 2007). According to the World Bank standards, the best practice of physical and economic performance of water sector in Libya is in the physical health of water infrastructure and smoothness of water transfers across sectors / regions / users. However, despite the development of infrastructure in the public and private sectors, Libya is failing to achieve acceptable levels of performance (Ferragina, Marra & Quagliarotti 2002).

[(1)] A project designed to transfer water from huge freshwater aquifers in the south to the northern residential and agricultural areas of Libya. The project will be discussed in detail later in Chapter Two.

[(2)] JPR is located in the north-west territory of Libya and will be described in more detail later in the "Research scope and delimitation" section.

Since the GMRP has been nearing final construction, the sustainability and efficient use of water resources has increasingly become an important field for researchers and a priority for Libyan policymakers. However the impact of groundwater management and water policies is an important issue among the people, especially those who rely heavily on water for their livelihood.

Farmers are immediately affected by water scarcity, as it directly affects farming methods. A water decrease does not only affect crop production but the source of farm energy as well, especially where there is inadequate access to utilities and infrastructure, a common condition for farmers in less developed and developing nations. This research thereby looks at designing a study to investigate farmers' attitudes towards water scarcity and the water efficiency models farmers use in irrigation. From this point, the study was directed at examining the challenges policymakers' face, not only in terms of coming up with effective water resource management strategies but as to how these policies take the opinions of farmers into account. This study provides insights into measures that could improve the GMRP water use sustainability.

1.4 Research question and objectives

According to the research problem, the following research question has been formulated:

- ✓ ***How can farmers and policymakers engage with each other to understand the key issues to facilitate more sustainable water policy?***

As the GMRP nears final construction, the sustainability and efficient use of water resources is increasingly becoming a priority for Libyan policymakers. The research focuses on the impact of water management policies on water scarcity and WUE.

Therefore, the research objectives are to examine the current Libyan water institutional frameworks and water management policies. This enables the exploration of the ability to improve WUE in agriculture in the JPR and to provide insights on how water saving and a more efficient water policy framework could improve water sustainability in the Libyan agricultural sector.

The research examines the challenges faced by policymakers in terms of formulating effective water resource management strategies and the potential impact of these policies upon farmers' viability. The research also considers farmer attitudes towards water scarcity and WUE, their interaction with policymakers and their response to proposed management strategies. As there has been only limited previous research in this areas, the level of consideration policymakers give to the opinions of farmers, and how this is factored in to the formulation of water policies, should also be investigated (Laamrani & Salih 2010) as politicians worldwide are known to treat water as a low policy priority.

1.5 Motivation

This research develops a theoretical framework for water management policy in the JPR which would optimise economic and social outcomes. It examines the assumptions underpinning policies and the uncertainties affecting agricultural water supplies, so as to improve the capacity for management of current and future risks in the Libyan context.

As a Libyan national, this researcher has been exposed to water scarcity as a part of everyday life. This motivates his commitment to making a contribution to a more sustainable water supply in Libya. Improved sustainability is essential in the agricultural sector to facilitate long term security of food and underpin the infrastructure of the economy. The gaps in the literature, due to limited research in the Libyan context, stimulate the researcher to help policymakers in framing water policy for JPR of Libya. Given that the JPR is typical of other agricultural areas in Libya (Eur 2003), it is anticipated that this framework will have national policy implications.

1.6 Research scope and delimitation

The study has been conducted in the JPR of Libya. The JPR is located in the north-western territory of Libya, covering a triangular area of approximately 20,000 km^2 *(See Appendix B)*. It is a bounded in the north by the Mediterranean Sea, the Tunisian border on the west; and on the south by a line running from the foot of Nefusa Mount on the Tunisian border to Homes, a coastal city on Mediterranean to the north-east of the capital Tripoli (GWA 2006). The population of the region was estimated at 2.66 million in 2000 (CPPAP 2003).

The highest population density and the largest industrial and agricultural activity in Libya are concentrated in the JPR. Accordingly water deficit was always the greatest in this region (LG 1999) and the highest agricultural water use was found in this region as well (Wheida & Verhoeven 2006) which exceeded the security drawing borders by 4.6 times [(3)]. Conditions on JPR are representative of the agricultural practices and water scarcity issues affecting Libya (GAFI 2007) and the region is of great interest to the Government. It is the site of Jabel Hasawna-Jefara Water System of GMRP (JHJWSG) (Phase II), with more than 67% of the water supplied devoted to agriculture (GMMRWUA 2010).

[(3)] More details about water deficit in JPR are in Chapter Two, section "Inefficient water use in the Jefara Plain Region and suggested plans".

Information collection is manageable and practical. The JPR has three types of farms, with ownership by the public, private or foreign investor sectors (GMMRWUA 2010). The research conducted interviews and collected information from a sample of farmers from each type of farm which uses waters of the JHJWSG. Water policymakers, managers and staff of the Authority for the Utilization of Jabel Hasawna - Jefara Water System of the GMRP (AUJHJWSG), the Authority of Implementation and Management of the GMRP (AIMG) and Ministry of Agriculture (MOA) are also included in the sample frame to better investigate the issue from different points of view (Neuman 2006). Libya is typical of most NENAR countries in having a Mediterranean climate. As the composition of the population in Libya is very similar in culture, religion, ethnicity, customs and traditions to other NENAR countries, the JPR represents an ideal area for the research. The findings could promote understanding or inform practice for similar situations (Leedy & Ormrod 2005).

1.7 Overview of research methodology

The research relies on the grounded theory method to highlight and determine a set of relationships that explain people's attitudes, behaviours, actions and interactions, and the pattern of events associated with the research problem. Grounded theory methodology reflects the source of the developed theory which is ultimately grounded in the behaviour, words and actions of those under study; it is grounded in data which have been systematically obtained through 'social' research (Goulding 2002, p. 40).

The qualitative approach was identified as the most appropriate for conducting this research as it would be able to measure farmer characteristics and circumstances and policymaker perceptions and explore the issues surrounding WUE and policy in agriculture in the JPR of Libya. The qualitative approach would be able to provide rich insights into the nature of a problem. A qualitative approach enables the discovery of problems existing within a phenomenon, assisting with the interpretation of information and the gaining of new insights to develop new concepts or theoretical perspectives about the phenomenon under study (Leedy & Ormrod 2005).

The population sample is located in the areas which use the water of GMRP in JPR. It is divided into: members of authorities related to water and members directly linked to farming and irrigation works in the public and private agricultural sector, including foreign investors in agriculture. A non-random purposeful sampling approach was used to select a sample of appropriate members from the authorities related to water and participants from the foreign investors in agriculture and the public agricultural sectors. The population elements in the private sector were divided into six homogeneous parts. Stratified random sampling was thus chosen as the best technique to select a sample from the private sector.

The primary sources of the information came from the interviews and observations. As a strategy for qualitative information collection, the use of semi-structured interviews with open and close-ended questions enabled clarification of and a deeper insight into participant responses and reasoning. Primary observation methods generated understanding and new knowledge about the way of life of the people associated with the study and their ways of thinking, behaviours, actions and interactions in relation to the research problem. Secondary data was gathered from databases, documents, audiovisual and graphic materials, reports and historical records of the AUJHJWSG, AIMG, GWA and MOA.

Analysis of interview responses and observation in this research focused initially on data reduction, data display and conclusion drawing and verification as identified by Miles and Huberman (1994). The secondary data was summarised and documented to use as a means of triangulating findings based on other data and information collected through observations or the interviews. Miles' (1994) matrices were useful to display reduced information drawn from the word processed text. Content analysis was used to capture policymaker experience and farmer opinion and attitude toward water scarcity. A narrative analysis was needed as a complementary means to explore linkages, relationships and socially constructed explanations that naturally occur within narrative accounts to analyse the data and information (Saunders, Lewis & Thornhill 2009).

Corbin and Strauss's (2008) coding techniques were useful in this context, since open coding identified the characteristics of each concept, and enabled similar concepts to be grouped together in categories as constructs in a grounded theory. The initial conclusions were drawn through making comparisons and contrasts, and clustering and counting the identified patterns and relationships. The use of grounded theory techniques to interpret recorded data and information was needed in the analysis to emerge a theory from the process of data and information collection.

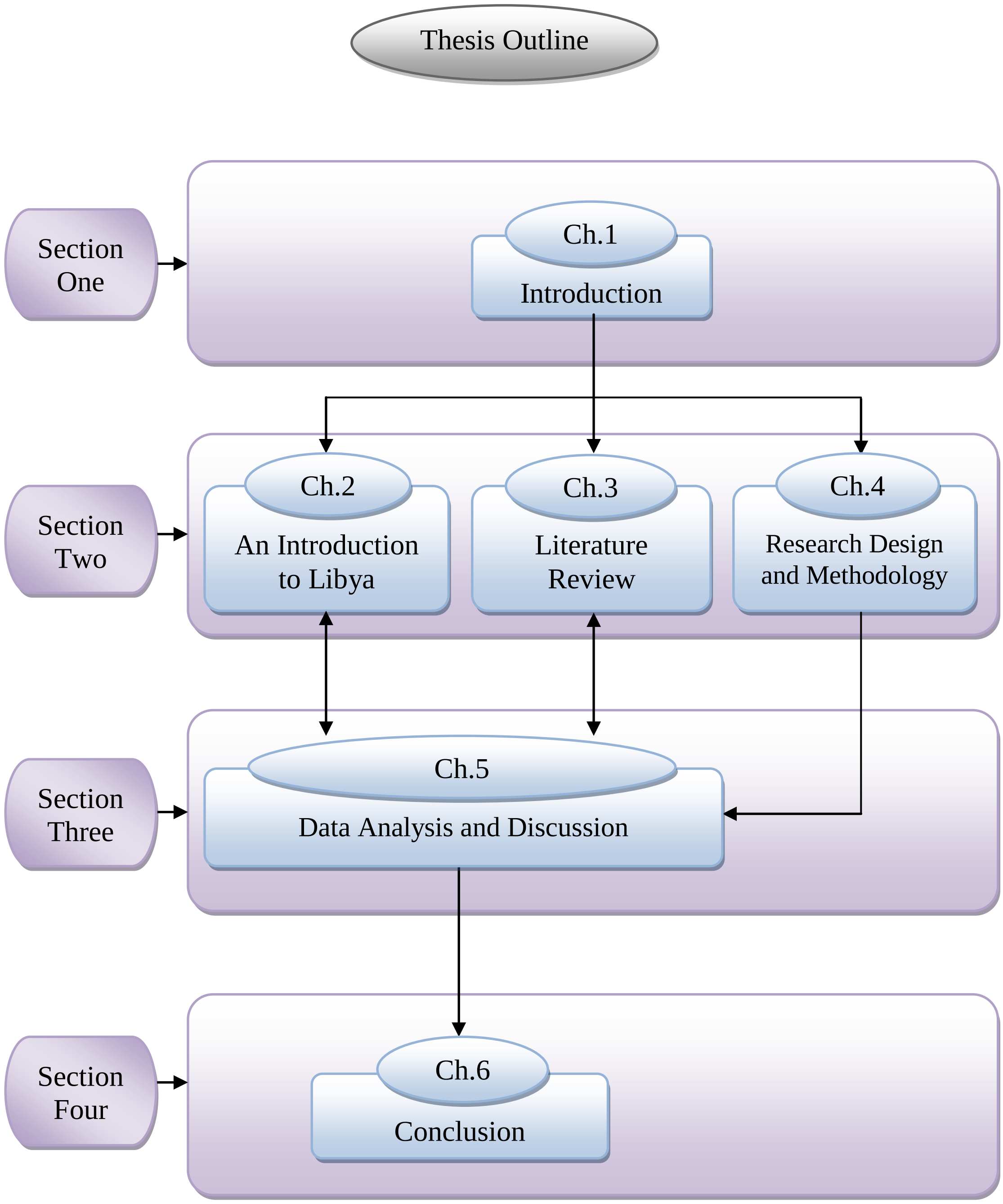
1.8 Thesis structure

The thesis is organised into six chapters covering four sections: an introduction to the research area; theoretical discussions of the research problem, the literature and the research methodology; analysis and discussion of the research data; and an overview of the research findings and implications *(see Figure 1.1)*.

The first section, Chapter One, the *Introduction*, establishes the context for the research by providing background information about the dimensions of the acute water problem in Libya and the need and motivations for the research to be undertaken. The chapter establishes the research problem and defines the research question, clearly stating the research objectives as well as identifying the research scope and delimitations and providing an overview of the proposed research methodology.

Chapters Two-Four comprise the theoretical section of this thesis. Chapter Two, *An introduction to Libya and the case study region*, examines and evaluates water resources management and water infrastructure in Libya using information obtained from databases, reports and documents from the Ministry of Agriculture and the Water Authorities related to water policies, economic and social factors, and the physical environment.

Figure 1.1: Structure of the thesis



Chapter Three, the *Literature Review*, explores the existing literature and the current debate about water management policies and the factors affecting their formulation and implementation in the arid and semi-arid zones of Libya and the NENAR countries. Relevant and significant experiences of other countries in the world facing similar challenges are also considered as well as relevant prevailing theories, ideas and opinions concerning the issues of water scarcity, conservation and management.

Chapter Four, *Research Design and Methodology*, outlines the research design and develops the methodology for undertaking the research. The research questions have been formulated to attain the research purpose through the answers given to these questions. The strategies, techniques and approaches undertaken to achieve the goal of theory building are outlined in this chapter. Components of the study population and the methods of sampling are introduced, with the analytical techniques presented in detail in the last section of the chapter.

Chapter Five, *Data Analysis and Discussion*, represents the analytical section of the thesis and provides an overview of the demographic and personal characteristics of the targeted participants. The chapter analyses the information and data gathered in relation to the research questions, discusses the categories, themes and concepts of the responses to each research question, and reports the research findings.

Chapter Six, the *Conclusion*, Section Four in the thesis provides an overview of the whole study, summarising the results and drawing the practical implications of the research. Contributions to the literature and practice are highlighted as well as the limitations of the research. The chapter also draws attention to a number of topics needing to be explored and gaps in the literature needing to be filled as a result of the research findings.

1.9 Summary

The water scarcity problem in Libya is compounded by a number of factors including: increasing demand due to population growth; over-extraction leading to a severe decline in groundwater quality and availability; the inefficient use of water in agricultural irrigation; and the absence of a clear mechanism for water pricing and its value collection. Poor performance, in terms of water usage and the absence of integrated and overarching water policy for the agricultural sector, has led to irresponsible and unwise use of huge quantities of GMRP water in agriculture. The sustainability and efficient use of water resources has increasingly become a priority for Libyan policymakers and people who rely heavily on water for their livelihood such as farmers.

Exploring the engagement between farmers and policymakers would enhance the understanding of the key issues in the search for sustainable water policy. It should enable the achievement of such research objectives as: examination of the current Libyan water institutional frameworks and water management policies; examination of the challenges faced by policymakers in terms of formulating effective water resource management strategies and its impact upon farmers' viability; and consideration of farmer attitudes towards water scarcity and their interaction with policymakers. The significance of the research problem for water security in Libya, has motivated the researcher, a Libyan national, to make a contribution through undertaking this research aimed at gaining a more sustainable water supply and helping policymakers to frame water policy for the JPR in Libya.

The JPR represents an ideal area for the research as the region not only has the highest population density and the most productive agricultural activity in Libya, but the greatest water deficit as well. Consequently, the region is of great interest and concern to the Government. For research purposes, the JPR's location near the coast in north western Libya would allow manageable and practical information collection.

Grounded theory methodology has been chosen as the most appropriate for the research as it reflects the source of the developed theory ultimately grounded in the information and data collected. A qualitative approach would provide an overview of farmer characteristics and circumstances and policymaker perceptions and allow for an exploration of the issues surrounding the research problem. The sample of participants has been taken from the population located in the farms which use the water of GMRP in JPR as well as policymakers, managers and staff of the authorities related to water management. The primary sources of the information are the interviews and observations, with secondary data gathered from databases and documents of the AUJHJWSG, AIMG, GWA and MOA.

2.0 CHAPTER TWO: AN INTRODUCTION TO LIBYA AND THE CASE STUDY REGION

2.1 Introduction

This chapter will examine and evaluate water resources management in Libya using information from databases, reports and documents from the Ministry of Agriculture and the Water Authorities related to water policies, economic and social factors, and the physical environment. The information from these secondary sources will enable the research to clearly identify the context of the case (Leedy & Ormrod 2005).

Information about the current state of water institutional frameworks, water infrastructure and water management policies in Libya will enable the research to identify and evaluate a range of options for improving WUE in agriculture and the potential role of water pricing in achieving sustainability. The overview of the existing water infrastructure will provide theoretical answers to the first and second research questions. It will allow the research to identify the combination of physical and organisational activities integral to water resources management and which support physical, economic, environmental and social human activities (ASCE 2009).

Local problems and socio-economic aspects must be considered when addressing the research issues (Araus 2004). The research will begin with an overview of the geography, climate and population of Libya, as well as the political and economic systems and the agricultural sector. In order to assess the current water situation in Libya, the water infrastructure will be examined through a review of the water legislation, its institutional framework and the infrastructure surrounding the various water resources. The national strategy for the management of water resources and the suggested plans to address the inefficient use of water in the JPR will be discussed. The last section will be devoted to the GMRP and water investment in JPR's agriculture, and will conclude by identifying the problems and obstacles facing the outcomes for these investments.

2.2 Geographic and demographic aspects of Libya

Libya is located in northern Africa, lying between Latitude 22°-32° North and Longitude 10°-25° East (Otman & Karlberg 2007) on the southern border of the Mediterranean Sea. Most of the population is concentrated along the 1770 km long coastline, with the capital Tripoli to the north-west and the second largest city and seaport, Benghazi, to the northeast (CW 2001b). With a total area of about 1,759,540 km^2, Libya shares common borders with Egypt and Sudan in the east, Chad and Niger in the south, and Algeria and Tunisia in the west (*See Appendix B*) (CW 2001b). The landscape is dominated by the low-lying and barren, rock-strewn plains and sand dunes of the Sahara desert, with two small areas of hilly land, rising to about 900m, in the northwest and northeast (FAO 2012c). A mild Mediterranean climate prevails along the coast, in contrast to the dry, extreme desert climate of the interior. The Ghibli, a hot and dry dust-laden southerly wind blowing from the interior and accompanied by dust and sand storms and large temperature fluctuations, can last for one to four days, more often in spring and autumn (CW 2001b).

About 95% of Libya is desert, with only 1.2 percent, about 2.2 million ha, able to be cultivated (Aquastat 2006). The country has four distinct regions: the northern coastal plains with dry summers and relatively wet winters; the Northern mountains close to the coastal plains, including Nafusah to the west and Akhdar to the east, with higher rainfall and humidity, as well as low winter temperatures and snow at higher altitudes; and two areas of desert lands, the interior depression, including several oases, and the Southern and Western mountains with a very hot and dry climate, large daily temperature variations and very scarce and irregular rainfall (Aquastat 2006).

With about 93% of Libya’s land surface receiving less than 100mm/year rainfall, desertification and the very limited natural fresh water resources are current and significant environment issues in Libya (CW 2001b). The average annual rainfall for the whole country is only 26mm. Rain usually occurs during the winter season, but varies greatly from place to place and from year to year. The highest falls are recorded in the Jabal Nafusah, Jabal al Akhdar and JPR regions, making them the only areas of the country exceeding the minimum value of 250-300 mm considered necessary to sustain rainfed agriculture (Aquastat 2006).

The total population of Libya reached 5,673,031 in 2006, including some 349,040 non- Libyans (Otman & Karlberg 2007). The median age was 24.5 years (CW 2012), and the ratio of males to females 1.03:1 (Otman & Karlberg 2007). While only 13% of the total Libyan population were rural in 2004 (Aquastat 2006), it had risen to 22% in 2010 (CW 2012). Already in 1995, 75% of the population was concentrated in just 1.5% of the total area of the country, with 54% living in the JPR and Misratha region of the western coast. By 2002, 72% of the urban population and 68% of the rural population had access to improved drinking water sources, with 97% of the urban population and 96% of the rural population having access to improved sanitation services (Aquastat 2006).

Around 97% of the population is of Arab and Arab-Berber ethnicity, with 3% from various ethnic groups, including Greek, Maltese, Italian, Egyptian, Pakistani, Turk, Indian, and Tunisian. The official language is Arabic, with 97% of the population Sunni Muslim (CW 2012). With a population growth rate of more than 3% annually, Libya is one of the 26 countries in the developing world whose population could conceivably double in the next 25 years. Higher rates of population growth result in increasing expenditure on non-productive services such as education, health, housing, utilities, and social security, thus there is a need for development policy makers to prioritise expenditure on education and human resource development as a basis for long-term prosperity (Otman & Karlberg 2007).

2.3 The political system

The Ottoman Turk administration of Libyan territory was supplanted by Italy in 1911 (CW 2012). The Italian colonisation of the Libyan provinces of Tripolitania and Cyrenaica, however, was never wholly successful because of armed Libyan opposition (Otman & Karlberg 2007). Following their defeat in World War II, Italy relinquished its hold in 1943, with Libya placed under United Nations (UN) guardianship (CW 2012). The British and French shared control, with British military governments established in Cyrenaica and Tripolitania, and the Fezzan region administered by the French military (Otman 2007).

Libya achieved its independence from Italy and the Allies on 24 December 1951. As a result of his social, economic and political influence, his legitimisation through Islam and his critical role in resisting Italian colonialism, Idris Al-Sanusi became King of Libya (Otman & Karlberg 2007). The newly independent country faced many problems. Libya had a lower per capital income than any other state in the Middle East, a very high birth rate, marginal or sub-marginal land, scarce and irregular rainfall and frequent droughts, an absence of mineral and fuel resources, and, critically, a lack of skills and education, in addition to the devastation caused by WWII and the struggle to achieve independence. The UN consequently formulated a wide-ranging aid plan for the economic and social development for Libya.

For a fee, the new Libyan Government granted rights to the United States (US) and the United Kingdom (UK) to establish air force bases in eastern and western Libya, giving the country an additional annual income to supplement the financial and economic assistance provided by the UN plan (Otman 2007). The Suez Crisis in 1956, however, led to nationalist agitation in Libya undermining Western prestige in the region. The pressure of Arab nationalist opinion opposing the use of any troops based in Libya against Egypt, led to political objections from the Libyan government ensuring that the British were unable to deploy their forces in Libya in the conflict. The later Israeli-Egyptian war of 1967 led to even more insistent demands for Libya to break military ties with the US and Britain. The discovery of extensive oil resources in Libya in 1959 further undermined the British and US position, as well as the legitimacy of the monarchy. Libya was no longer dependent on foreign financial support, and contrary to popular expectations, the monarchy had failed to enact reforms and deliver a better life. At the same time, the new oil money encouraged a culture of corruption in the Libyan administration.

In 1969 the king was 79 years old and seemed increasingly disinterested and remote from governance and his royal responsibilities (Otman & Karlberg 2007). There were widespread reports of his failing health and imminent abdication in favour of his nephew, the Crown Prince. On 1 September 1969, while Idris was out of the country, a group of young military officers under the lead of Colonel Muammar Gaddafi launched a bloodless coup. They abolished the monarchy (Otman &

Karlberg 2007) and established a directorate of twelve, the Revolutionary Command Council (RCC). Gaddafi's initial role was as Chief of State but he soon began to espouse his own political system (CW 2012).

Gaddafi replaced the Parliament with a General People's Congress and the Council of Ministers with a General People's Committee. The Head of Parliament was replaced by the Secretary of the General People's Congress and the Head of Government by the Secretary of the General People's Committee (CW 2001b). The ministries were renamed as People's Committees, with the head of each ministry titled a Secretary, as for example, the Secretary of the General People's Committee for Agriculture, Economy, Health, or Education (CIA 2012). Although the country was in theory governed by the populace through representative local councils, it was in practice controlled by a military dictatorship (CW 2001b).

Gaddafi encouraged his fellow Libyans to commit to the ideals of a new and politically engaged society. The power of the masses was to be exercised by popular committees responsible for local and regional administration to be established at various levels and in different segments of the population, such as in regional localities, government ministries, businesses, and universities. People's Committees were set up all over Libya. While, in theory, the committee members were democratically elected, in practice, both the elections and the exercise of authority were "guided" by the General People's Committee. The whole structure was controlled by a concentration of handpicked military officers, revolutionary converts and adherents, and supporters of Gaddafi's own political ideology in government posts, thus enabling the establishment of a dictatorial regime. Although technically appointed by the General Popular Congress at its annual meeting, the General People's Committee was in effect selected by Gaddafi himself (CW 2001a).

Gaddafi's system of government, the Jamahiriya, was notionally based on the decisions and recommendations made by the Basic People's Congresses to the General People's Congress, and then submitted as a comprehensive report to different People's Committees to work on their implementation (OBG 2008). Taking increasing control of the country, Gaddafi used oil funds during the 1970s and 1980s to promote his ideologies outside Libya (CW 2012). The country became involved in various activities and alliances in opposition to the western international community and its interests, which ultimately led to the squandering of Libya's wealth.

The UN sanctions imposed on Libya in 1992 following the downing of the Pan Am Flight 103 over Lockerbie in Scotland, isolated Gaddafi politically. During the 1990s, he began to rebuild his relationships with Europe. The UN sanctions were suspended in April 1999 and finally lifted in September 2003 after Libya accepted responsibility for the Lockerbie bombing (CW 2012). Poor governance, however, in Libya led to the deterioration of economic conditions, poor services in various sectors, widespread unemployment and the suppression of freedoms.

Since the late 1970s, all aspects of the political regime had been penetrated by a nebulous body of civilians belonging to the Revolutionary Committees' Movement. Intensely loyal to Gaddafi, they played a significant role in shaping Libyan politics, especially at the domestic level. Initially established by Gaddafi to supervise the People's Committees, the Revolutionary Committees rapidly began to dominate the political life of the country, developing a broad power-base within Libyan society. Intent on eliminating any opposition to the regime, they worked for the suppression of internal dissent and the physical liquidation of any symbols of dissent and leaders at home and abroad. Their permission was necessary recruitment in all sensitive sites affecting regime security (Otman & Karlberg 2007). The power and influence of the Revolutionary Committees was later reinforced by three official security services: the internal security service, the external security service, and the security battalions. In contrast to the wider role of the official military and the civilian police in Libyan society, the focus of the Revolutionary Committees was to ensure regime security.

One of the Arab Spring popular uprisings, the Libyan revolution erupted on 17 February 2011 and quickly spread to several Libyan cities. On 5 March 2011, a Transitional National Council (TNC) was formed in Benghazi with the stated aim of overthrowing the Gaddafi regime and guiding the country to democracy. On 23 October 2011, the TNC officially declared Libya liberated following the defeat of Gaddafi's security battalions remnants in their last stronghold and Gaddafi's death.

2.4 The economic system

Despite the presence of significant gas and oil deposits in Libya and the potential for prosperity, the economy under Gaddafi has been characterised by poor governance and mismanagement. On coming to power in 1969, Gaddafi had claimed that economic independence and equity could only be attained through massive state intervention, in other words through socialist practices. The new Government consequently undertook a policy of nationalisation of the private sector, and, as of 1975, the state had taken control of virtually all economic domains. Until the mid-1980s, the Government placed numerous obstacles in the way of private sector development. All enterprises run by workers' committees did not accept economic efficiency or profitability as valid objectives, which made effective management almost impossible (CW 2001a, 2001b).

This led to an increasing reliance on the oil sector and the deterioration of other sectors. Since the lifting of the UN and US Libya-specific trade sanctions in 2003 and 2004, the government has pursued a series of reforms aimed at diversifying the economy and lightening overdependence on hydrocarbons (Otman & Karlberg 2007). These policies abandoned the tenet of centralisation which had dominated the economy for the past three decades. The Government undertook a package of measures towards enhancing the role of the private sector in the economy, widening the ownership base, encouraging foreign investment, and transferring state-run businesses to private sector back again (OBG 2008).

Many of these reforms appear to have been implemented in a poorly planned and non-transparent manner. Successive attempts to reduce Libya's reliance on petroleum income have not succeeded. There have been significant failures to integrate many parts of the reform package as a single unit, and reforms initiatives are often out of step with each other. Further, fiscal and budgetary matters have been complicated even more by the conflicting roles of the Central Bank of Libya, the Ministry of Finance and the major development funds. The implementation of reforms has proved an elusive and often confusing process. The Libyan economy has remained still largely controlled by the state and heavily dependent on the oil sector (Otman & Karlberg 2007).

Until the early 1960s, the Libyan economy had a strong agricultural base. Agriculture provided the raw materials for the industrial sector, exports, and trade, and contributed about 30% of the GDP. After the discovery of petroleum, Libya became a classic example of a dual economy (CW 2001a, 2001b). By 2007, oil was contributing 71% of GDP whereas agriculture's contribution was only 2%. Little by little the Libyan economy had been transformed from a poor, largely agricultural economy to one of Africa's stronger and wealthiest economies based on oil and gas industries (European Commission 2009).

The World Bank has classified Libya as an upper-middle-income developing country, as it has the highest income per capita of the developing countries in the Mediterranean region (European Commission 2009) *Table 2.1* compares the per capita income of Mediterranean Developing Countries in the GNI and GDP in the period 2008 - 2009.

Table 2.1: Per capita income in Mediterranean Developing Countries, 2008 - 2009

Country	GNI per capita (PPP CI$)		GDP per capita (PPP US$)	
	2008	2009	2008	2009
Libya	16,710	16,880	15,150	9,957
Turkey	14,890	14,260	10,298	8,554
Lebanon	12,150	13,050	7,219	8,321
Tunisia	8,390	8,760	4,345	4,169
Algeria	7,940	8,300	4,967	3,952
Jordan	5,720	5,790	3,922	4,242
Egypt	5,710	5,940	2,079	2,371
Syria	4,790	5,080	2,678	2,692
Morocco	4,240	4,440	2,793	2,828

Adapted from (WBG 2012)

The GDP has risen over the past few years; at around US$ 19.843 billion in 2002, it had reached US$ 62.360 billion in 2009 (WBG 2012), a figure influenced by a boom year in 2008, and in line with oil price rises in the first half of 2008 (OBG 2008). The annual percentage growth rate of GDP has shown volatility in the rise from -1.3% in 2002 to 2.1% in 2009 (WBG 2012). This represents the growth and rising inflation occurring since the repeal of UN sanctions in 2003 and US sanctions in 2004 (OBG 2008). The GNI represents the steadying growth, rising from Current International $ (CI$) 58.223 billion in 2002 to CI$ 105.745 billion in 2009. As a consequence, GNI per capita increased from CI$ 10,710 in 2002 to CI$ 16,880 in 2009 (WBG 2012). Details of the Libyan GDP and GNI at current prices in the period 2002-09 are shown in *Table 2.2*. The sectoral distribution of GDP in the period 2002-07 is shown in *Table 2.3*.

Table 2.2: The Libyan GDP, GNI at current prices, 2002-09

Item	2002	2003	2004	2005	2006	2007	2008	2009
Gross National Income (GNI) in billion	58.223	67.813	70.680	80.348	90.104	99.529	102.731	105.745
GNI per capita	10,710	12,240	12,500	13,930	15,290	16,520	16,710	16,880
Gross Domestic Product (GDP) in billion	19.843	24.063	33.385	44.000	56.484	71.803	93.168	62.360
The annual percentage growth rate of GDP	-1.3	13.0	4.4	9.9	5.9	6.0	3.8	2.1
Inflation, consumer prices (annual %)	-9.8	-2.2	-2.2	2.7	1.5	6.3	10.4	2.5
GDP per capita	3,651	4,343	5,906	7,626	9,584	11,921	15,150	9,957

Adapted from (IMF 2008; WBG 2012)

Table 2.3: The sectoral distribution of GDP (percent), 2002-07

Sector	2002	2003	2004	2005	2006	2007
Oil sector	50.1	57.6	64.1	69.5	72.3	71.6
Agriculture, fishing & forestry	4.3	3.6	2.8	2.2	2.0	2.0
Manufacturing	2.2	1.9	1.7	1.3	1.1	1.2
Electricity, gas & water	2.2	2.0	1.5	1.3	1.2	1.1
Construction	6.4	4.8	4.5	4.0	3.9	4.3
Trade, hotels & restaurants	5.7	4.9	4.4	3.9	3.4	3.4
Transportation, communication & storage	5.0	4.7	3.9	3.5	3.3	3.3
Financing, insurance & business services	1.7	1.5	1.3	1.0	1.0	1.0
Housing	12.5	10.0	8.0	6.3	5.6	5.2
Public services	9.9	9.0	7.7	6.8	6.2	6.8
Other services	0.1	0.1	0.1	0.1	0.1	0.1

Adapted from (IMF 2008; WBG 2012)

The unemployment rate in Libya has reached about 30% (Aquastat 2006). While the relative dominance of the oil and gas sector in the economy has increased, employment in the extraction industry is less than 2% of the labour force, while agriculture employment has declined to about 7%, from about 70% before the growth of the oil industry (European Commission 2009). *Table 2.4* shows employment figure percentages for the period 2001-2007. The migrant labour workforce has been estimated as twice as high as indicated, when illegal immigrants are taken into account (European Commission 2009).

Table 2.4: Labour Force Employment figure percentages, 2001-2007

Item	2001	2002	2003	2004	2005	2006	2007
Agriculture, forestry & fishing	7.8	7.2	6.7	6.9	7.0	7.3	7.6
Oil & gas extraction	1.0	1.0	1.0	1.1	1.8	1.8	1.8
Mining & quarrying	0.7	0.7	0.7	0.8	1.3	1.3	1.3
Manufacturing	8.0	8.0	7.9	7.9	7.9	7.9	7.9
Electricity, gas & water	2.9	2.9	2.9	3.0	3.0	3.1	3.1
Construction	3.9	3.7	3.4	3.1	2.8	2.6	2.4
Trade, hotels & restaurants	11.4	11.8	12.1	11.8	11.4	11.2	10.9
Transportation & communication	6.8	6.9	7.0	7.2	7.3	7.6	7.8
Finance, insurance & real estate	2.0	2.0	2.0	2.1	2.1	2.3	2.2
Public administrations	16.3	16.5	16.6	16.6	16.3	16.3	16.2
Education services	27.2	27.4	27.7	27.6	27.2	27.1	27.0
Health services	11.8	11.9	12.0	12.0	11.8	11.7	11.7
Other services	0.08	0.04	0.01	0.01	0.01	0.01	0.02
Total employment							
Libyans	87.8	88.3	88.9	89.4	88.8	89.4	89.9
Non-Libyans	12.2	11.7	11.1	10.6	11.2	10.6	10.1

Source: (European Commission 2009)

Despite the volatility of oil prices, rising inflation and major changes affecting all sectors of the economy over the past five years, the Central Bank of Libya has regularly adjusted the Libyan dinar (LYD) value to remain almost stable against major international currencies (OBG 2008). Since 2002 it has remained in the range of LYD 1.21-1.35 to the US dollar, LYD 1.26-1.79 to the Euro and LYD 1.81- 2.51 to the British Pound (CBL 2009). *Table 1.5* shows the value of the LYD against the US Dollar, Euro and Sterling in the period from 1998 to 2009.

Table 2.5: Value of the LYD against the US Dollar, Euro and Sterling, 1998-2009

Year	US Dollar	Euro	British Pound
1998	0.45154	---	0.75398
1999	0.46077	0.46482	0.74270
2000	0.54340	0.48501	0.79206
2001	0.64409	0.57512	0.92545
2002	1.21063	1.26172	1.93930
2003	1.30187	1.62680	2.31199
2004	1.24440	1.69339	2.39186
2005	1.34864	1.59099	2.32222
2006	1.28178	1.68669	2.51370
2007	1.22116	1.79412	2.44208
2008	1.24540	1.75570	1.80530
2009	1.22190	1.77770	1.95070

Source: Central Bank of Libya (2009)

2.5 Agriculture in Libya

The agricultural sector's importance to Libya's economy has been in steady decline, contributing only 4.3% to Libya's GDP in 2002 *(Table 2.3)*. By 2007, the figure had dropped to just 2% of GDP, with just 135,700 people working in the agricultural sector out of a total of 1.8 million workers in Libya (OBG 2008). In common with other oil producing countries in NENAR, agriculture has become a marginal sector (Casas 1999) and Libya currently exports only about 0.3% of its agricultural produce (European Commission 2009).

Many of the rural poor depend on households to use their food production, sold locally or for local consumption, with low productivity and limited access to markets. They coexist with large farms that are more highly mechanised, using more agricultural inputs with relatively less amounts of labour (European Commission 2009). About 95% of Libya is desert, which leaves only 1.2% or 2.2 million ha, of cultivatable land (OBG 2008). Most arable land lies in the Jefara Plain Region on the west coast and Jabal al Akhdar Region on the east coast (CW 2001a, 2001b). Annual crops account for 1.8 million ha, permanent crops for only 300,000 ha and permanent pastures for 13.3 million ha (OBG 2008).

Libya relies heavily on imports to satisfy food requirements (Aquastat 2006). Agricultural imports have accounted for more than 25% of the total import bill (Casas 1999). Domestically, however, Libya is 80% self-sufficient in vegetables, fruit, eggs and meat, and is able to meet about 25% of the demand for wheat, barley, olives, dates, citrus fruits, vegetables, and peanuts. As the growing population will require an increase in food consumption to meet domestic needs, the poor soil and climatic conditions in some areas will limit production. Because the population growth and food demand is soaring, keeping up with growing demand given the current food supply presents a huge challenge for the local agricultural sector (OBG 2008). Alongside the low level of food self-sufficiency, the acute water shortage is a key problem of agriculture in Libya (European Commission 2009).

2.6 Water infrastructure in Libya

According to the American Society of Civil Engineers (ASCE 2009) infrastructure is the combination of physical and organizational activities that support physical, economic, environmental and social human activities. It includes those systems such as energy production, transportation and communication, management of water resources, provision of commodities, and environmental protection that improve the living conditions of society, as well as the basic facilities, services, and installations which a country or organisation uses in order to work effectively. Any discussion of water infrastructure in Libya, therefore, entails an examination of water resources and their management, as well as the water legislation and institutional frameworks.

2.6.1 Water legislation

Libya's first water law to regulate the exploitation of water resources was issued in 1965 and later amended by Law No. 3 of 1982. The legislation has since been complemented by a number of laws, decrees and regulations and in theory addresses all water resource issues in Libya, such as water ownership, usage, responsibilities for control and management, licensing, water quality and penalties. In practice, however, much of the legislation remains formal and has not been applied, despite the availability of the necessary judicial bodies, because of difficulties, obstacles and mismanagement at the institutional and local level (LG 1999). This study attributes the failure to fully apply the legislation to three major factors, social and cultural, planning and economic.

- Social and cultural considerations

The continuing subdivision of farmland by inheritance or sale has encouraged the drilling of new wells, new constructions and the cultivation of high water consuming crops for a quick return. Self-interest, rather than public interest, has been given priority; a situation fostered by a general lack of awareness about of the seriousness of the water situation, and a failure to apply sanctions for water law violations.

- Planning considerations

The absence of an integrated agricultural policy, in particular in relation to marketing, has led to fluctuating prices encouraging farmers to illegally consume more water for quick, guaranteed profits. At the same time, a lack of coordination between the General Water Authority and other authorities, such as with the Ministry of Agriculture, Industry and Facilities, has led to inefficient planning and management of water resources. For example, agricultural land has been reclaimed and industries and new housing schemes set up in areas where the use of water resources is restricted. In addition, a proliferation of legal authorities, with a consequent overlapping of responsibilities and lowering of their capacities, has exacerbated the problem.

- Economic considerations

There has been an expansion of irrigation at the expense of rain-fed land to gain a better return. There has been little incentive for farmers to change their behaviour and cropping patterns to contribute to water saving, when there is no compensation for any damages or losses incurred from their conforming to water conservation legislation. In addition, a failure to protect the market and control prices has led to a rise in the price of some high water consuming crops, such as watermelons, peanuts, tomatoes and oranges, to the extent that farmers are encouraged to plant them in contravention of the legislation.

Fees collection systems have been reviewed and new legislations have been issued [(4)] to impose GMRP's water use charges for all purposes. The General Water Supply and Sewage Company, for example, is at present reorganising the collection of water fees for household and non-household (except agricultural) use (CPPAP 2003).

2.6.2 Water institutional frameworks

Five major institutions in Libya are responsible for the development, management and monitoring of water resources and policies: the General Water Authority (GWA), the Authorities of Implementation and Management and Water Utilisation

[(4)] They are described in turn and in details later.

of the GMRP, the General Company of Water Desalination (GCWD), the General Water Supply and Sewage Company (GWSSC) and the General Environment Authority.

- The General Water Authority (GWA)

The GWA was established in accordance with Law 26 of 1972 and re-organised by Government decisions: 249 of 1989, 757 of 1990, and 695 of 1991. The GWA conducts studies and research into water, and proposes general water policy. It is responsible for implementing national water resources policy, proposing the priorities of all water related projects, programming the use of water, and monitoring the quantitative and qualitative changes in water resources. It is also responsible for issuing well drilling licenses and approving the design and construction of dams (LG 1999).

- The Authorities of Implementation and Management, and Water Utilization of the GMRP

  - The AIMG was established in accordance with Law No. 11 of 1983. The AIMG has responsibility for laying out plans and programs, and conducting the contracts for the implementation of actions that achieve the objectives of a project. The authority manages and operates the main project and its accessories to transfer the water from their resources until it is delivered to investors (LG 1999).

  - The Authorities for the Utilization of the GMRP systems was originally established as one body in 1990 to invest the water of GMRP. In 1995-6, it was divided into three authorities; the AUJHJWSG, the Authority for the

Utilisation of the First Phase of Benghazi Plain Region and the Authority for the Utilisation of the First Phase of the Middle Region. These authorities organise the exploitation and investment of the GMRP water, and are responsible for the establishment and management of agricultural projects directly or in partnership, as well as providing the machinery, equipment and supplies needed for the projects (LG 1999).

- General Company of Water Desalination (GCWD)

This GCWD is an offshoot of the Ministry of Electricity, Water and Gas (MEWG), set up by the Government Resolution 924 of 2007. The GCWD assumed the task of implementing plans and programs related to water desalination from the MEWG. Since 28th October 2007, the company has been responsible for the management and operation, maintenance and renewal of desalination plants under the supervision of the MEWG. It also collects the sale fees of desalinated water from the General Water Supply and Sewage Company (GWSSC) in favour of the MEWG, with a price of 0.860 LYD the cubic metre (GCWD 2012b).

- General Water Supply and Sewage Company (GWSSC)

The GWSSC was established under Law 8 of 1997. Its role was to invest in water and preserve the large investments that are employed in water and sanitation facilities by rationalising consumption and increase the efficiency of operating. The company also aims to achieve set standards for local and international drinking water and sanitation. The GWSSC specialises in the management, operation and maintenance of all water facilities and sanitation, including wells and networks, pumping stations and treatment (LG 1998, 1999).

As the water supply in Libya is a public good, the Government Decision 367 of 1998 determined the formal water selling prices for the GWSSC, with the water prices for domestic consumers set at 0.250 LYD / m^3, and 1.300 LYD / m^3 for companies, plants and commercial markets. This decision provides for the adjustment of water prices in response to changes in conditions having a direct effect on the cost per cubic metre such as electricity and fuel costs and GMRP water prices (LG 1998).

- General Environment Authority

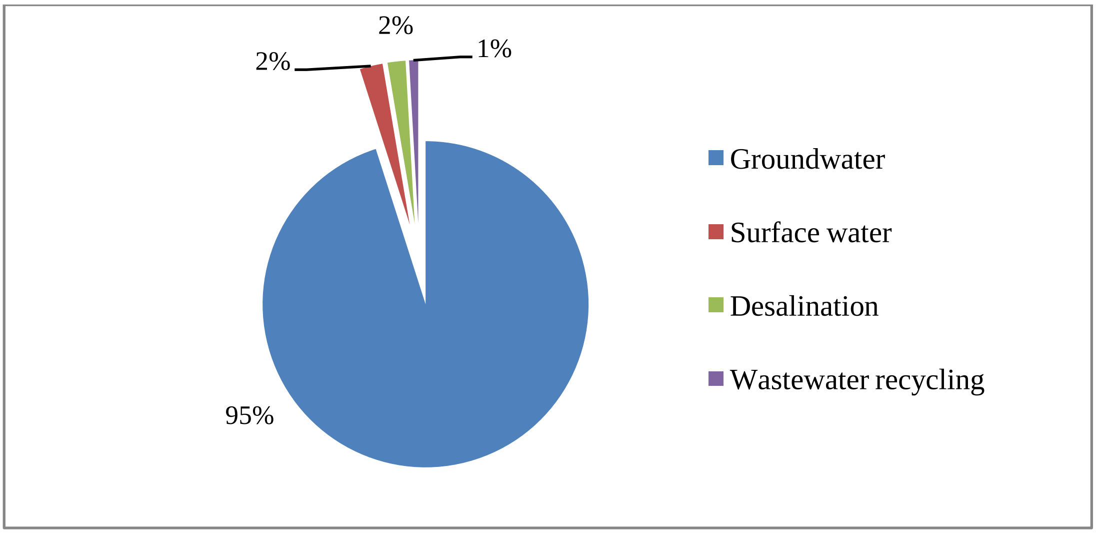
The General Environment Authority (GEA) was established by Resolution 263 of 1999 with the aim of protecting the human environment including water, soil, air and food sources. The authority proposes environmental protection plans and programs and supervises their implementation. It helps raise public awareness about the need to protect the environment from pollution and responsible disposal of waste materials through information campaigns. International cooperation is a priority, and the authority follows international conventions and treaties for the removal of pollution (LG 1999; Wheida & Verhoeven 2007a).

The Oxford report (2008) mentioned to some other bodies indirectly related to water resources management include: the Ministry of Agriculture, the Agricultural Research Centre, the Ministry of Planning and the General Electricity Company.

2.6.3 Water resources in Libya

Water sources in Libya come from four sources: groundwater, providing almost 95% of the country’s needs; surface water, including rainwater and dam constructions; desalinated sea water; and wastewater recycling (Wheida & Verhoeven 2007a).

Figure 2.1: Percentages of available water in Libya in1998



Adapted from (Wheida & Verhoeven 2007a)

2.6.3.1 Groundwater

The major sources of groundwater in Libya come from five water basins: Jabal al-Akhdar, Kufra / as-Sarir, the JPR, Nafusah / al-Hamada and Murzek. Groundwater in the country can be divided into renewable resources, mostly found in shallow aquifers, and the non-renewable resources (fossil water) encountered in deep aquifers. Groundwater reservoir characteristics are summarised in *Table 2.6*.

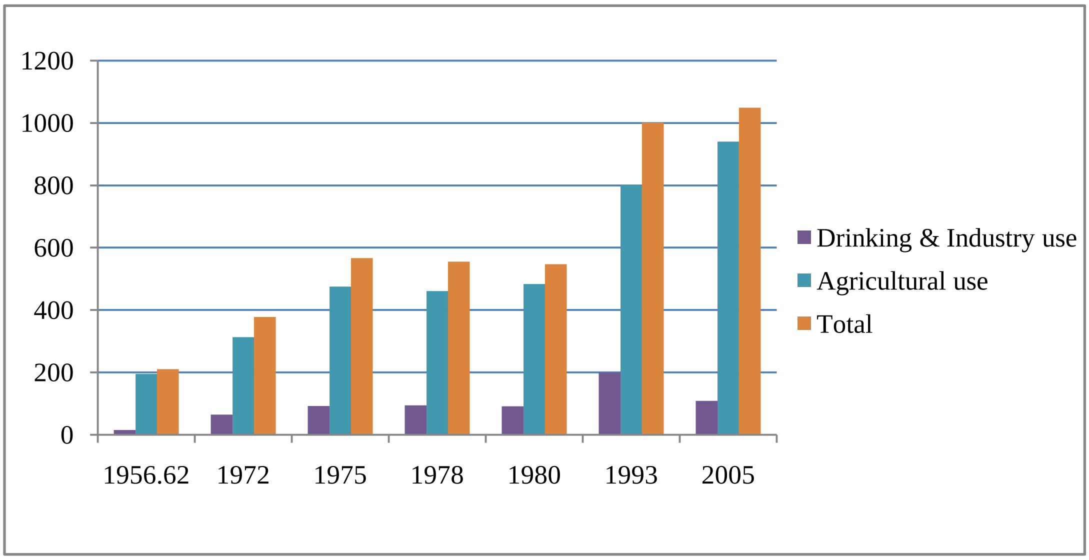
Table 2.6: Groundwater reservoirs characteristics

Basin characteristics	Area, $(km)^2$	Renewable, 10^6 m^3	Non-renewable, 10^6 m^3	Total dissolved solids, mg/l
Jabal al-Akhdar	145,000	200	50	1,000 - 5,000
Kufra / as-Sarir	700,000	–	1,800	200 - 1,500
Jefara Plain Region	18,000	200	50	1,000 - 5,000
Nafusah / al-Hamada	215,000	250	150	1,000 - 5,000
Murzek	350,000	–	1,800	200 - 1,500

Adapted from (Wheida & Verhoeven 2007a)

The amount of water drawing has increased sharply over time, and will undoubtedly increase in the future in response to continuous population growth and corresponding increases in water requirements for the domestic, industrial and agricultural sectors. *Figure 2.2* below summarises the increase in the past five decades in the JPR, the research area of interest and one of the most important territories in the country, population wise.

Figure 2.2: Average underground water drawings in JPR (Amount of water by million m^3 / year)



Adapted from (GAFI 2008; GWA 2006)

2.6.3.2 Surface water

In northern Libya, the annual rainfall varies between 200-300 mm (GWA 2006), with totals gradually decreasing towards the southern regions and almost no rain falling in Kufra, Murzek and Sarir (LG 1999). The surface water resources existing in the northern regions of the country have been mobilised to a certain extent by the construction of a few dams (Wheida & Verhoeven 2007a). The total amount of surface water annually available is 60×10^6 m^3; however the dams have been designed for storage capacity of 389×10^6 m^3 because of a continuing decline in rainfall levels, leakage and the need for maintenance. *Table 2.7* shows the potential storage capacity and the existing storage of the dams.

Table 2.7: Dam capacity and storage in Libya

Region	Dam name	Location	Designed capacity $10^6 m^3$/year	Existing storage, $10^6 m^3$/year
Jabal al-Akhdar	Wadi Qattara	Benghazi	135.00	12.00
	Wadi Qattara-2	Benghazi	1.50	0.50
	Mrks	Ras-hlal	0.15	0.15
	Zara	Aloqurea	2.00	0.80
	Derna	Derna	1.15	1.00
	Abomansour	Derna	22.30	2.00
Kufra (as-Sarir)	Garif	Sirt	2.40	0.30
	Zhawia	Sirt	2.80	0.70
	Ziud	Sirt	2.60	0.50
	Benjuid	Benjuid	0.34	0.30
	Wadi Zgar	Jufrah	3.65	0.20
Jefara Plain Region	Wadi Mejnean	Ben-Gashir	58.00	10.00
	Wadi Ghan	Gharyan	30.00	11.00
	Wadi Zart	Rabta	8.60	4.50
Nafusah (al-Hamada)	Wadi Ekaamm	Zliten	111.00	13.00
	Wadi libda	Homes	5.20	3.40
	Wadi Tibreat	Zliten	1.60	0.50
	Wadi Edkaar	Zliten	1.60	0.50
Total storage capacity (million m^3)			**389.89**	**61.35**

Adapted from (GAFI 2008; GWA n/d)

The flow of natural springs in Libya is variable and dependant on rainfall. 39 springs have a productivity of more than 5 litres / second, with a total of about 2612 litres / second (LG 1999).

2.6.3.3 Desalination

The population of Libya is unevenly distributed and concentrated in the fertile land and zones of industrial activities along the Mediterranean coastline, resulting in considerable water supply deficits in these areas. In the 1960's, Libya turned to desalination as an additional source of water (Wheida & Verhoeven 2007a), becoming one of the largest users of both thermal and membrane desalination technologies in the Mediterranean region (Abufayed & El-Ghuel 2001). *Table 2.8* shows the technical details for the larger water desalination plants in Libya in 1999.

Table 2.8: 1999 details of water desalination plants in Libya with a capacity of more than 4000 m^3/day

Location	Design capacity m^3/day	Existing capacity m^3/day	Operation Year	Remarks upon existing capacity
Benghazi	19200	–	1969	Out of order
Zuara	13500+4500	–	1974–1979	Out of order
Derna	9000	4000	1975	44%
Al-Brega	7200	–	1975	No data available
Benghazi	48000	10000	1976+1978	21%
Sirt	9000	–	1976	Out of order
Zilitn	13500+4500	–	1975–1978	Out of order
Tripoli-West	23000	4600	1976	20%
Tobruk	24000	8000	1977	33%
Sousa	13500	2500	1977	19%
Zuitina	5500	–	1977	Out of order
Benjwad	6000	–	1978	Out of order
Tobruk	6000	–	1979	Out of order
Homes	40000	25000	1980	63%
Ras-lnof	24000	–	1983	No data available
Sirt	9000	–	1982	Out of order
Al-Brega	4800	–	1982	No data available
Benwlid	7000	–	1982–1983	No data available
Zuitina	30000	–	1983	Out of order
Tajoura	10000	One unit	1984	No data available
Ras-lanof	8400	–	1984	No data available
Misrata	30000	30000	1987	100%
Bomba Gulf	30000	18000	1988	60%
Misrata	10000	–	1984	Out of order
Sirt	10000	9000	1986	90%
Zilitn	30000	20000	1992	67%
Zuara	30000	–	–	Not implemented
Tobruk	40000	–	–	Under construction
Sousa	10000	–	–	Under construction
Tripoli-West	10000	–	–	Under construction
Total of capacities	**539600 m^3/day**	**131100 m^3/day**		**24%**

Adapted from (LG 1999)

Despite these installations having an annual production of around 47,851,500 m^3 of desalinated water, the supply has been relatively insignificant in proportion to the total demand, covering only part of the municipal and industrial water requirements of communities in areas experiencing water shortages (Wheida & Verhoeven 2007a). Other problems in supply and production have stemmed from only a small part, 24%, of the total design capacity being available, with many installations either out of order or working at reduced levels due to a lack of regular maintenance, difficulties in providing spare parts, obsolescence and the need for further development (Aquastat 2006).

According to GCWD statistics, the total production of desalinated water in 2009 was 51,432,675 m^3 or about 140911 m^3 / day. Comparing these figures with total capacities for 1999 *(Table 2.8)*, it is clear that the sector has seen no noticeable improvement or development over the past decade (1999-2009). *Table 2.9* shows desalinated water production details for 2009.

Table 2.9: The quantities of desalinated water produced in 2009 in Libya.

The area	The plant	The produced quantities
Jefara Plain Region	Homes	3,794,396
	Zuara	4,822,703
Total of Jefara Plain Region		**8,617,099**
Rest of the Libyan coast	Tobruk	13,008,873
	Bomba Gulf	4,173,885
	Sousa	3,590,242
	Abo -Traba	12,759,569
	Zuitina	39,510
	Zilitn	8,526,124
	Derna	717,373
Total of the rest of the Libyan coast		**42,815,576**
Overall total		**51,432,675**

Adapted from (GCWD 2012a)

In the period 2009 / 2010, the GCWD targeted the completion, implementing and operation of some plants, as well as researching and planning the construction and expansion of number of other plants. More details are shown in *Table 2.10*.

Table 2.10: Targeted water desalination projects in 2009 / 2010 in Libya

Target	The plant	The capacity (m^3 / day)
Completion and operation of plants during 2009	Derna	40,000
	Sousa	40,000
	First unit of Zawua in JPR	Part of 80,000 [5]
Completion and operation of plants during 2010	Rest units of Zawua in JPR	Rest of 80,000
	Zuara in JPR	40,000
Total		**200,000**
Plants under development	Homes in JPR	50,000
	Tripoli-Eest in JPR	500,000
	Jefare in JPR	300,000
	Zawua in JPR	100,000
	Zuara in JPR	50,000
	Tobruk	150,000
	Bomba Gulf	50,000
	Derna	100,000
	Sousa	100,000
	Abo-Traba	50,000
	Sirt	100,000
	Benghazi	300,000
	Misrata	100,000
	Zilitn	50,000
Total		**2,000,000**
Overall total production		**2200000 m^3 / day**

Adapted from (GCWD 2012c)

The data shows that the total amount of desalinated water from plants under construction and under study in the JPR were projected to reach 1,120,000 m^3 / day.

[5] The figure 80000 is repeated in 2010 due to the lack of data available, on the size of each unit, to be separate in each year.

2.6.3.4 Wastewater recycling

The rapid increase in population has necessitated a large increase in construction, imposing the establishment of apposite infrastructures, large water and sewage networks, and water treatment plants. Wastewater treatment has been implemented at varying levels of interest in Libya from the 1970s to the early 1990s for the purposes of agriculture and environmental protection (LG 1999). The existence of larger plants in major cities surrounded by agricultural areas *(summarized in table 2.11)* makes the cost of treated water conveyance minimal (Wheida & Verhoeven 2007a).

Table 2.11: Details of wastewater treatment plants in Libya

Treatment plants	Installation year	Design capacity m^3/day	Existing capacity m^3/day	Remarks
Ejdabya	1988	15600	5000	32%
Benghazi A	1965	27300	–	Out of order
Benghazi B	1977	54000	–	Provisional test
Al-merg A	1964	1800	–	Out of order
Al-merg B	1972	1800	–	Out of order
Al-beada	1973	9000	–	Under construction
Tobruk A	1963	1350	–	Out of order
Tobruk B	1982	33000	–	Out of order
Derna	1965	4550	–	Out of order
Derna	1982	8300	–	Under construction
Sirt	1995	26400	–	Under construction
Abo-hadi	1981	1000	600	60%
Al-brega	1988	3500	2700	77%
Zwara	1980	41550	–	Not used
Sebrata	1976	6000	–	Out of order
Sorman	1991	20800	–	Under construction
Zawia	1976	6800	–	Under construction
Zenzour	1977	6000	–	Not used
Tripoli A	1966	27000	–	Out of order
Tripoli B	1977	110000	20000	18%
Tripoli C	1981	110000	–	No data available
Tajoura	1984	1500	500	33%
Tarhouna	1985	3200	1260	39%
Gheraan	1975	3000	–	No data available
Yefren	1980	1725	173	10%
Meslata	1980	3400	–	Not used
Homes	1990	8000	–	Not used
Ziliten	1976	6000	–	Out of order
Misrata A	1967	1350	–	Out of order
Misrata B	1982	24000	12000	50%
East Garyat	1978	500	–	Out of order
West Garyat	1978	150	–	Out of order
Topga	1978	300	–	Out of order
Shourif	1978	500	–	Out of order
Sebha A	1964	1360	–	Out of order
Sebha B	1980	47000	24000	51%
Total of capacities		**617735**	**66233**	**11%**

Adapted from (Wheida & Verhoeven 2007a)

The proportion of the existing capacity to the designed capacity in treatment plants, except for those under construction (71300), is just 12%. Wastewater treatment has faced recent technical challenges from the substandard condition of most water pumping stations, plants coming to the end of their operational life and the need for spare parts and maintenance (Aquastat 2006). At the same time, the stations require a highly skilled workforce to enable them to function efficiently (LG 1999). Another factor has been the reluctance of farmers and consumers to use treated wastewater, having a negative effect on its use as a significant and reliable water source (Wheida & Verhoeven 2007a).

It is worth mentioning that in 1998 just 6000 hectares of the areas of agricultural projects were irrigated by treated wastewater in Tripoli and Benghazi *(Table 2.12)*. The development plan for the water sector in 2007 – 2010 [(6)] does not include any mention to wastewater recycling.

Table 2.12: Agricultural projects irrigated by treated wastewater in 1998

Project location	stage	Discharge capacity, m^3/day	Irrigated area, hectare
Tripoli	1st stage	27,000	2500
	2nd stage	110,000	1500
Benghazi	1st stage	27,000	360
	2nd stage	27,000	658
	3rd stage	27,000	1000

Adapted from (Wheida & Verhoeven 2007a)

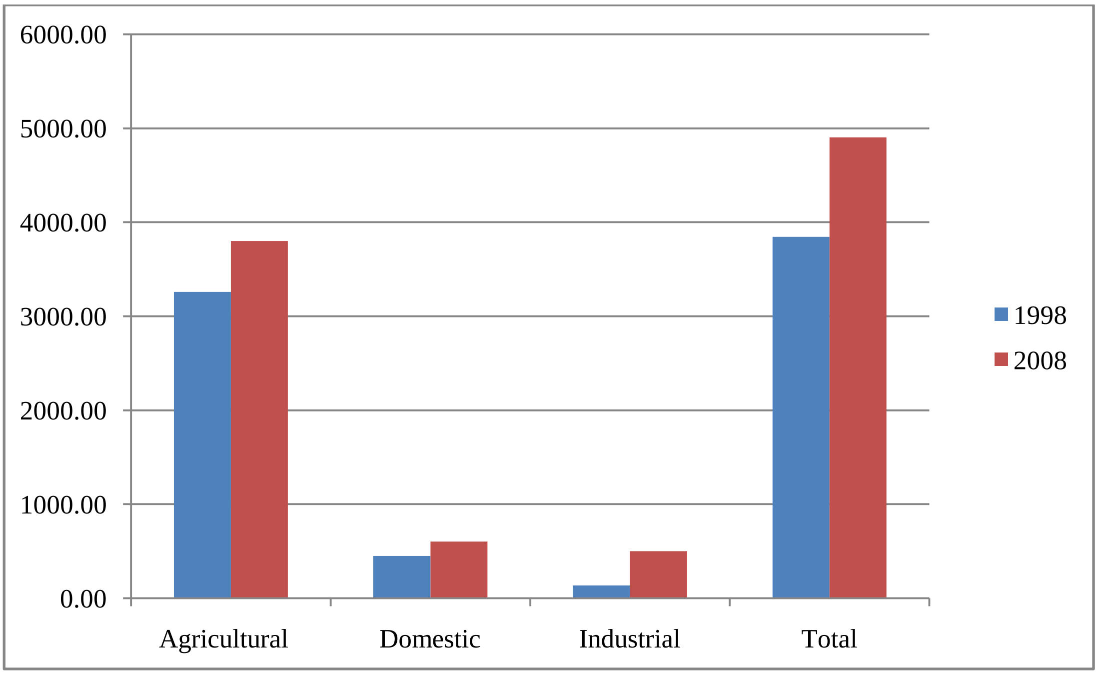
The production from all water development projects in dams, wastewater recycling and water desalination does not cover the deficit of water in Libya (Mustafa 2001).

[(6)] More details about this plan will be stated later in this section.

2.7 The water situation in Libya

The severity of the water scarcity situation in Libya necessitates cooperation between all the specialised authorities in the formulation of water policy and the determination of the quantities of allowed drawings from ground reservoirs so as to exploit them economically and reduce their poor use in agriculture, where overuse of water in irrigation has led to the deterioration of the agricultural production rates, high salinity levels in the soil, and the deterioration of irrigation facilities, all causing degradation of the environment (Bouzid 1996). The total water withdrawal for agricultural, domestic and industrial purposes is estimated at 3843 mm^3 in 1998 (Wheida & Verhoeven 2007a), increasing to 4903 mm^3 in 2008 (GAFI 2008).

Figure 2.3: Water use in 1998 and 2008 (Amount of water by million m^3 / year)



Sources: - 1998 adapted from (Wheida & Verhoeven 2007a)

- 2008 adapted from General Authority For Information (GAFI 2008)

The excessive use of water in 1998 resulted in the withdrawal of 1154 million cubic metres more than the estimated available water (Wheida & Verhoeven 2007a). It is clear from *Figure 2.3* that agriculture has the highest water consumption of all sectors, about 80%. In 1998 the total irrigated area covered 309258 hectares, with the irrigation water needs amounting to 3259.27 mm^3 (Wheida & Verhoeven 2006). In 2007, sources of irrigation, numbers and areas of agricultural fields ware distributed as in the *Table 2.13*.

Table 2.13: Number and area of agricultural fields in 2007 (Area in Hectares)

Source of Irrigation	No.	Area
Irrigated by rain	123560	509662
Irrigated by well	135215	281221
Irrigated by dam	464	1135
Irrigated by a spring of water	1191	2145
Irrigated by well of the state	4054	44730
Irrigated by other sources	3835	13226
Not mentioned	15213	49463
Total	**283532**	**901582**

Source: (GAFI 2008)

It can be seen that the irrigated area increased from 309258 to 901582 hectares between 1998 and 2007. The required quantities increased from 3259.27 mm^3 to estimated quantities [(7)] of 5129 and 5794 mm^3 in 2005 and 2010 respectively (CPPAP 2003).

Urban consumption includes water consumed by house holders, gardening, hospitals, schools, universities, public offices, hotels, cafes, and commercial markets (Wheida & Verhoeven 2006). Increases in urban water use are inevitably linked to population growth, as in Libya. Domestic water use in Libya is about 12%, and is the second

[(7)] There is no data about the actual quantities in 2007 can be used for the comparison.

ranking sector for consumption (GAFI 2008). Urban water comes from three sources: GMRP; local groundwater in each region; and desalination. The reliance on local groundwater has decreased significantly in the period 1999 - 2008. *Table 2.14* highlights the crisis of local groundwater in Libya and the increased reliance on the GMRP, and to a lesser extent, desalination.

Table 2.14: Water sources for urban purposes in 2008 compared to 1999

Source	1999	2008
GMRP	42%	53%
Local Groundwater	54%	36%
Desalination	4%	11%

Sources: - 1999 adapted from (Wheida & Verhoeven 2006)

- 2008 adapted from General Authority For Information (GAFI 2008)

Industrial water consumption encompasses its use in air conditioning and refrigeration, manufacturing and the infrastructure and operations of factories, with a total use of 135.64 mm^3. A major use of industrial water is in the oil industry, (injection, processing and some domestic use) (Zidan 2007) , about 76% of the total (Wheida & Verhoeven 2006).

CPPAP (2003) predicts that the population in Libya will reach 11.7 million by the year 2025. The total estimated quantity of available water for investment (excluding desalinated water and wastewater) is estimated at 3820 mm^3, comprising 170 mm^3 surface water, 650 mm^3 renewable groundwater and 3000 mm^3 non-renewable groundwater (including GMRP water). The rates of renewable water and surface water per capita in Libya are the lowest in the NENAR region. In the context of the estimated water availability and the forecast population growth in Libya, the per capita renewable water and surface water rates show a steady decline from 170 m^3 in 1995 to a projection of 70 m^3 in 2025.

Population growth in Libya has been accompanied by a growth of irrigated agricultural areas, making an increase in the volume of water used in agriculture inevitable, as well as increasing domestic and industrial water consumption. Using data from a 2003 (CPPAP) report, *Table 2.15* summarises the projected water situation in Libya 2005 – 2025, highlighting the size of the problem and its evolution over time.

Table 2.15: The water situation in Libya 2005 – 2025 (Water in million cubic metres per year)

Item	**Year**	**2005**	**2010**	**2015**	**2020**	**2025**
Population "in millions"		6.7	7.8	9	10.3	11.7
Available Water (Supply)	Surface water	170	170	170	170	170
	Renewable groundwater	650	650	650	650	650
	Total	820	820	820	820	820
	Cubic meter per capita	122	105	91	80	70
	Non-renewable groundwater	3000	3000	3000	3000	3000
Total of the available water (Supply)		3820	3820	3820	3820	3820
Irrigated areas "1000 hectare" [8]		450	500	550	600	650
Consumed Water (Demand)	Agricultural	4342	4825	5307	5790	6272
	Domestic	573	708	870	1060	1280
	Industrial	214	261	318	386	470
Total of the consumed water (Demand)		5129	5794	6495	7236	8022
Water deficit		**-1309**	**-1974**	**-2675**	**-3416**	**-4202**

Adapted from (CPPAP 2003)

The water deficits at the level of the entire country shown in *Table 2.15* represent the over-exploitation of water at the expense of future generations and the use of water, which is unfit for use such as salt water.

[8] According to GAFI 2008, *Statistics Book*, Tripoli,<., the actual irrigated area in 2007 was amounted 901582 hectares.

According to the 2007 (MEWG) Report on the water sector development scheme, the overall total of investments in the water sector for the period 2005 -2010 amounted to 5,027,200,000 LYD. *Table 2.16* summarises the scheme in detail.

Table 2.16: Total investments in the development plan for water sector 2007 – 2010 (Costs in LYD)

Project	Cost in LYD		
Water desalination stations:			
Under construction	574,500,000		
Under contracting	1,469,000,000		
Total		**2,043,500,000**	
Water transport:			
Under construction	307,100,000		
Under contracting	1,176,600,000		
Total		**1,483,700,000**	
Water distribution (virtual)		1,500,000,000	
The overall total of investments in water sector:			**5,027,200,000**
Total of investments in US$ approx [9]			**3,921,216,000**

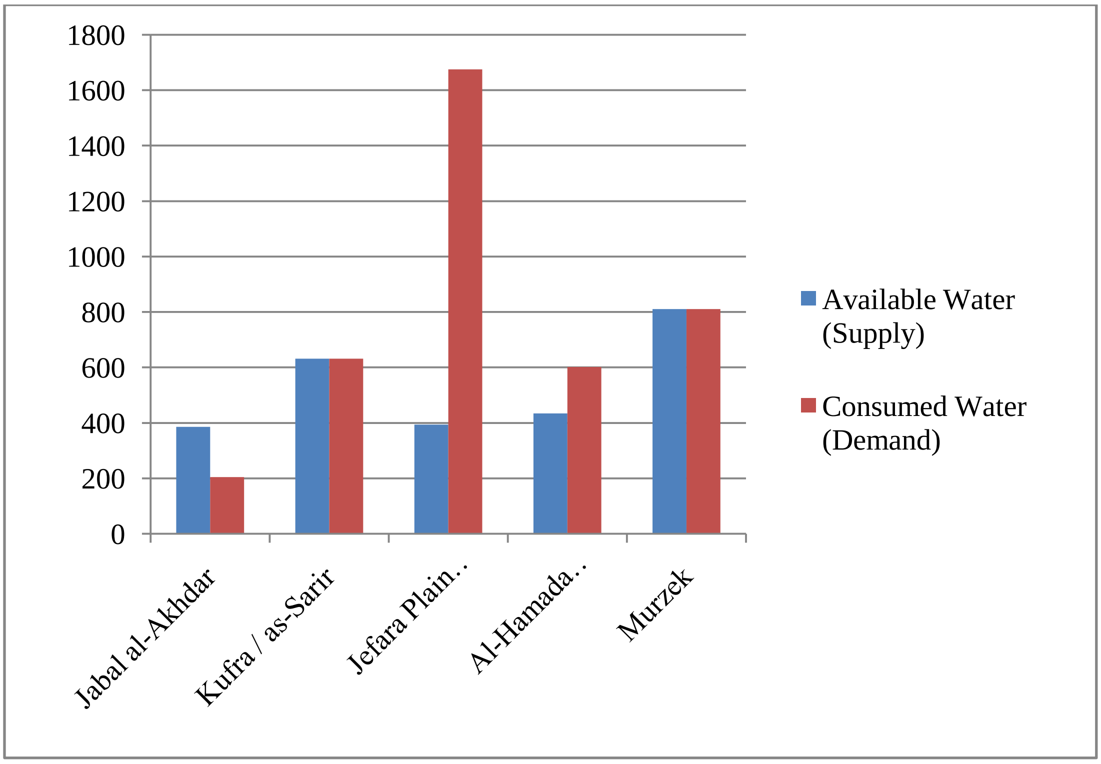
Source: (MEWG 2007)

2.8 Inefficient water use in the JPR and suggested plans

The problem of water scarcity varies from one area to another in Libya. As such the attention given to resolving water scarcity also varies. According to the study of the water situation by LG (1999), the actual water deficit in 1998 in the JPR alone was 1281 mm^3/year. The highest agricultural water use was found in this region as well, amounting to 1402.86 mm^3 (Wheida & Verhoeven 2006), and exceeding the security drawing borders by 561%. *Figure 2.4* shows the size of the water deficit in the Jefara basin compared to other basins in Libya.

[9] Exchange rate of the US$ versus LYD is approx 1.282

Figure 2.4: 1998 water deficits in Libyan basins (Amount of water by million m^3 / year)



Adapted from (LG 1999)

There has been wastage and inefficiency in using water resources of nearly 60% in agricultural crop irrigation in the JPR (Almontaser 2009). According to Almontaser (2009), a different crop composition in the JPR could economise the volume of water use by 60% with an accompanying increase in farmer's income. Already in 1994, the National Consulting Bureau and Mott MacDonald (NCBMM) [(10)] acknowledged significant losses taking place in groundwater stock in the JPR as a result of the over-exploitation of water, with the volume of withdrawals exceeding the recharge by four to six times. For example, withdrawals for 1993 were estimated at 1002 mm^3 (NCBMM 1994), and 1300 mm^3 for 2000 (WTNWR 2003), with the recharge rate estimated at about only 200 mm^3 / year, and coming from rain, the flooding of

[(10)] The (NCBMM) are the Libyan National Consulting Bureau and Mott MacDonald of the UK. They put the General Plan for Utilisation of the GMRP Waters phase (II) in spring of 1994.

valleys and flowing quantities derived from irrigation systems and water supply systems. Average water use for typical needs, according to the water efficiency standards, should be 6293 m^3 / hectare / year in the JPR. However, the actual average use in 2007 amounted to 9880 m^3 / hectare, and water losses due to inefficient use was 3587 m^3 / hectare (Almontaser 2009). Over-exploitation of water has led to groundwater pollution and the deterioration of their quality along the Libyan coast as a result of seawater overlapping (LG 1999). In addition, agricultural and industrial pollution have exacerbated the problem, with chemicals from factories, sewage from treatment plants and the run-off from agricultural fertiliser and pesticides contaminating groundwater sources (Abdulaziz 1999). A 1994 (NCBMM) study concluded that if the water withdrawals were to be halted, the JPR would require 200 years for the quality of water in the groundwater reservoir to recover and reach levels prior to the deficit caused by the negative imbalance between withdrawal and recharge. The severity of the water crisis can only be reduced with a commitment to the recommended security level of withdrawals from groundwater stock. Groundwater should be used efficiently to prolong its life span, and in this context, its use should be limited (CPPAP 2003). Water quality and its levels will not stabilise in the ground reservoirs until withdrawals are reduced to reasonable limits. This is considered critical to achieve irrigation sustainability in the JPR in the long term, taking into account population and economic growth.

2.9 The national strategy for the management of water resources in Libya

According to the General Planning Council in the (2003) CPPAP Report, the continuation of development and its sustainability require following a development strategy that can be implemented, and by laying down a balanced, integrated plan to develop the country's resource productivity (CPPAP 2003; LG 1999). The national strategy for the management of water resources in Libya, for the period 2000 - 2025, aims to lay the foundations for sustainable development that can ensure plugging the water deficit (quantitative and the qualitative) for current generations and secure the rights of future generations in water resources. The most important aspects of this strategy are:

1- Developing human and institutional capacity in the preparation and implementation of the national strategy for the management of water resources.

2- Reducing water deficits through good management of the water demand, reviewing agricultural policy as agriculture is the biggest consumer of water, and restricting the amount of water used in urban and industrial purposes.

3- The setting up of advisory bodies, education and information awareness programs, as well as introducing a water pricing system, to sensitise people to the value of water for life.

4- The development of both conventional water resources and non-conventional, such as dams and springs, and the provision of funding sources for desalination and wastewater recycling plants, and other water conservation projects.

5- The protection of the environment and protection of water resources from pollution by: the rationalisation of the use of chemical for agricultural purposes; cleaner and more efficient industrial techniques in relation to the environment and water resources; the imposition of fees on polluters; and giving support to the regulators and the judiciaries responsible for the protection of the environment.

6- Directing water policies to recover the costs of providing water and to secure the necessary finance to develop water resources.

7- The modernisation and development of valid water legislations in Libya and the activation of its role.

8- The development of technical cooperation with Arab organisations, regionally and globally, in the fields of water resource management.

The technical committees examining the water situation in Libya faces some complex challenges requiring careful handling and determination to manage the crisis. Prevailing concepts and practices are not conducive to water conservation. Significant challenges include a lack of expertise, transition possibilities and monitoring, analysis and water treatment techniques. The situation is made more difficult by the extremely limited availability of accurate, reliable and full information and data concerning water resources [(11)].

2.10 The Great Man-made River Project (GMRP)

The GMRP was established under Law No. 11 of 1983, and is considered one of the largest projects, in the world for transferring and distributing water (GMRP 2011). The project involves the transfer of groundwater from southern Libya to the fertile northern regions where the population is concentrated. Groundwater existing in deep aquifers under the desert sands in the south of the country, with a volume of 3850×10^6 m^3 is fossil water, is therefore a non-renewable resource. The GMRP project was established for the purpose of providing water for urban uses, industrial facilities and converting of thousands of hectares of arid land into productive agricultural areas (Mustafa 2001). It is designed to transfer more than 6 mm^3/day of water through the GMRP systems after all stages are completed (GMRP 2011; Zidan 2007).

[(11)] Later in Literature review Chapter, section 3.8 is dedicated for history of water management policy in Libya.

Investment opportunities are available in the agricultural sector, where up to 20,000 hectares of large farms irrigated by the GMRP are being offered for foreign investment within the framework of state policy and economic and social development objectives (GMMRA 2010). Abdulaziz and Ekhmaj (2007) have identified the main objectives of the GMRP as follows:

1- Political goals to achieve food security through investment in the water for agricultural purposes to achieve self-sufficiency in key and strategic commodities.
2- Economic goals to increase the contribution of agriculture in GDP and improve the trade balance by reducing agricultural imports and increasing the exports.
3- Social goals to provide employment opportunities and improved health services, as well as the achievement and maintenance of stable populations in areas affected by water shortages.
4- Environmental goals to address the problems of overlapping seawater, desertification and deterioration of the vegetation overlay.

GMRP construction began in 1984. Costing an estimated $US 25 billion, it is expected to take 25 more years to complete (GMMRA 2010). However, substantial delays have occurred in construction due to problems in financing and management, as well as the circumstances surrounding the Libyan revolution and the resultant radical changes in the political system. The project has an expected life span of 50 years of irrigation to coastal areas (EON 2010). Consisting of more than 1300 wells, more than 500 m deep (Zidan 2007), the GMRP was designed in five phases, each largely independent, that will eventually combine to form an integrated system *(See Appendix C)*. Five major systems are available for the transfer of water (GMRP 2011):

- Sarir - Sirt / Tazerbo - Benghazi System.
- Jabel Hasawna - Jefara Water System.
- Ghadames - Zwara - Zawia System.
- Kufra - Tazerbo System.
- Ajdabya - Tobruk System.

Although the current production capacity of the GMRP is about 4 mm^3 / day, it produces only 1.6 mm^3 / day due to lack of readiness of subsystems and some agricultural projects. The average operational cost per cubic metre of GMRP water is estimated at 0.089 LYD /m^3. With the capital cost estimated at 0.146 LYD / m^3, the total cost per cubic metre is 0.235 LYD (GMRP 2011). According to GMRP (2011), in comparison to other water supply resources, the GMRP currently remains the best economic alternative.

Water pricing for the first phase of GMRP was set by the government in Resolution No. 218 on the 26/04/1994. The selling prices were subsidised for agriculture and urban use while for industrial use was value-added more than twice as follows: 0.048 LYD / m^3 for agricultural use; 0.080 LYD / m^3 for urban use; and 0.796 LYD / m^3 for industrial use. These prices were also adopted for the JHJWSG (Aljuhawy 1997; LG 1999).

Due to the importance of the GMRP and the magnitude of its capital investment, the government issued multiple laws to finance it (GMRP 2011). The legislation determined the resources to fund the GMRP such as fees on documentary credits and bank transfers, fees on tobacco products, and fees on the derivatives of oil and gas. Funds collected from the beginning of the project until 31/12/2010 amount to 11,554,251,000 LYD and are distributed as shown in *Table 2.17*.

Table 2.17: Funds received from the beginning of the GMRP to 31.12.2010

Item	Amount	Ratio%
Fees of oil derivatives	2,164,812,000	19.00%
Fees of tobacco	515,226,000	4.00%
Fees on airline tickets	99,129,000	0.97%
Fees on banking transactions	6,299,087,000	55.00%
Allocations from the public treasury	1,379,037,000	12.00%
Commercial licenses	3,987,000	0.03%
Other resources	1,092,973,000	9.00%
Total	**11,554,251,000**	**100%**

Adapted from (GMRP 2011)

The cost of all phases of the GMRP from the beginning until 31/12/2010 amount to 10,914,811,000 LYD and are distributed as shown in *Table 2.18*.

Table 2.18: GMRP expenditure from the beginning of the project until 31.12.2010

Item	Amount	Ratio%
Construction cost of GMRP systems	6,901,854,719	63.20%
Consulting offices	254,023,389	2.30%
The financial burden and currency differences	2,541,484,708	23.00%
The burden of the loan	570,988,739	5.10%
Operating and maintenance expenses	284,924,377	3.00%
Expenses of managerial and fittings	348,217,558	3.00%
The expenses of training and development	13,317,510	0.10%
Total	**10,914,811,000**	**100%**

Adapted from (GMRP 2011)

The funds required to complete the project are estimated at 5,110,259,000 LYD for the period 2012 to 2017, distributed as shown in *Table 2.19*.

Table 2.19: Funds required completing the GMRP during the period 2012 – 2017

Item	Amount	Ratio
Completing the Sarir - Sirt / Tazerbo - Benghazi System	235,037,000	4.60%
Completing the Jabel Hasawna - Jefara Water System	134,044,000	2.62%
Completing the Ghadames - Zwara - Zawia System	338,069,000	6.62%
Completing the Kufra - Tazerbo System	2,806,428,000	54.92%
Start implementing the Ajdabya - Tobruk System	1,117,581,000	21.87%
Operating and maintenance expenses	479,100,000	9.38%
Total	**5,110,259,000**	**100%**

Adapted from (GMRP 2011)

According to Alghariani (2003), the increasing cost of pumping water from greater distances and greater depths, combined with the falling costs of desalination, has recently reduced the cost-effectiveness of the GMRP as compared to desalination. Alghariani's (2003) research indicates that the average cost of GMRP water cubic metre could escalate to more than 1.112 LYD (0.83 US Dollars) per cubic metre, and that as the exploited aquifers are non-renewable, when sustainability is taken into account by considering 'the depletion cost', with costs conceivably reaching 3.153 LYD (2.35 US Dollars) / m^3. While the cost of water cubic metre of GMRP was competitive with the cost of seawater desalination twenty years ago, in 1999 the situation shifted in favour of seawater desalination where costs have dropped to less than 0.738 LYD (0.55 US Dollars) / m^3 (Alghariani 2003).

Responding to these claims, the authority of implementation and management of GMRP points out that the average cost of a cubic metre of GMRP water is only 0.329 LYD (0.245 dollars), and argues that water depletion costs should not be taken into account as GMRP water comes from uninhabited areas, and that, according to hydrological surveys, the water reserves are massive. Further, the price of a cubic metre of GMRP water includes production and transfer costs. In contrast, the price of desalinated water is for production only, and does not include water transfer and distribution costs. Consideration of these factors could conceivably double the cost per unit of desalinated water. At the same time, the authority recognises the key role of social and political factors in relation to the continuing construction and completion of the remaining phases of the GMRP. In this context, the Libyan government itself is aware that the GMRP is not a panacea for the country’s water supply, and in 2003 began a program to build eleven new desalination plants (European Commission 2009). The water sector authority has included 228 wells, costing 69 million LYD (53.82 million US$) in the water sector development plans for 2007 - 2010 (MEWG 2007).

With GMRP water beginning to flow, the vastness of the country led the government to establish three major authorities for GMRP water investment (LG 1999):

- The Authority for the Utilisation of Jabel Hasawna – Jefara Water System established by Resolution No. 230 of 1995.
- The Authority for the Utilisation of the First Phase of Benghazi Plain Region established by Resolution No. 246 of 1996.
- The Authority for the Utilisation of the First Phase of the Middle Region established by Resolution No. 247 of 1996.

The general goals of these authorities are to optimise water yield through producing a maximum of major agricultural products, so as to achieve food security, encourage investment in the agricultural field and contribute to the creation of job opportunities in the agricultural sector (AUJHJWSG 2005; GMRP 2011), in addition to achieving environmental protection goals. The existing infrastructure of areas along the coastline affected by water shortages should be integrated and rehabilitated, enabling the delivery of the water supply required to maintain agricultural soils and enhance agricultural production, thus contributing positively to economic activity (AIMG 2008).

2.10.1 Jabel Hasawna - Jefara Water System of GMRP (JHJWSG)

The JHJWSG targets to transfer 2 mm^3 / day of water (with a maximum capacity of 2.5) from the fields of wells in the Jebel Hasawna region to the west coast, the JPR and Nefoussa Mount (Aljuhawy 1997), with 67.3% of this amount allocated for agricultural purposes (AUJHJWSG n/d.). The system began partial operations in August 1996 with a capacity of 250,000 m^3 / day, with a current available production capacity of 2 mm^3 / day. The system currently produces about 750,000 m^3 / day, with the water transferred up to December 2010 amounting to 2,471,429,601 m^3. JHJWSG began full operations in 2006 when the available productivity reached 2 mm^3 / day (GMRP 2011). The components of JHJWSG as follows:

- Wells fields with 484 wells.
- Four water pumping stations.
- A water collection pipeline system from the well fields with a total length of 753 km, and pipe diameters ranging from 0.30 metres to 4 metres.
- Main pipeline along the 983 km with diameters 3.6 and 4 m.
- Six break pressure tanks.
- Two stations to control the flow.
- A fibre optic cable communications system linking the well fields with the public telecommunications system, enabling the transfer of control signals for all JHJWSG facilities.

- A system of monitoring and controlling the balance between supply and demand, which includes a main control room in the Bin-Ghashir region in addition to four sub-control rooms linked to the pumping stations mentioned above.
- Eleven electricity stations for the transmission and distribution of electric power.
- Three support centres for operations and maintenance in the Bin-Ghashir, Alchuirv and Hasawna regions.

The estimated capital costs to set up all the components of Jabel Hasawna - Jefara Water System amounts to 3,273,169,000 LYD. The system is designed for a maximum production capacity of 2.5 mm^3 / day (Aljuhawy 1997). The estimated cost of annual operation and maintenance of the system, assuming maximum production capacity, would amount to 77,506,000 LYD. Assuming a targeted capacity of 2 mm^3 / day, however, the annual expenditure would amount to 64,245,000 LYD (Aljuhawy 1997). *Table 2.20* shows details of the estimated costs of a water cubic metre, for both targeted and maximum capacity.

Table 2.20: The estimates costs of the water cubic meter of the JHJWSG

Item	**The annual cost on the basis of production and transport 2 mm^3**	**The annual cost on the basis of production and transport 2.5 mm^3**
The estimated capital costs	3,273,169,000	3,273,169,000
The estimated operating and maintenance costs for 50 years	3,212,250,000	3,875,300,000
The estimated costs for replacement of the system equipment after 25 years	416,075,000	416,075,000
The estimated total cost for 50 years	6,901,494,000	7,564,544,000
The water amount supposed to transfer for a period of 50 years "assuming 350 days / year"	35,000,000,000	43,750,000,000
The estimated cost per cubic meter	**0.200 LYD**	**0.170 LYD**

Adapted from (Aljuhawy 1997)

According to Aldarrat, Bakir and Alsaleh (2003), the estimated cost of JHJWSG water amounts to 0.454 LYD per cubic metre of water assuming an operational efficiency of 85%, or 0.377 LYD, assuming a 100% operational efficiency.

2.10.2 Water investment plans in agriculture in Jefara Plain

Complementing the general goals of the GMRP water investment administrators, the Authority for the Utilization of Jabel Hasawna – Jefara Water System aims to support existing agricultural projects and farms in the JPR and to achieve population stabilisation. It also encourages local and foreign investment, with the goal of providing a competitive environment to facilitate the introduction of modern techniques in irrigation and raise the level of production quality and quantity (AUJHJWSG 2010b).

The NCBMM (1994) developed a master investment plan for the Jabel Hasawna - Jefara Water System administration in the spring of 1994, with the goal of creating a balance between maximising the realisable irrigated area and raising WUE levels. The plan aimed to improve agricultural production for the JPR and protect aquifer water in the region from degradation. According to the NCBMM (1994) plan, aquifer reservoir conditions would be fixed and stabilised at the levels and quality of 1993 by reducing the amount of groundwater withdrawals from 1002 mm^3 / year to 250 mm^3 / year. The deficit would be covered by the water from the Authority for the Utilization of Jabel Hasawna – Jefara Water System. *Table 2.21* summarises the 1994 plan as compared to the situation in 1993.

Table 2.21: A comparison between the master plan of NCBMM (1994) and the water situation in 1993 in Jefara region of Libya in million cubic metres annually.

Type of supply		**Supplies according to the master plan**			**Actual groundwater supply**
		Hasawna system	**Local groundwater**	**Amount**	
Agricultural	Projects of agricultural Scheme & coastline	481.9	—	481.9	220.0
	Bin-Ghashir & Sawani region	248.1	—	248.1	215.0
	Other regions	—	200.0	200.0	367.0
Municipal supplies		182.5	50.0	232.5	200.0
Total		**912.5**	**250.0**	**1162.5**	**1002.0**

Adapted from NCBMM (1994)

The 1994 NCBMM plan provided for the prohibition of all water withdrawals for irrigation on the coastline and the Bin-Ghashir region, as well as an interdiction on the issue of any new licenses for the drilling or deepening of wells in the rest of Jefara Plain. Aljuhawy (1997) believes that the Jefara Plain water needs could be even greater than the actual amount produced and transferred by the Authority for the Utilization of Jabel Hasawna – Jefara Water System, with estimated needs in 1997 amounting to 3,265,670 m^3 / day. The NCBMM (1994) plan proposed the construction of wastewater treatment facilities in urban areas on the coast. In this context, the Electricity, Water and Gas Company signed two contracts to desalinate sea water for urban use as part of the water sector development plan 2007-2010 for the Jefara Plain: a contract to construct the Zawia plant with total a capacity of 80,000 m^3 / day, and a contract to expand the Zwara plant to a total capacity of 40,000 m^3 / day. The GCWD plan for the period 2009 - 2010 included the construction of new desalination plants in the Jefara Plain east of the Tripoli, Homes and Jefara regions and the expansion of the Zawia and Zwara plants. The total designed capacity of the targeted plants is 1,000,000 m^3 / day [(12)].

In its recommendations, the NCBMM (1994) plan identified an urgent need to develop policies to conserve water. Users should be aware of the problem of water scarcity and encouraged to take bold steps to conserve water, for example by changing crop patterns and raising the level of efficiency in irrigation systems, such as with the use of drip irrigation systems. Farmers could be financially compensated to change their current practices as a policy of raising prices for water use is implemented. The use of desalinated water to irrigate grain and fodder crops could

[(12)] More details about these plants are to be found in the desalination section of this report.

reduce the burden on fresh water use, while still providing farmers with access to a good productivity (Sholuak & Abo-Zweek n/d.).

AUJHJWSG has been assigned the task of managing water investment. According to its establishing Resolution, it is responsible for maximising the return on water in established and integrated projects and individual farms (AUJHJWSG 2005). The AUJHJWSG sells the water with value of 0.060 LYD / m^3, that with the added value of the purchase price of the authority of implementation and management of GMRP, 0.048 LYD, comes to 0.012 LYD /m^3 (AIMG 2008). In 2003 the Government published a list of existing projects, new projects and their water allocations included in the investment plan of AUJHJWSG (WTNWR 2003). This list was updated in 2011 by the Authority for the Utilisation of Jabel Hasawna - Jefara Water System of the Great Man-Made River. Details of the projects are shown in *Table 2.22*.

Table 2.22: AUJHJWSG projects

Project		Irrigated area / Ha	Number of farms	Allocations of water	
				m^3 / day	mm^3 / year
A-	**Existing projects**				
	Tomeena and Al krareem project	2844	898	70,000	25.55
	Al daavniah and Naima project	2352	503	50,000	18.25
	Imhammid Al mgrreef farm	275	1	14,000	5.10
	Garhabuli agricultural project	4438	1497	94,527	34.50
	Beer Atterfas agricultural project	2365	473	30,603	11.20
	Al wadi Al hay agricultural project	3504	418	60,000	21.90
	Abu Shebah agricultural project	1851	121	40,000	14.60
	Al heera agricultural project	2679	484	69,891	25.50
	Wadi Al mjineen agricultural project	360	72	10,109	3.70
	Jndooba agricultural project	1521	318	24,430	8.90
Partial total of the existing projects		22189	4785	463,560	169.20
B-	**The affected areas of the coastline**				
	Private holdings	76870	19676	1,053,020	384.40
C-	**New projects**				
	Abu Aisha agricultural project	3320	664	80,000	29.20
	Tarhouna agricultural project	950	173	25,000	9.13
	Wadi Tajmaut agricultural project	700	5 fields	20,000	7.30
	Souf Al gene agricultural project	2000	24 fields	95,000	34.67
	Grarat Algataf agricultural project⋆	2000	27 fields	G. water	G. water
Partial total of the new projects		8970	893	220,000	80.30
D-	**Water tanks**				
	The rural and pastoral areas	---	73 tanks	65,000	23.73
Total		**108029**	**25354**	**1,801,580**	**657.63**

⋆(Based on the use of Sparkling local groundwater)

Adapted from (AUJHJWSG 2010b; WTNWR 2003)

The investment plans of the AUJHJWSG are of two types:

A- Projects supervised directly by the AUJHJWSG

The authority has opened the agricultural projects of Abu Aisha, Tarhouna and Graart Al Gtaff to foreign and domestic investment in the agricultural field (Abdulaziz & Ekhmaj 2007; AUJHJWSG 2007, 2010b; WTNWR 2003). *Table 2.23* shows the investment details.

Table 2.23: Investments in AUJHJWSG agricultural projects

Agricultural Project	Investor	Investment in area/Ha	Authority's share
Abu Aisha	National Individuals and Companies	330.5	Fees of water use and the network maintenance services
	Assanabel Addahabia Company	20.0	35%
	Almutahida Company	37.5	Not mentioned
	AUJHJWSG	983.0	100%
Tarhouna	TechnoFarm International LTD	315.0	60%
	Andalusia Agritechnique Company	414.0	70%
	AUJHJWSG	157.0	100%
Grarat Algataf	TechnoFarm International LTD	390.0	70%

Adapted from (AUJHJWSG 2010b)

In addition to water and arable land, the AUJHJWSG's participation and contribution to projects varies from one to another, variously providing such items as agricultural machinery and equipment, irrigation instruments, fuel and electric power, while their partner takes responsibility for planting and agricultural work, and the delivery of the crop in its final form (AUJHJWSG 2007).

The AUJHJWSG's encouragement of foreign investment in water is aimed at introducing advanced and efficient technologies, improved seeds and good management in the agricultural sector. It contributes to the financing of operating and maintenance requirements, as well as helping in the establishment of the infrastructure of transport, storage, coolers, food industries, packaging and packing. Improving efficiency through foreign investment in the natural resources of water, soil and others should be seen from the perspective of sustainable development. The cost of damage to the environment must be passed on to the investor (Abdulaziz & Ekhmaj 2007).

Contracts with national individual companies provide them with the land and waters at the farm gate. The investor pays the fees of operating, maintenance and land rent for the duration of the contract in advance. The water use fee is 0.060 LYD / m^3.

B- Projects and private holdings managed by owners and beneficiaries

This type of project is of two kinds: farms owned by farmers, by purchase or inheritance; and neglected (ignored) lands confiscated by Government, held by agricultural projects and re-delivered to other beneficiaries by usufruct contracts forever subject to law 123 (AUJHJWSG 2008). The AUJHJWSG provides the owner of a farm or the beneficiary with a certain amount of water a day, depending on the size of the farm. The user pays a water use fee of 0.060 LYD / m^3. *Table 2.24* shows the authority's revenue during the period from 01/01/2010 to 31/12/2010.

Table 2.24: Miscellaneous revenue statement for the period 01/01/2010 to 31/12/2010

Revenue	Amount (LYD)
Olive oil sale	45,386.000
Crops sale	473,404.990
Investment	1,415,586.542
Seedlings sale	1,024.500
Water use	379,876.564
Miscellaneous revenues	127,395.000
Assets sale	525,841.700
Total	**2,968,515.296**

Source (AUJHJWSG 2010b)

2.10.3 Problems and obstacles faced the investment plans in Jefara Plain

The implementation of some investment contracts has been delayed by objections from citizens, who have had their lands confiscated under government sanctioned decisions of expropriation in the public interest, arguing their own legal ownership of the land. These lands would normally have been delivered in the form of farms to beneficiaries by usufruct contracts forever (AUJHJWSG 2010b). Another obstacle, according to AIMG (2008), is the lack of a clear, binding and effective legal mechanism for the collection of water fees in the AIMG and the authorities for the utilisation of water systems, including the AUJHJWSG. Other problems are farmer debt, which amounted to 201 million dinars at the end of 2007, and the faltering of new contracts to provide farmers with water (AUJHJWSG 2010a). These circumstances have resulted in a deficit to cover operating expenses, despite the Water Pricing Decision No. 218 of 26/04/1994 requiring these expenses be covered from water sale revenue (AUJHJWSG 2007).

One of the reasons for farmer non-payment for water use in full is the failure to achieve good economic returns, especially in small farms. This report acknowledges this and identifies some of the problems experienced by farmers, such as the need for agricultural guidance and education and training to implement the modern and efficient agriculture methods and practice. There is a real need for agricultural cooperative associations to provide farmers with agricultural equipment and the production supplies such as seeds, fertilisers and pesticides. Farmers require grants and soft loans to enable the production of strategic crops that can achieve high economic returns. NCBMM (1994) has identified these same problems, as well as the additional problems of marketing constraints, inadequate import controls and the need to stimulate exports.

2.11 Summary

The water scarcity problem in Libya is exacerbated by a growing population and its dominant arid geography and desert climate. An increasing reliance on oil revenues has seen agriculture decrease to only 2% of GDP by 2007, and facing significant challenges, with domestic food supplies unable to meet demand and cultivation limited by a lack of arable land and water. Despite an institutional framework supported by legislation, water sector governance has been poor and water development projects unable to cover Libya’s water deficit.

Political, social, cultural, planning and economic factors underlie the mismanagement, in particular, inefficient farming practices and a lack of expertise, transition possibilities, water monitoring and treatment techniques, and water fee collection in the AIMG. Poor economic returns, marketing constraints and the faltering of new water contracts have also led to significant levels of farmer debt. Agricultural education, training and funding are needed to implement modern and efficient methods and practice.

The research will go beyond examining the feasibility of the GMRP as compared to desalination to meet water deficits. The target is to achieve sustainability of water flows by considering the operating expenses for as long as possible at optimal use. The water quality and levels in ground reservoirs will not stabilise until withdrawals are reduced to reasonable limits. This is critical to achieve irrigation sustainability in the JPR in the long term, taking into account both population and economic growth.

This chapter provides theoretical answers to the first and second research questions. More complete answers will come from the analysis of information from interviews and comparisons of the situation in Libya with that of other countries. The next chapter will therefore review the experiences of the NENAR and other countries in the world facing similar challenges, comparing them to the Libyan experience.

3.0 CHAPTER THREE: LITERATURE REVIEW

3.1 Introduction

This chapter explores the current debate about water management policies and the factors affecting their formulation and implementation in the arid and semi-arid zones of Libya and the countries of the NENAR. In this context, relevant and significant experiences of other countries in the world facing similar challenges are also considered (Sachdeva 2009). The literature pertaining to water management policies is examined to better understand the processes and the experiences of water management reform in these countries and the variables affecting them. A review of the existing literature should establish a basic framework for integrated water resources management that would allow the development of a viable water policy able to achieve sustainable water security in Libya.

The study of the current state of water institutional frameworks, water infrastructure and water management policies should provide insights into the parameters and scope of research into improving WUE in agriculture and the effect of water price on farmers' viability. The literature review allows both an identification of, and an investigation into, the challenges faced by policymakers in framing water policies, as well as the prevailing views, theories, ideas and opinions of farmers in relation to water scarcity and WUE in irrigation (Laamrani & Salih 2010).

The literature review also highlights the economics of ground water management and international and regional water policies related to water scarcity. Theoretical approach to the water demand, policies dealing with water scarcity and its use efficiency are included in this chapter. Libya and the NENAR countries, many of them Muslim with common traditions, are located in the world's driest region (FAO 2012b). There is a need for viable and effective water utilisation policies in the NENAR as a whole, because with a similar climate and terrain, these countries face a common challenge in using and managing their often limited water resources efficiently. The chapter concludes with an overview of the history of water management policy in Libya and an examination of relevant prevailing theories, ideas and opinions concerning the issues of water scarcity, conservation and management to determine any gaps in the literature.

3.2 Water scarcity and the economics of ground water management

Water scarcity is a global issue, affecting at least 1.2 billion people, a fifth of the world's population (WHO 2009). Factors such as population growth, increasing urbanisation, water demands from agriculture, industry and households, the over-pumping of aquifers, a lack of infrastructure and poor water quality due to pollution all underscore an increasing need for better water management policies and practices globally [(13)] (WHO 2009).

Rainfall is critical in ensuring a sufficient water supply, but fresh water resources, such as rivers, lakes and waterfalls, are also highly dependent on whether enough groundwater is trapped to eventually make its way up to the surface (Pereira, Cordery & Iacovides 2009). Changing climates, warming temperatures and deforestation can cause these water channels to dry up. Water scarcity is a sustainability issue as well as an environmental factor (Pereira, Cordery & Iacovides 2009) and is also dependent on geographic factors. World-wide, the NENAR has the

[(13)] *10 facts about water scarcity,* WHO Water Fact File, 2009 least amount of natural water resources. On the other hand, while tropical Asia and South America have the most natural water resources they also experience water crises. Water scarcity can be seasonal, and periods of drought across the world are very common (Postel 1992).

Essential to sustain life, water resources are highly valued, requiring good management to provide adequate supplies of quality water to meet the needs of people, agriculture, industry and the environment. In practice, management systems need to be both economically and politically viable, particularly in the context of pricing and institutional reform. According to Koundouri (2004), water resource management should be driven by policies able to respond to inefficient practices in water distribution and utilisation, and take into account issues such as water markets, agricultural needs and measurement of groundwater scarcity.

There should be a working economic paradigm to ensure efficient and effective management. This is critical as water is subject to competition when considering who will get to use the water, and the amounts they will be allowed to use. As a finite resource, water requires efficient use. Ideally, the implementation of more effective and efficient water policies to manage consumption and usage would improve levels of productivity. In examining the economics of water use, in particular irrigation, Schoengold and Zilberman (2007) point out that an increasing demand for water supply calls for decisions at many levels to meet the demand, all of which impact upon WUE.

While irrigation is considered a practical and effective supply solution for agricultural productivity, its expansion has had significant negative impacts, such as the misallocation, mismanagement and overdevelopment of water resources, overspending of capital, and costs from contamination and losses in the ecosystem. For Al-Jayyousi (1995), enhancing management of water resources should be given priority in future water policies. Demand management needs to be put in place to control water use through direct measures, such as regulation and technology, and indirect measures affecting voluntary behaviour, such as market mechanisms and financial incentives (Shideed, Oweis & Osman 2003).

With many nations, such as Libya, depending on groundwater for water resources, groundwater management is a critical practice. Rausser (2000) views water negotiation processes through two theoretical models: (a) Nash-Harsanyi's collective choice or bargaining approach, and (b) a non-cooperative multi-bargaining framework. For Rausser (2000), these models, before implementation, should fit the political character of the nation, as found in governance functions; physical water systems; the political power structure; and the economic structure. From a Marxist perspective, Selby (2005) sees that the keys to understanding water problems in Middle East are the major structural features of the region's political economy rather than natural limits or technical inadequacies.

According to Koundouri (2004), water management is based on the idea that water is a commodity. Although it is not traded, water is subject to negotiation, especially among nations that share common water resources and courses. In addition, any groundwater resource management model is best designed according to a country's political economy, as there are many factors to take into consideration, individually and institutionally. Countries with different political and economic structures have varying priorities and may approach water solutions quite differently. Nations driven by agriculture are more likely to allocate water resources to this sector, whereas nations heavily invested in industries may not value the agricultural sector as much and source food from elsewhere.

It can be seen that the design of water policies, including groundwater resource management in transaction and negotiations, is influenced by internal political mechanisms and socio-cultural aspects in countries and territories. Accordingly, it is important to review water policies designed by international organisations. The next section gives an overview of some of these policies.

3.3 International and regional water policies

The (FAO 1993) report [14] on Food and Agriculture provides important insights into the complex relationship between water resource issues, agriculture and water policies, examining the many initiatives aimed to address and identify issues such as water scarcity; world water use; water and health; and water as a strategic resource. The report establishes an important relationship between the water sector and the national economy. Water fuels the domestic, industrial, agricultural and environmental sectors and a decline in supply can jeopardise the way of life of the people, affect production capacity, and lead to many environmental problems and costs. Water policies, therefore, are typically oriented towards responding to relevant challenges. In practice, although there are a wide range of water policies depending on country or regional needs, these are usually implemented according to policy guidelines endorsed by international organisations.

The UN (2006), actively promotes the advantages of establishing joint water programs by creating integrated water resources management initiatives at regional,

[14] Part III – Water Policies and Agriculture, FAO, State of Food and Agriculture, 1993.

country and local levels [(15)]. For example, the pressure on the local or country water resources can be reduced by “Virtual Water Trade”. The concept of Virtual Water Trade is associated with the comparative advantage concept in international trade theory (Wichelns 2001). A country can import virtual water by importing the products that require a lot of water in their production and export the products and services that require less water or that generate greater incremental values (UNESCO 2012). This is dependent on the conditions of production such as the location and time of production and WUE. In other words, the virtual water trade depends on how much we can save from the water if the products were imported rather than produced locally (Hoekstra 2003). The Asian Development Bank [(16)], similarly promotes water reforms, effective water management, and regional cooperation based on information and resources exchange (ADB 2001).

Water scarcity problems in Egypt have led the government to adopt bold reforms in the agriculture sector depending on water irrigation projects. Water management strategies based on recovering the full costs; pricing based on quantitative measures; the adoption of formal water allocation; and private sector participation in funding and management have been introduced (Baietti & Abdel-Dayem 2008). The sanitation program in Egypt has been considered one of the major intervention projects in water management in the world with total investment up to 1000 million USD (FAO 2003). The Egyptian government also adopted a surface water irrigation project instead of groundwater pumping (Baietti & Abdel-Dayem 2008). This sanitation program and the surface water irrigation project have increased the

[(15)] As an example see the 2006 UN publication of strategies to address water scarcity, *Coping with Water Scarcity: a strategic issue and priority for system-wide action.*
[(16)] The ADB is an international organisation targeting sustainable water policies in Asian countries.

revenues and dramatically improved land affected by salinity (Baietti & Abdel-Dayem 2008; FAO 2003).

According to Baietti and Abdel-Dayem (2008) Tunisia has been a pioneer in exploring the feasibility of water desalination by means of solar energy to provide potable water in response to an expected increase in water demand due to its growing population and to its expanding industrial compounds, as well as an influx of tourists. Desalination stations using renewable energies were installed in cooperation with the French Commissariat for Atomic Energy in a number of arid southern Tunisian cities in the early 1980s. Tunisia makes a typical case study for desalination needs assessment in the Mediterranean region (BenJemaa, Houcine & Chahbani 1998).

Mualla and Salman (2003) examine the pressures on the Syrian government to increase the possibilities of a new water supply to respond to increasing demands for water. Since the new water sources have become more and more scarce and the costs of projects for increasing the supply of water have become very high, the focus has shifted to other alternatives for efficient use of water, such as the modernisation of irrigation and the implementation of water demand management (Mualla & Salman 2003).

Despite the fundamental challenges existing in Jordan in terms of water legislation, institutional structure, and required data, policymakers and the public believe that dealing with future water scarcity can be achieved through management and utilisation of water sources (Shatanawi & Al-Jayousi 1995). While progress in Jordan has been made, and despite efforts to improve irrigation efficiency and encourage farmers to grow crops that consume less water, agricultural water demand has not decreased appreciably (Scott et al. 2003). Shatanawi and Al-Jayousi (1995) recommend that market mechanisms should be introduced on a pilot basis in terms of new pricing policies, as this would provide an incentive to economise water use and cover operation and maintenance costs as well as part of the capital cost. The Ministry of Water and Irrigation continues to be concerned about the acute water scarcity the country faces, as well as the need to continue working with concerned stakeholders to assure future water supplies (Scott et al. 2003).

The World Bank report (Xie 2006) on Singapore's experience in addressing water scarcity (The Singapore Green Plan 2012), indicates that the Singapore People's Action Party Government has set sustainable water supply as the main target of water strategy since independence. The core of this strategy has depended on: diversifying and enhancing water supply sources; developing water demand management strategies; building up a robust water industry; encouraging private sector participation; and exploring alternative policies, technologies and strategies to ensure long-term sustainable water supply. These measures, with the strong political will and support from the government, has led to Singapore's remarkable progress in efficient water management and offers useful lessons even for large countries (Xie 2006).

Looking at the general nature of water scarcity, Postel (2000) formulates two goals to solve the issue: reserving water for eco-systems, and doubling water production. This water management approach addresses efficient use as a solution to making the most out of what is available without creating any harm to the environment and water resources.

It can be observed that many policies and relevant laws are more concerned about water and its impact at a higher level. Policies relevant to farming tend to focus on how farms can use water sustainably, rather than on the response of the farmers towards water scarcity. The various regional policies that Libya is a signatory to will be explored in the context of the Jefara region to ensure that the agricultural sector is sustainable and has the ability to support itself. The effectiveness of these policies will also be used to create a framework for sustainable water and agricultural policies.

3.4 Water demand

3.4.1 Water demand management

Demand management controls water use by both direct measures like regulation and technology, and indirect measures that affect voluntary behaviour, such as market mechanisms and financial incentives (Shideed, Oweis & Osman 2003). The efficient market mechanisms have to be developed and constantly adapted to meet changing demand within the social and environmental constraints of irrigation communities (Bjornlund 2003). The price of water has recently become to be seen as the main instrument to regulate demand, as evidence suggests that efficient water pricing reduces the pressure on water resources (Arabiyat n/d.; Lawgali 2008).

There is a also a growing emphasis on managing water demand through improved efficiency of water allocation mechanisms (Johansson et al. 2002). Effective future water policies should give priority to measures that enhance water demand management (Al-Jayyousi 1995). Libya has made great strides in the provision of new sources of water from the desalination water recycling and finally GMRP. The high costs of getting water from these sources require urgent transformation from water supply management to water demand management to achieve the economic sustainability for the country (Wheida & Verhoeven 2007a).

3.4.2 Price elasticity of water demand

Water demand can be reduced by reducing demand for goods produced with water, either by substitution in production and consumption with other goods, or importing them. This indirect demand reduction is the primary determinant of prices in water markets (Berrittella et al. 2007). In order to influence water demand through pricing policy, it is important to understand the price elasticity of water demand. However, it is difficult to analyse and calculate elasticity between higher water prices and lower consumption in NENAR because of the lack of metering data, and the influence of other factors on demand (Lahlou & Attia 2005). Water supply is very much a function of price elasticity. In other words, as prices rise demand decreases and vice versa (Lawgali 2008; Wheida & Verhoeven 2007a). However, the relationship is not as simple as it first appears. Arabiyat (n/d.) finds that the relationship between water price and demand in agriculture in Jordan is quite inelastic in the long-term.

It was also found that large variations in gross margins were related to high water price demand elasticity. In other words, as gross margins fell, farmers used less water at a given price and as gross margins increased farmers used more water (Doppler et al. 2002). In contrast Salman and Al-Karablieh (2004) find that water demand for agriculture in Tunisia is quite price elastic over a long interval. However, it is inelastic where there is a decrease in the overall water supply.

In Tunisia, the price elasticity of demand for agricultural water is relatively low, but it varies by region (Lahlou & Attia 2005). Schaible (1997) notes that water demand for the Pacific Northwest in unrestricted groundwater use is inelastic. This literature indicates that the elasticity of demand is not conclusive. It can be said that elasticity depends on a number of factors and, varies from country to country and region to region, which necessitates exploring this in the context of Libya.

3.5 Policies dealing with water scarcity

3.5.1 Indirect restriction of fresh water use

Electricity rationing is a useful tool to improve WUE. According to Scott et al. (2003) a mix of energy rationing and pricing mechanisms can reduce water demand in Jordan. Another tool would be to provide incentives for farmers in developing countries to use recycled water by lower recycled water prices and subsidies to obtain new equipment (Qadir et al. n/d.). For example, in Crete, there is evidence that farmers are willing to use recycled water if the full economic price for fresh water is charged (Menegaki, Hanley & Tsagarakis 2007).

Some of the measures Libya has introduced with a degree of success have been raising the electrical power price or using block charges by increasing block tariffs (the more you use the more you pay), and presenting incentives for using recycled water to save fresh water (Wheida & Verhoeven 2007a). GWA is at present working to find a relationship between the quantities of water withdrawn and the electricity consumed in the process of pumping in order to dispense water meters (GWA 2010).

3.5.2 Privatisation and water allocation mechanisms

Privatization of water sector would have significant benefits (Perry, Rock & Seckler 1997). In the United States and Australia, irrigators cope with severe water scarcity by becoming increasingly familiar with water markets and following market signals (Bjornlund 2003; Dinar & Subramanian 1998). Although the monarchies and socialist and Islam inspired governance systems of Libya, Egypt, Iraq, Iran, Syria and Tunisia made some progress in privatizing reforms in the water sector in the twentieth century, the will for such reforms was poor (Allan & Allan 2002).

Governments can encourage consumers to use water more efficiently by promoting the development of water rights and water markets (Dinar & Subramanian 1998) with sufficient autonomy, financial and otherwise, to operate and maintain systems adequately and sustainably (Savenije & van der Zaag 2002). On the other hand, this neo-liberal free market approach to water supply, which is mainly based on profit motives, may not achieve the benefits it was supposed to bring to the poor (Prasad 2006). Burdening the poor with extra changes is a major problem. A rationing system could be another option or an alternative to neo-liberal free market.

A water rationing system refers to a specific volume of water allocated to water access entitlements in a given season (AWR 2005). Water allocation responds to the scarcity value of water (Rosegrant, Schleyer & Yadav 1995) through various mechanisms such as user-based allocation and water markets (Dinar, Rosegrant & Meinzen-Dick 1997). Tradable property in water facilitates reallocation of the water between sectors and creates incentives for efficient water use (Dinar, Rosegrant & Meinzen-Dick 1997). Dinesh, Kumar and Singh (2001) consider tradable private property and water use rights as answers to Gujarat's (India) water problems.

For The World Bank, water markets are the most effective way to manage the NENAR water scarcity, as private rather than public management is generally more efficient (Moustakbal 2009). Johansson et al. (2002) conclude that to improve WUE for irrigation agriculture *"getting prices right"* is seen as one way to allocate water, but how to accomplish this remains a debatable issue. For Dinar, Rosegrant and Meinzen-Dick (1997), no single type of allocation can be generalized; each has advantages and disadvantages. The requirements and outcomes need to be carefully examined.

3.5.3 Water pricing

Another important facet of the policymaking is the water pricing (Koundouri 2004). The 1992 *Dublin Statement on Water and Sustainable Development* identifies water as an economic good, beginning an ongoing debate as to whether water is a private good, subject to allocation through competitive market pricing, or a basic human need and therefore a public good (Perry, Rock & Seckler 1997). Water pricing should change the present concept of water from water as a free common pool resource to water as an economic good in the market place, and accurately reflect water's economic, or scarcity value (Alghariani n/d.; Dinar & Subramanian 1998). As an economic good, water has a cost and should be priced. However, as a human need, water should be used efficiently and equitably.

In many countries, irrigation water is essentially a free good, and when a government intends to set or raise water charges it usually faces intense political and bureaucratic resistance (Al-Jayyousi 1995). Both the OECD (2010), and Dinar and Subramanian (1998) believe that the appropriate pricing of water usage would encourage people to waste less water and invest more money in water infrastructure. The policy of the low price of the water does not provide incentives to water users to use the water more efficiently (Dinar & Subramanian 1998; Salman & Al-Karablieh 2004). Pricing should reflect the scarcity of water, discourage wasteful use, and promote water-saving behaviour (Lahlou & Attia 2005). The World Bank recommends limits to water tariffs, with water costs not exceeding 5-6% of the incomes of the poorest households (Salman & Al-Karablieh 2004).

Generally, the price of water is used as the main instrument to regulate demand by the relationship between water use and price, when all other factors are held constant (Lawgali 2008). In northern China, pricing mechanisms have a high priority in dealing with water scarcity (Yang, Zhang & Zehnder 2003). In the Spanish context, Berbel and Gómez-Limón (2000) believe that water use will not decrease until prices reach such a level that they negatively affect farm income and agricultural employment. However, in Jordan, farmers are willing to pay two and a half times the prevailing price of groundwater without this having any impact on the cropping pattern or the planted area (Salman & Al-Karablieh 2004). In Morocco, an increase in tariffs by 21% led to 32% saving in water (Lahlou & Attia 2005). Speelman et al. (2009) point out as well that farmers in South Africa are quite responsive to even small changes in water price by more WUE.

Charging for water use is one of the effective means to reduce water wastage and this policy has not been implemented satisfactorily in Libya (CPPAP 2003). The CPPAP's report (2003) states that the price of water in Libya must reflect the real cost of water so that water will not be wasted, and that the cost of the agricultural products must bear the real cost of water. Already, the Arab Organization for Agricultural Development (AOAD) see the extent to which a farm can contribute to bearing the burden of the cost of availing water services as one of the most important aspects of policy in rationalizing irrigation water application (AOAD 1997). The AOAD (1997) suggests that the share would be within the limits of LD 0.067 / m^3, on the basis that water share of the net farm income is around 30%.

Water pricing nevertheless has weaknesses as a policy (GPC 2003). In Italy, Bartolini et al. (2005) note the complexities of farm reactions to water pricing.

Current water pricing in Jordan does not always send the right signals to users (Arabiyat n/d.). Despite high irrigation water prices in the Yellow River basin of northern China and also in Tunisia, the effect of water pricing on water use behaviour has been intrinsically weak (Frija et al. 2009; Yang, Zhang & Zehnder 2003). Many factors need to be considered in relation to water pricing in Libya, such as farmers’ reactions, price costs, and the maximum price advocated by The World Bank. Significant differences in the circumstances between NENAR countries have to be considered as well as more understanding of the problem in the Libyan context.

3.5.3.1 Volumetric water pricing

The need for volumetric pricing, metering, movement away from uniform tariffs and abolishing minimum prices have been considered in many countries (Dinar & Subramanian 1998). In Italy, costs for water are usually distributed according to an area payment unrelated to the actual water use. However, this does not provide incentives to reduce water usage (Viaggi et al. n/d.). Salman and Mualla (2008) propose using market-like instruments such as volumetric prices or quotas instead of the fixed charges at flat-rate basis to create incentives for water saving. Dinesh Kumar and Singh (2001) are convinced that volumetric pricing of irrigation water can be used to manage the water demand in Gujarat.

As long as the farmers pay fixed charges, the competition will be in the production regardless of the volume of water used. Farmers in Libya have always taken into account the electrical power tariff in irrigation *a fortiori* in considering the volume of water used and this would be expected in any introduction of volumetric water pricing.

3.5.3.2 Full cost pricing

Full-cost recovery prices should encourage irrigators to use water more efficiently on higher value crops, and force those who are unable to make the necessary adjustments to cease irrigation and sell their water to those who can use it more efficiently (Bjornlund 2003). For agriculture purposes, the real cost of agricultural products should be calculated, including the actual cost of water, the energy used, and any other factors of unsubsidised production (CPPAP 2003).

Water savings could be realized through full cost pricing (Scott et al. 2003). Theoretically, if water users pay the marginal cost and scarcity rent of supplying that water, more efficient water use would be made (Johansson et al. 2002). Scott et al. (2003) and Viaggi et al. (n/d.) agree that water demand can be reduced if water users bear the environmental costs of water extraction as well as the financial and the opportunity costs of water provision.

Arabiyat (n/d.) asserts that water pricing policies need to be based on the assessment of costs and benefits of water use and should consider the financial costs of providing services and resource costs. For example, the provision of water irrigation pricing policies in Jordan are based on the assumption that water prices should cover at least the cost of operation and maintenance and should be used as an incentive to improve on-farm irrigation use efficiency. Shatanawi and Al-Jayousi (1995) argue that new pricing policies in Jordan should consider the opportunity lost value of water, and cover operation and maintenance costs and part of the capital cost to motivate WUE. In Libya's case, the economics of water supply should be reconsidered and water policies orientated toward the recovery of the costs of providing water. This should be in a manner which ensures the necessary funding for the development of current water resources and other alternative sources for any sources may be depleted (LG 1999).

In principle, full cost pricing will be difficult in Libya because farmers have not experienced having to pay for water before, even at subsidised prices. Moreover, the full cost of GMRP's water will be very high. This study is considering the feasible costs which would lead to a pricing scheme that on one hand could be afforded by consumers, whilst on the other hand could also serve as an incentive price for the conservation of water. Two significant risks associated with the water pricing policies appear in the literature, rises in the water price and the effect of subsidies in irrigated agriculture. These risks are outlined in the next section.

3.5.3.3 The associated risks with the water pricing policies

Risks of rises in water prices... Increases in water prices involve some risk (Speelman et al. 2009). They could lead to a reduction in a country's agricultural production, increase prices for consumers, and threaten food self-sufficiency policies which could then result in increased imports and the loss of market share for local irrigators (Liao, Giordano & De Fraiture 2007; Tardieu & Préfol 2002). In Libya, it is the problem of water scarcity itself that threatens food self-sufficiency. The Government could conduct a feasibility study comparing domestic cropping and the importation of products using the real cost of water to govern the decision to produce or import the product.

Subsidy in irrigated agriculture... Some levels of subsidy in irrigated agriculture can be positively included in water markets such as free irrigation water that farmers trade or subsidized power supply to wells (Perry, Rock & Seckler 1997). However, overuse of irrigation water is usually encouraged by massive subsidies (Asia 2003).

NENAR governments have been looking for ways to pass part of the cost on to consumers and offer some conservation subsidies (Roudi-Fahimi, Creel & De Souza 2002). Already in 1996, a national committee in Libya formed to re-evaluate the water situation recommended lifting subsidies on less efficient irrigation systems and raising custom duties and taxes to limit their use (Miludi n/d.).

3.6 Water use efficiency (WUE)

3.6.1 The concept of WUE

The sustainable use of groundwater can feasibly be assured through producing larger crop harvests with less water use or, in other words, by improving WUE (Oweis & Hachum 2012). WUE is a term used to assess irrigation systems' performance. WUE is the ratio of the amount of water required to produce a specific production level to the actual used amount (Shideed, Oweis & Osman 2003). In an economic context, water productivity can be measured by the volume of water taken into a plant to produce one unit of the production, such as one KG of production (Hamdy n/d.).

The available information on WUE and crop water productivity in Libya reveals that, within certain limits, efficiency can be effectively increased while maintaining the same, if not more, total agricultural productivity (Alghariani n/d.). On the other hand, (Oweis & Hachum 2012) point out that the WUE does not lead necessarily to maximized profit and that WUE may not achieve maximum profit. Proper management should take into account, as well as the interests of farmers in long-term sustainability of water resources, the value of water at the national level and at the farmers' level.

3.6.2 Farmers' options in response to water scarcity and the rise in its price

This section shows farmers' performance and behaviour in response to water scarcity and the rise in the price of water.

3.6.2.1 Changing the pattern of crops

The concept of water productivity can be used as a tool for water allocation among crops competing for the limited water supplies of a country (Alghariani n/d.). Irrigation systems allow crop diversification, as water allocation and crop planting choices respond to the scarcity value of water (Rosegrant, Schleyer & Yadav 1995). Water Productivity can be used for crop selection according to the principles of comparative economic advantages and the opportunity cost of water (Alghariani n/d.). Farmers will continue to grow water-intensive crops because it is profitable as long as they do not have to pay for the large amounts of water required (Rosegrant, Schleyer & Yadav 1995).

Al-Weshah (2000) shows that, in Jordan, the selection of crops which need less water maximize the net revenue from agricultural production, and demonstrates that a 9% net water saving was possible while still maintaining the same level of profitability. Switching to less water-dependent crops in NENAR and Africa, selling them in the international market, and importing more water-dependent crops could also help conserve water (FAO 2010; Roudi-Fahimi, Creel & De Souza 2002). For example, in Morocco a 21% increase in water tariffs led to a 38% increase in crop intensification (Lahlou & Attia 2005). Similarly, in Tunisia, when prices for irrigation water were raised, Tunisian farmers sensibly shifted to higher value crops (Brooks & Wolfe 2007). Water use did not decrease but farmers switched to higher value crops which gave increased returns to compensate the increase in water prices.

Cropping patterns in Libya lack balance and do not comply with the technical requirements of ideal crop combinations compatible with the concept of water productivity (Bouzid 1996). Yields of agricultural projects in the JPR could conceivably be improved by using alternative patterns of crop combinations depending on water availability, with some crops previously not cultivated becoming economically more feasible (NCBMM 1994). Almontaser (2009) suggests a modification of the existing crop combination for Jefara region could economize the quantities of water by 60%, as well as increasing farmers' incomes. In the Jefara region, the average net return per hectare for the proposed crop combination was 2298 LYD, while the existing crop combination was 1664 LYD. The net return on the unit irrigation crop combination proposed was around 375 LYD, compared to returns of 168 LYD from the existing crop combination (Almontaser 2009).

As is the case in Jordan, Tunisia, Morocco and NENAR in general, the concept of water productivity as a tool for water allocation among competing crops can be used in Libya as well, as the same climate is prevalent and the same crops grow in the region. According to Bouzid (1996), optimizing the economic use of available water resources, especially those from the GMRP, requires determining the most suitable crop patterns and agricultural rotations able to be implemented in field crop production. The resulting increase in the efficiency of irrigation water usage would achieve the maximum net return per unit of irrigation water use in agricultural plant production.

3.6.2.2 Changing the techniques of irrigation

Water-saving technologies in irrigation can also be adopted to improve irrigation efficiency. For example, Yang, Zhang and Zehnder (2003) point out that in northern

China water-saving technologies are the ultimate way to deal with the challenges facing irrigated agriculture. In terms of the rationalization of water use, developing and adopting modern facilities and methods of irrigation in Libya increases the efficiency of irrigation by about 30%, which economizes about 1.2 billion cubic metres of water annually (Bouzid 1996).

Salman and Mualla (2008) suggest that the government in Syria could adopt a subsidy policy to support irrigators in their possession of water saving technologies. The adoption of such a policy entails the setting up of factories for the manufacture of modern irrigation technology; preparing and implementing training programs for farmers and technicians on modern farming techniques and the use of technology; the provision of the necessary funds to farmers for the acquisition of these technologies; and the development of appropriate agricultural legislation to be implemented by farmers' associations (Bouzid 1996).

In the Spanish context, Berbel and Gómez-Limón (2000) argue that the revenue from water should be administered by farmers' associations themselves to induce the members to invest their financial resources in water-saving technologies. The Government of Libya has started using nuclear techniques which identify appropriate land and irrigation management practices to improve irrigation for more crops per drop of water. According to the International Atomic Energy Agency, the project is already giving positive results (AfrolNews 2010). The key point here is that low water prices in themselves do not provide incentives to adopt water saving technologies (Salman & Al-Karablieh 2004).

3.6.2.3 Moving to other sectors

As water prices increase, water tends to move from agriculture to higher value industries in other sectors (Wheida & Verhoeven 2007b). In Jordan, national programs promoting business development increase the rate at which water moves from agriculture to industry (Scott et al. 2003). Given the scarcity of water and food security in Libya, it has been argued that it is more rational to import most of the high water consuming crops and develop an economic policy based on trade, tourism and industry (Wheida & Verhoeven 2007b). According to Salem (2007), in order to improve WUE in Libya, increasing returns and reducing agricultural water use should be considered.

3.7 Water utilization in the NENAR

A number of countries in the NENAR have implicitly implemented virtual water strategy because the water available does not cover their growing demand (Allan 1996). Some public officials in NENAR countries are reluctant to acknowledge the role of virtual water related to political concerns in their food security strategies. A common concern centres on self-sufficiency versus food security and the “independence of food supply”. However, despite this, food imports in the region have remained a significant part of total food supplies (Wichelns 2001). According to Hammaad (2009), Libyan crops with a high price of water required per cubic metre from GMRP in comparison to the cubic metre price for its production abroad must be imported and vice versa, taking into account the economic returns. Global trade in Virtual Water helps partially in restoring the water balance in Libya. It saves water for more efficient use and will lead to more cost effective agricultural products which will in turn benefit future generations (Hammaad 2009).

Inefficient water utilisation and wastage in the agricultural sector is a major issue in NENAR (Araus 2004). The region accounts for 10% of the total global area under irrigation, using 88% of the water withdrawn in agriculture (FAO 2006). Significantly more water is delivered per unit area *(Hectare/Square meter)* than is required (Hamdy n/d.). At present, irrigation efficiency in the world's developed and NENAR countries is only 40% (Abu-Zeid & Hamdy 2002; Seckler 1996). In Syria, low on-farm WUE (40-60%) results from evaporation, poor maintenance and over-irrigation through traditional basin irrigation methods (Salman & Mualla 2008).

Water scarcity varies in different areas in NENAR, as does the attention given to resolving the problem. Water savings of up to 40% in Libya could come from improved user behaviour and perception of water issues in agriculture (Miludi n/d.). WUE can be effectively increased while maintaining the same, if not more, total agricultural productivity (Alghariani n/d.). Inefficient water utilisation is a global problem, but water scarcity in NENAR, especially Libya, exacerbates its effect. Libya's population growth rate is among the world's highest (Miludi n/d.). Growing from 1.1 million in 1955 (UNPD 1994) to 5.3 million in 2006 (NPC 2010), the population is predicted to reach 12.4 million in 2025.

With the total annual renewable fresh water supplies in Libya estimated at 4,600 million m^3/ yr., the average annual per capita water availability in Libya has decreased alarmingly from 4,103 m^3 in 1955 and 1,017 m^3 in 1990, to about 113 m^3 in 2006 (Alghariani 2003; Wheida & Verhoeven 2007b). Agricultural irrigation accounts for 84% of water usage in Libya while agricultural production provides little more than half of Libya's food and exports only about 0.3% of its agricultural production (European Commission 2009, pp. 26-7; GAFI 2008). The current inefficiencies in agricultural water use point to Libya's water shortages worsening in the future without major intervention (Alghariani 2003). Given that Libya is highly dependent on imported food, food security is a major issue and liberalisation is expected to increase dependence on imports (European Commission 2009). The country's acute water shortage and the low level of food self-sufficiency are crucial issues for Libya's policy in agriculture and water sectors.

3.8 History of water management policy in Libya

The country has been subjected to a variety of water management policies, some even dating back to before Gaddafi's rule. However, most of the current management policies are associated with the Gaddafi regime (1969-2011). Before Gaddafi's rule, there were no major bodies contracted to oversee the management of the water bodies. Most of the water issues in the Jefara region were addressed in an amateurish manner devoid of professionalism. However, the region still depended on surface and groundwater as the major water sources. Maddy-Weitzman (2003) states that there were no credible means to manage the water reservoirs. This led to the region being able to harness only 3% of the water supplies. The region did not have most of the dams created to control the water resources. The author adds that later sixteen dams were constructed that could store over 60 million cubic meters of water per year. These dams were mainly filled by several sources including natural streams (Maddy-Weitzman 2003, p. 76). These streams provided water to several regions including the Jabel Akhdar, Jabel Nefusa and most of the central zones.

The Jefara region was mainly complemented by groundwater sources as the main source of water supply. The water was extracted via wells that ranged from several meters to thousands of meters in depth. These groundwater aquifers were both renewable and non-renewable. Most of the renewable aquifers were located in the Northern regions and thus fell under the high precipitation regions. They mainly ranged in age from the quaternary to cretaceous age categories. These sources were able to contribute more than 2400 million cubic meters per year. However, this was against an annual recharge of 650 million cubic metres. Using these figures, it is important to note that these sources will eventually run out. It indicates that the management did not consider the three core considerations of water conservation: the nature, the current generation and the future generation (Loucks & Gladwell 1999, p. 9).

The Jefara region has large sedimentary water basins that covered an extensive part of the region. This contributed a great amount of water for the local use and the agricultural development. The agricultural development was not that advanced in the period as there were no credible bodies charged with that mandate. Therefore, the agriculture was still done in small scale in that period of time before Gaddafi's rule. Later, well fields were developed to address some of the water shortages. These wells supplied the GMRP (Hannah 1995, p. 54). This was done with a vision that the project would be able to supply the agricultural fields with more than six billion cubic metres per day. They would also cater for the population centres in the north.

The hydro-geological studies predicted that the GMRP's water would be able to address the water deficits in the zones. Hannah (1995) adds that the unconventional water resources that were in the form of desalination were rare and could only cover a minimal portion of the demands stemming from the industries and domestic use. Back then there were no ample resources to cater for the management of the sewage water and most of the water was usually considered as waste. However, the little amount that was able to be rehabilitated was put to use in the farms as irrigation water.

During the pre-Gaddafi era, the aquifers contained in the water basins were of great importance. These aquifers included the Post Eocene in Libya. The water did not have great water quality and was not viewed as ample enough to cater for the increasing water demands. The basin was subjected to several studies that accompanied deep drilling and a number of geological surveys. According to Hannah (1995), the generated results assisted in determining the hydraulic properties and direction of flow of the water. This enhanced the setting of a base for the continuous monitoring of several wells. The said basin was in use since the early 1950s in the provision of water to several irrigation projects and for oil production activities, more recently the GMRP conveyance system (Alsharhan 2003, p. 42).

3.8.1 Water institutional frameworks and water infrastructure

According to Otman and Karlberg (2007) the Libyan water resources have never been plentiful due to the natural aridity of the region. The country is stated to be one of the most water-scarce countries in the world. The Jefara region has also been notorious in terms of minimal amounts of rainfall, specifically 200-400 mm / year. The monthly rainfall amount is mostly negligible. The temperatures are usually hot due to the burning winds emanating from the desert. It is however moderated by the cooler air coming from the sea (Miludi n/d.). A Mediterranean climate prevails over the region most of the time. The desert zones usually have a mean summer temperature of around 40 degrees. The water resources are usually limited due to precipitation and the ground water recharge.

Miludi (n/d.) states that the country depends on the groundwater as the main source and several strategies have been implemented by the policymakers and the government to utilise the water resources available in order to make up for the water loss. This is an attempt to be able to cater for the rising water resources. Some of the strategies that have been used include desalination and reuse of waste water. The author points out that noble attempts have also been made at creating manmade resources like the GMRP. There has been a mismatch between the availability of water and demand in the coastal areas. This has eventually led to a situation where there is a crisis of unregulated development of ground water. The drawdown of water remains at an all-time high of four metres a year (DiPiazza 2006, p. 43). Some other development issues also pose a risk to the crisis. For example, there is an unregulated development of agriculture in the desert regions. This has led to another situation where there is a risk of improper management of quantity from the desert aquifers. The private sector managed to address part of this crisis by initiating an irrigation process in the desert region. Thereafter, the irrigated area improved from 60,000 ha in the late - 1990s to 200,000 ha in 2006.

The *Oxford Business Group Report* (2008) states that there have been various challenges in the administration of the water resources. The manmade resources were therefore developed to address this situation as they could cater for the shortage (Oxford 2008). The manmade resources have therefore been used to provide 2.4 billion cubic metres of water every year. This has caused it to be labelled as the most essential water resource in the country. According to the report (2008), most of the water is diverted to agriculture, with a greater percentage (70%) ending up in farming (Zidan 2007). The greater risk in the coastal regions is that this water may end up in low value utilisation.

However, the Oxford report (2008) adds that there have been several factors that have hampered the water projects. One important problem is the deterioration of water quality. For example, there has been an increase in the salinity content of the water. There is also the issue of inadequate sewage collection that may contaminate the water and render it unusable or unfit for human consumption. The report also states that there has been poor drainage in some parts of Libya, especially the south-western regions of the country (Ham 2007). This has inevitably led to degradation of soil and thus rendering it unfit for farming purposes. The report also notes that several initiatives were made in order to address the challenges. Some of the progressive steps included instituting the GWA.

The GWA was given the mandate of implementing the water policies and regulating the same (Al-Samarrai & Al-Mejribi n/d.). The body would regulate the water usage and the methods of harvesting the water. It was also credited with the process of managing how the water will be distributed or how it will be allocated to different parties. The body was also given the mandate of conducting relevant research about the water projects and also supervising the water projects and development activities in the region. Some of the additional tasks included the dam construction projects and irrigation procedures that ran throughout the entire country.

The Oxford report (2008) also adds that the GWA was also credited with the drainage processes and soil conservation issues. The GWA would be heavily involved in the planning and follow up of the projects as well as the creation and interpretation of the statistics. The report then states that six branches were created at the five zones. The government also instituted other governing bodies to assist in the water management issues. These bodies had separate responsibilities. However, the responsibilities overlapped at times. These bodies included the *General Environment Authority*, *Ministry of Agriculture*, *The Agricultural Research Centre* and the *Ministry of Planning* in additional to *General Water Authority*. Some of the bodies whose mandates did not directly clash include the *General Electricity Company* and the *GMRP Authority*.

The report adds that there were several problems that arose from the issue of having many bodies governing the management of water resources. For instance, the GWA lost the total control of the management of water resources and the development management. This also directly meant that there was an overlapping of mandates between the GWA and other authorities. However, all these bodies worked towards common goals, most of which were achieved in the succeeding years (UNESCO 1998, p. 69). Some of the activities included the development of the human and institutional resources that would be used in the whole country.

The other major activities that these bodies addressed included decreasing the water deficit in major regions, the Jefara region included. The bodies also had to develop the conventional and the non-conventional water resources. The bodies also had to address the issue of water pollution and also formulate policies that were aimed at addressing the pollution issue. Other issues that were looked at by the bodies included addressing the costs of providing water supplies in the arid and semi-arid regions in a constant supply. This includes the introduction of water projects that may guarantee Libya proper water resource allocation and sound water management policies (Wallace, J. & Wilkinson, B. 2004, p. 161). They would also be in charge of protection of the country against desertification and, where applies, formulate laws that would be used in curbing the menace. They also had to develop amicable cooperation with regards to the management of water resources.

3.8.2 Non-Governmental Organizations (NGO) involvement in the water sector

The problem of water deficit needs handling at a global level and all governments, water authorities, NGOs, civil societies, communities, companies and others must redouble their efforts. They should change their approaches, acting together and shifting responsibilities to each other to achieve the dream of placing pure water for all within the reach of humanity (Winpenny & Michel 2003). In order to avert a possible crisis, several measures have been implemented in order to manage the Libyan situation well. There have been several collaborations with other interested bodies keen on ensuring a sustainable water policy and water security for the Libyan population. NGOs have directed their efforts to assist the government on the measures that have already been taken.

According to United Nations Development Programme (UNDP) reports, there has been a great level of involvement by NGOs in the water management of Libya. In early January 2009, the NGOs took significant steps in addressing the water issues in Libya. The UNDP signed a new project with the GWA to assist it in its water management initiatives. According to the report, the GWA is solely credited with the management, investigation, and development of water projects and resources in Libya. Libya has been under continual water shortage strain that led to considerable concerns from the UN body. This is due to the fact that Libya is one of the driest regions on earth. Only 5% of its land receives annual rainfall of over 100 mm (UNEP 2010, p. 98). This level is the most appropriate for agriculture. There are other reasons that have hampered the water management strategies of Libya. For example, the exploitation of Libya’s ground water supplies in the recent past has greatly reduced the sustainability of the water and this has placed the said country’s important groundwater reserves at a major risk of being contaminated by seawater thus making them unusable. Therefore, UNDP committed itself to ensure that Libya’s water resources were utilised and managed effectively. The project initiated was called “Strengthening GWA Technical Capacity in Water Planning and Management”.

Under this project, UNDP Libya would assist the GWA in upgrading the central laboratory and also assist in the capacity development of the GWA employees. This initiative was meant to improve the water monitoring capabilities of GWA. It would also allow for the proper scrutiny that would effectively prevent the depletion of Libya’s scarce water resources. According to Wallace and Wilkinson (2004), this project also had a component that focused on gender mainstreaming. This component would also address the potential gender inequalities that would be witnessed in the project. These issues would be addressed in the project implementation stage and thus ensure that the venture advocates for gender equality in the country (Wallace, J. & Wilkinson, B. 2004).

According to Wallace and Wilkinson (2004), the Jefara region would benefit from the project as it would be one of the main regions earmarked for inspection. This region was targeted along with other regions that were stated to be at risk of suffering from an acute water shortage for the next 50 years. The director of the project stated that the situation was dire as most people could not identify with the inherent need of a water management project as the water was still in plentiful supply. He stressed that the coming generations would be put at considerable risk given the severity of the situation.

Wallace and Wilkinson (2004) add that the improving tourism industry will also add more unnecessary pressure on the already strained water resources. It was hence decided that early intervention would be imperative to the sustenance of the country's groundwater resources and also improve the water quality. This project was based on a commendable history between the UN body and the GWA. The road goes all the way back to 1997 when the UNDP Libya was involved in plans concerned with the development and management of a system that would monitor the water depletion levels of the country. The country was losing its water supplies at an alarming rate and necessary measures had to be deployed to curtail the process. UNDP Libya was confident of the fact that the enactment of this process would set the stage for many more developments with the country especially on issues to do with water management.

In line with this, it can be said the NGO involvement in the water sector has been immense. This is because the UN body and GWA have been cooperating over a period of several years on the issue of water governance spanning seven Arab states. Using these initiatives, the UNDP has been seeking to act as a catalyst for proper and effectual water management and development. This includes protecting water sources not only in the Jefara region, but also in the surrounding regions and even extending to other countries (Matar & Thabit 2004, p. 82). This was effectively done through the provision of financial support and advice to the concerned authorities in the Jefara region and the rest of Libya depending on the aridity of the region. The initial focus of the agenda was to provide the national agencies such as GWA with support and capacity development.

Matar and Thabit (2004) indicate that the other main issue was the development of policies that would ensure the sustainable use of water and funding for various important projects. The UNDP also advocated for other equally important areas such as the continual water supply and improved sanitation. The other critical issues that were also addressed but on a lower scaled included the adaptation to climate change. The director of the GWA stated that the country had to adapt itself to the different weather and climate conditions as there would be times that it would need to rely on the reserves entirely for the survival of the country. Matar and Thabit (2004) add that the country is in an unfortunate region that cannot rely on rainwater only. They also state that the UN body also decided to support the GMRP. Its main role would be to oversee the development of the Geographical Information System. These projects are stated to be an indication of the NGO's undying desire to both manage and preserve the minimal water resources of the country. This could not have come at a better time as the levels of human exploitation and inefficiency have reached new lows. This was so dire that the entire Jefara region's water supply had been put at a great risk (Brauch 2003, p. 69).

Food and Agriculture Organization (FAO) is one of the organizations involved in the water sector in Libya through the provision of information, the exchange of experiences, and the holding of the meetings and conferences (FAO 2012a). It works through the regional office for Africa on: identifying and planning priority activities for the region and the organization, monitoring their implementation and drawing attention to any shortcomings (Wiser 2006). In 2008, the Libyan Government funded and held a conference in Sirte. The conference *Water for Agriculture and Energy in Africa: the Challenges of Climate Change* was sponsored by FAO, as the chair of UN Water, and was held in cooperation with the Ministry of Agriculture and the GWA in Libya.

The process addressed food and energy security in Africa through an integrated approach of critical resource factors: water, energy, technology and knowledge. It considered the actual and forecasted scenarios for climate change as the framework for action. The FAO recommends the necessity of building on the outcomes of the Sirte conference and to effectively boost investment in water sector development to achieve food and energy security as a political and financial priority across Africa (FAO 2008).

The ICARDA organization is located in Aleppo, North West of Syria. It is concerned with developing soil fertility and nutrition so as to improve livelihoods and food security in dry areas. Through research and partnerships, ICARDA seeks a continued increase in agricultural productivity and income while conserving natural resources. As well, it develops technologies to improve the productivity of water and ensure sustainable water resource management, including water harvesting, irrigation systems (ICARDA 2012).

Libya's Agricultural Research Centre and ICARDA have worked towards setting up a research program to evaluate current irrigation water management practices and WUE in different parts of Libya. Their objective was to develop more efficient, economic and sustainable irrigation practices to maximize crop production per unit of water applied and assess how irrigation water is being used in different crops (ICARDA 2010). ICARDA has aimed to improve yields and water productivity through supplemental irrigation of cereals in rainfed areas. WUE is here defined as (Grain yield) / (Rains + Irrigation water). ICARDA provides training for the Agricultural Research Centre staff on data collection and analysis and the use of mathematical modelling approaches in irrigation water management (ICARDA & ARC 2010).

The NCBMM have involvement in AUJHJWSG's plans through the General Plan for the Utilisation of the GMRP Waters (Phase II). The Libyan National Consulting Bureau was established by the law No. 63 of 1975 to work in the consultation field, and contribute in setting out the development plans and programs of the country (NCB 2011). The Mott MacDonald Group Limited is a diverse management, engineering and development consultancy located in Croydon, UK. It adopts development policies and programmes as well as advance sustainability to deliver the plans and solutions for public and private clients world-wide (MMGL 2012).

The National Consulting Bureau in collaboration with the Mott MacDonald Group Limited of the UK put forward two plans: the first being the "Final Water Management Plan", and the second, the "Final Agricultural Master Plan". The objective of Water Management Plan was to use the JPR's water in an appropriate way to improve agricultural production, and in addition, to improve the conditions of the aquifer where water quality and groundwater levels were declining. NCBMM worked on development of a computer model covering the JPR to assess the changes in water quality and groundwater levels under different scenarios of possible development (NCBMM 1994).

Studies under the auspices of the Agricultural Master Plan evaluated the suitability of the soils in the JPR and identified areas unsuitable for agriculture. Radically different cropping farm and livestock models were evaluated in these studies to determine the most satisfactory form of development (NCBMM 1994). NCBMM's contribution in setting the General Plan for the Utilisation of the GMRP Waters (Phase II) has been discussed in more detail in *chapter two*.

The AOAD is one of the NGOs that have played a role in the water sector in Libya. This organization was established by Resolution 2635 of the League of Arab States in Khartoum, Sudan on 11/3/1970. The AOAD aims were to contribute to the creation and development of the natural and human resources available in the Arabic agricultural sectors, and improve the means and methods of its investment on scientific grounds. It continues to monitor, evaluate and rationalize the use of Arab natural resources such as the water and lands, forests and pastures (AOAD 2012).

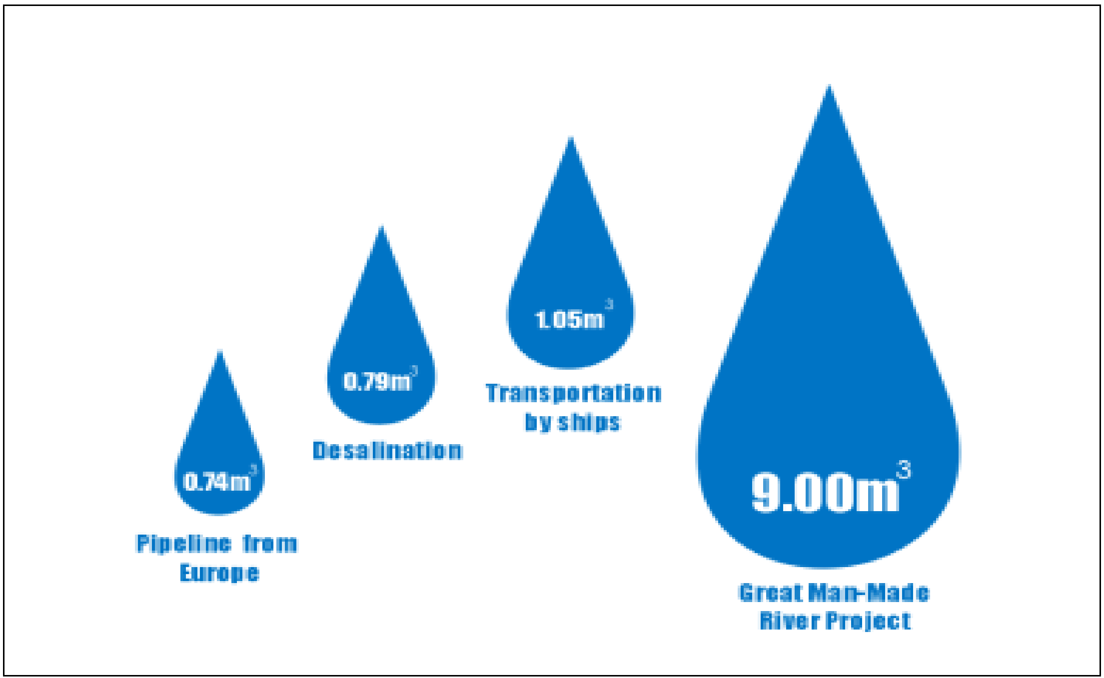
In the 1990s, AUJHJWSG assigned the AOAD the task of conducting the Technical and Economic Feasibility Study of the Utilisation of the GMRP Waters (Phase II) along the Conveyance System and Al-Jabal Al-Gharbi Regions. Within the rational use policy of water resources, the study paid special attention to identifying the proposed methods to rationalize irrigation water application. The study addressed several alternatives to estimate to what extent the farm could contribute to the cost of availing water resources services, as a key policy for rationalizing the use of this vital resource, and identified the implications for the farms in affording this burden. The study also evaluated charging fees to cover the costs of availing water to the farmers depending on water productivity (AOAD 1997). In 1997 the AOAD report gave a number of suggestions and recommendations in relation to the investment rationalization of GMRP's waters in order to achieve economic, social and environmental efficiency.

3.8.3 Prospects of addressing the problem of water scarcity in Libya

3.8.3.1 Ensuring a water supply

Options open to obtain additional quantities of water include: importing water; desalination of seawater; laying a pipeline from Europe; and transferring water from the huge aquifers in the south to the northern residential areas of Libya. The last option was adopted and is known as the GMRP, as it was perceived to be more cost effective than the other options (Zidan 2007) *(See Figure 3.1)*.

Figure 3.1: The cost of water per cubic meter of the four options



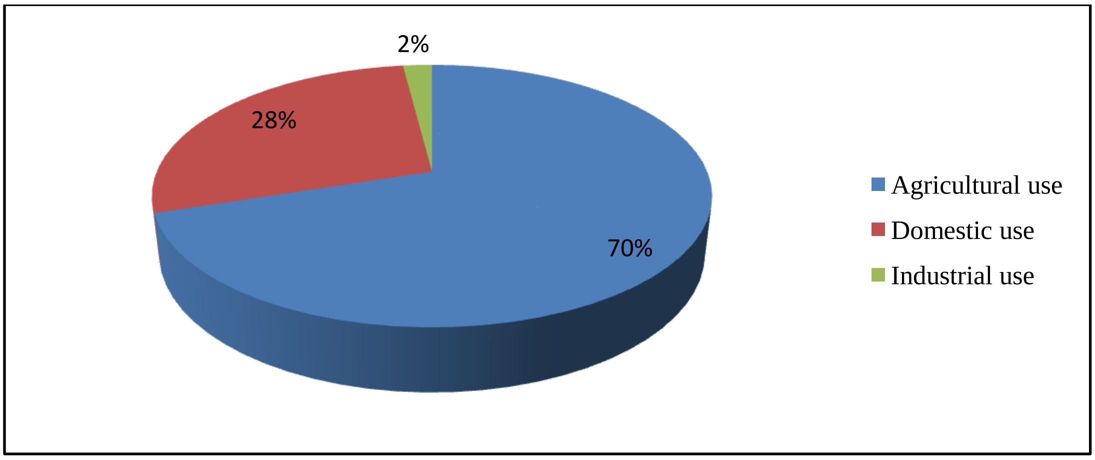
Source: www.gmmra.org

The GMRP is a project pumping groundwater from deep aquifers under desert sands in the south of Libya to various demand sites along the fertile coastal strip of the country (Wheida & Verhoeven 2007a) *(See Appendix C)*. The estimated volume of the exploitable groundwater reserves is $1,700\times10^9$ m^3 (European Commission 2009).

Construction of the GMRP began in 1984. Costing an estimated $US 25 billion, the GMRP is expected to take 25 more years to complete (GMMRA 2010).

The project can supply 6,500,000 m³ of freshwater per day (Zidan 2007). Over 70% is intended for agricultural development *(See Figure 3.2)*.

Figure 3.2: The average of GMRP water distribution according to the authority's plan



Adapted from (Zidan 2007).

It is expected that 130,000 hectares of agricultural land will be developed (GMMRA 2010), in addition to current irrigated areas of 500,000 hectares (Zidan 2007) in the coastal areas, where 80% of Libya's agriculture is located (EON 2010). Determination of the GMRP water quantity for irrigation is one of the most significant challenges of managing water scarcity in Libya, with water policy objectives seeking to minimise the water budget deficit. Water use in Libya could be reduced by minimising losses in irrigation and re-orienting the agricultural policies to improve WUE (Miludi n/d.; Salem 2007).

GMRP's American designers predicted that the Al Kufrah and Sarir aquifers could sustain the present rate of pumping for 50 - 100 years without depletion (Chapin 1987). However, some foreign observers doubt that GMRP's benefits will resolve the difficulties facing agriculture productivity because the desert aquifers are finite fossil reserves and will not last indefinitely (Chapin 1987). The GMRP has increased water availability but it is only a temporary solution to Libya's water scarcity problems (Alghariani 2003).

3.8.3.2 Water management and policy

Groundwater is Libya's main source of water, but mismanagement and lack of monitoring have led to excessive extractions. It is considered critical for the Libyan Government to develop a strategic groundwater management approach to ensure water supply sustainability. Mindful of these limitations, Al-Samarrai and Al-Mejribi (n/d.) examine Libya's irrigation potential as a means of ensuring agricultural productivity. Their findings endorse the Government response to the situation in creating the GWA to oversee the development and implementation of water policies and regulations. In addition to the GWA, other water agencies could address relevant issues such as environmental water and agriculture.

According to Al-Samarrai and Al-Mejribi (n/d.), problems emerged in 2001 as a result of decentralisation. Government agencies were losing control over water management and policy development due to the overlapping and conflicting objectives of the GWA and other agencies. Eventually, the Gaddafi Government launched the *National Strategy for Water Resources Management 2000 to 2025* to unify policymaking and targets to better address the water challenges in Libya. However, the uncertain political situation in Libya now and the political changes may produce a new post-Gaddafi strategy for managing these resources and addressing these challenges. In all circumstances, the new national strategy will require institutional restructuring and integrated water resources planning.

For the issue of scarcity, policies have focussed on fixing the water deficit by developing and defining conventional and non-conventional water resources. Demand management procedures, which evidently affect farmers, require losses in irrigation to be minimised in addition to imposing a limit to agricultural expansion. As demand is managed according to needs, Libya has minimised production, choosing to curtail exportation of agricultural products in order to focus on meeting the needs of the local population. As a means to control the irrigation system, the use of treated sewage water is also under consideration (Al-Samarrai & Al-Mejribi n/d.).

Libya's current challenge is to come up with policies that will be both workable and acceptable for its farmers. Present water management approaches typically impose restrictions in the agricultural sector so as to prevent the water table from drying up due to high demand for water. Water irrigation systems in Libya are controlled in order to manage the water supply, at the same time jeopardising the business and trade of farmers.

Châtel (2007) observes that farmers are usually undervalued in these arrangements. Because their water supplies are controlled and managed, the farmers often rely on the Government or relevant agencies to direct their agricultural strategies. Despite instances where irrigation systems are fuelled by water outside the allowable amount, farmers can either look after their own welfare or follow Government directives. According to Châtel (2007), despite water shortages, Libyan farmers are still growing wheat, even in arid areas with poor soil and low rainfall.

Based on the information gathered, Libya faces three challenges in the area of reform: effective groundwater management; policies to address farmer needs; and a reconstruction of its overall agricultural production strategy. Libya needs to approach the water scarcity problem in a holistic manner thus establishing the justification for an inquiry from a social economics perspective.

3.9 The prevailing theories, concepts, ideas and opinions on the issue

There are several theories, ideas, concepts and opinions in relation to the available resources, government efforts and farmer education:

Complexity Theory... It is the most prevalent theory in this issue. The complexity is used to define a situation that is difficult to comprehend. Wallace and Wilkinson (2004) add that this is due to the fact that the situation is beyond the basic level of human understanding or control. In their description of complexity, the authors contend that complexity arises whenever there is a situation where there is a negative and positive polarity feedback loop. However, it has to be within a defined system and should be operating at the same time. This type of relationship is called a feedback relationship, which according to the authors is a situation where the action and information affect each other generally. An example would be the situation where a system can become dormant and unable to adapt to the changing situations.

The authors' description of a negative feedback would be a thermostat controlling the temperature of the house. Any temperature that will be above a fixed point will inevitably lead to cooling while the temperatures below it will lead to heating. On the other hand, positive feedback has been described as a series of events that can be repetitive. They can also be stated to be self-reinforcing. This positive feedback can be said to introduce some level of uncertainty into the behaviour of systems (Lacis 2010). This eventually leads to the reinforcement of small events that can generate a system-wide phenomenon. In the case of complex system behaviour, chaos can be the most likely outcome.

In this research, which is methodological in nature, the complex systems would be used to imply that we cannot have a perfect comprehension of the complex water systems. This means that the knowledge that we possess of complex systems can best be provisional or limited in nature. This invariably means that we have to demonstrate a sense of modesty about the claims that we can make or insinuate about the water systems.

Wallace and Wilkinson (2004) further point out that the institutional and strategic uncertainties and unknowns are usually witnessed in issues to do with water management. The strategic do exist due to the fact that several participants are usually involved. The strategies that are used to address the matter are based upon the perceptions or comprehension of the issue and the solution advanced thereafter. This may not necessarily be similar to the views of other external parties. The diverging and conflicting strategies are usually the end result of this scenario. They may cause some stagnation and dead ends in the policy debates. The other scenario is that they may also lead to surprising and unexpected outcomes. The institutional uncertainty stems from the fact that the decisions on the water issues are usually made in differing locations. In those locations, there are also differing arenas and personal policies and views. The arena could either be at an international, regional, or local level (Reed 2004, p. 66). The actors form various policy networks and organisations can participate, each entitled to their own views.

According to Wallace and Wilkinson (2004) there are several assumptions that underline the water management issues in the Jefara region. They add that assumptions usually have very important consequences due to the method one attempts to acquire knowledge about the social world. The different assumptions are most likely to drive the researchers towards different methodologies. Reviews of the water management protocol of Libya in general are enough to give a basis for the different assumptions involved in the issues and the particular truths that they hold. It should be investigated if they communicate the nature of the knowledge as being definable or separable. This can give an insight as to whether they can be transmitted in a tangible form or if the knowledge is complex. Wallace and Wilkinson (2004) add that supporting the systematic process of assembling the theoretical or strategic methodologies, there are several underpinnings and recommendations that can be analysed. The analysis would effectively address the subsequent attempts at the formulation of the methodological models. It would therefore provide an excellent account of the resource management theories in relation to farmer viability and continual sustainability.

Economic theory of natural resources ... It pertains to the supply, demand and allocation of natural resources. It has an interdisciplinary approach, aiming to achieve sustainability and balance between supply, production and consumption from a range of different natural resource management approaches. Hackett (1998) points out that:

> *... the economics of sustainability is concerned with understanding the interactions between economy, environment, and social/political institutions over the long term and with using this information to fashion policies that move us closer to a sustainable society.*

This theoretical framework is critical to the research as it integrates social, economic, and environmental factors, three factors of sustainability essential for consideration in any formulation of water policies (Crocker 2002).

Integrated Water Resources Management … In response to the negative outcomes of past water resource policies, water resource planners, environmental scientists, water resource engineers and economists worked together in the late 1980's and the 1990's to develop a co-ordinated approach of Integrated Water Resources Management (Allan 2003). Established in 1996 with the aim of fostering Integrated Water Resources Management, the GWP (2002), defines it as

> *a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment.*

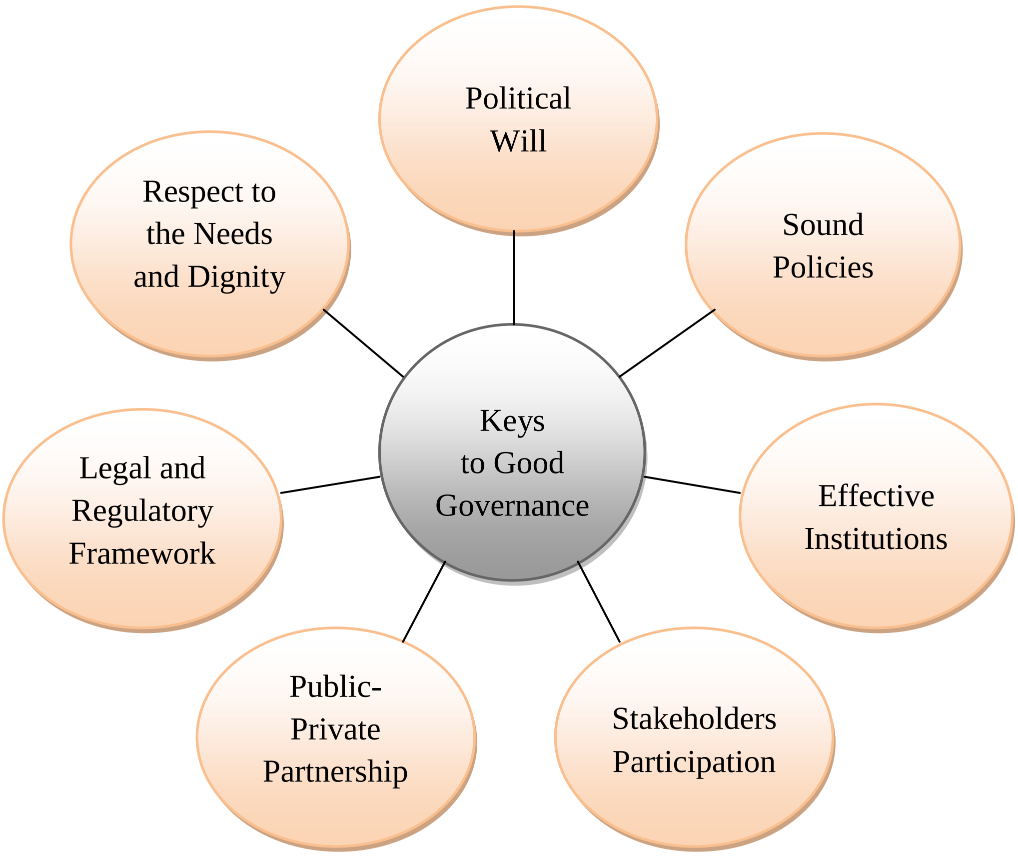
GWP (2000) sees the current water crisis as one of water governance, GWP (2002) indicates that it works with stakeholders to bring about changes in

> *…the range of political, social, economic and administrative systems that are put in place to regulate the development and management of water resources and the provision of water services at different levels of society.*

With the concepts of both water governance and Integrated Water Resources Management having social, economic, political, and environmental dimensions, for Dayem and Odeh (2008) "water governance" provides the framework which enables integrated water resources management application.

The enabling environment for good governance ... Improving water governance and management is a key and urgent challenge for Libya and other Arab countries where inefficient policies and institutions have led to weaknesses in water sector governance. An increasing demand for water and poor water governance has led to severe pressure on natural resources. Improved water governance and management has become a priority in order to meet sustainably current and future generations' needs and assure environmental protection (Dayem & Odeh 2008). According to Tiihonen (2004) effective or good water governance is dependent on meeting conditions of equity, transparency, participation, predictability, responsiveness and accountability. For effective and good water governance to occur, an appropriate enabling environment needs to be developed in which all parties are committed to making and implementing decisions as well as developing the institutions, policies and the political and legislative frameworks. Tiihonen (2004) calls these elements "Keys to Good Governance" *(see figure 3.3)*.

Figure 3.3: The enabling environment for good governance



Adapted from (Dayem & Odeh 2008).

Hydrosocial Contract and Resource Capture ... Turton and Meissner (2002) mention to the concepts of Hydrosocial Contract and Resource Capture which is associated with the research subject. Hydrosocial contract is an unwritten contract between the public and Government (Turton & Ohlsson 1999). It comes into existence when individuals are no longer capable of mobilising sufficient water for their own personal survival, and acts as a mandate by which Government takes on and executes this responsibility. It acts as the basis for institutional development, and determines what the public deems fair and legitimate to which policymakers react, such as the desire for ecological sustainability (Turton 2000). Two different permutations of the hydrosocial contract exist, the Lockean and Hobbesian form.

Lockean's form of hydrosocial contract, which closely resembles the elements of John Locke's (1690) philosophical writing and is the result of the interaction of hydropolitical dynamics that are a triangular configuration between the Governments, the water-consuming public and special interest groups. This form is result of series of events when existing supply-side solutions fall short of water demand and a condition of water deficit prevails (Turton & Meissner 2002). The authors define these events the *'Second Transition'* when future augmentation being considered too costly or environmentally unacceptable. This grows civil society that generates new form of social conscience in environmentalism form that works toward protecting the natural environment from destruction or pollution (Turton & Meissner 2002).

Hobbesian's form of hydrosocial contract that resulted from the interactions of hydropolitical dynamics during the *'first Transition'* which closely resembles the elements of Thomas Hobbes' (1651) philosophical writing, it often gives rise to a bipolar configuration between Government and the water-consuming public (Turton & Meissner 2002). The first transition occurs when the prevailing condition of water scarcity, accompanied by drought or period of rapid population growth for example, is encountered by a given social entity (Turton & Meissner 2002).

Resource capture defines the Hydropolitical arena that is mainly driven by ecological marginalisation of weaker groups of people. Several writers such as Homer-Dixon and Percival (1996) and Ohlsson (1999) have extensively written on the actions of powerful major role players and the social effects these actions have on scarcity of environmental resources such as water. These powerful role players monopolise access to this resources. Capital had been recognised by Karl Marx that the owner of a waterfall had ‘free gift of nature’ which improves his or her competitive power (Fuentes, Pfütze & Seck 2006).

Farmers have long held the opinion that there have never been enough measures made to counter the water scarcity issues. Due to their first hand experience of the perils of water shortages in relation to their crops, they have been most vocal when it comes to outlining the setbacks that lead to this scarcity. The main issues that they raised were to do with the consistency and integrity of the way the water management issues are handled. The ethics behind the water management efforts have been questioned by the farmers as they insist that there has been political influence that has hampered every effort to rehabilitate the water sector.

All in all, their main focus is on the ethics behind the water management policies of the Jefara region of Libya. The issue of ethics is always considered as too formal and, at times, irrational for institutional efficiency. From a practical viewpoint, it is easy to conclude that the ethical principles have minimal impact on the modern approaches to water conservation, management, and policies (Llc 2010, p. 56). This can be assessed from the angle that checks the social and environmental dimensions of the resource development initiatives. There should be a pragmatic balance between the investment needs, the economic needs, and the dire need of regulation. Environmental ethics has been considered as a more recent branch of applied philosophy that focuses on intrinsic evaluation in an attempt to assess the environmental costs on the issue of capital investment on the development projects.

People have undermined themselves inadvertently by destroying the environmental resources on which their societies depended and cause unintended ecological suicide-ecocide (Diamond 2005). The author classifies the processes led to damaging environments to eight categories. Water management problems and human population growth are included in these categories. To damage the environment today is considered morally culpable (Diamond 2005).

The environmental ethics has gradually evolved over the last few years built on Aldo Leopold's fundamental and other highly regarded scholars' view that the major causes of the ecological crises are philosophical. The environmental ethics has changed its core focus to political economy and the conception values. Based on the ideas related to the topic, it would be important to come up with the principles that act as the driving force behind the formulation of the water policies that relate to the Jefara region of Libya. In order to effectively address the farmers' concerns and opinions, it would be important to utilise a few principles regarding the management of resources. The first principle is the principle of precautionary and preventative actions. It is aimed at protecting the rights and entitlements of the future generations (Vandewalle 2008, p. 43). This principle is usually implemented under the environmental conventions. However, there are several criticisms levelled at it. For example, the applications lack any feasibility and have minimal short term gains. Practically, it may be impossible to apply the principle given that there is a water resource scarcity in Libya and this can inevitably lead to other disasters such as food shortage (World Bank 2006). This implies that the decisions have been based on simpler approaches.

The other principle is the principle of the *Natural Systems* values. This supports the nature preservation and also human well-being in conjunction with the socio-economic development (UNDP n/d.). The steps to amend the structure of nature for preservation values are greatly rejected. The criticism of the system is mainly drawn from the lack of the likelihood to differentiate the natural from the unnatural systems and on the moral issue of restriction to a single alternative of preservation. This is in the course of resisting the alterations while leaving out the nature restoration options.

According to Vidal et al. (2001, p. 18) the third principle is a major collaboration of the two principles. Solidarity-based risk management focuses on the tallied risks related to the disaster management, human encroachment of the water sources, and the civil protection. The large disasters are replicating with an adverse effect on the society and the environment. Therefore, the issue of disaster management has become a universal concern on the international reconstruction strategies (Long, Reich & Gasiorowski 2002, p. 81). This approach may meet unwarranted resistance as it displays the abandonment of the goals that have a wider sustainability. It also disregards the previous approaches with the institutions in support of the socio economic advancements and environmental conservation. The ethical relevance of water in the agricultural growth of the Jefara region is based on the diversities of the basic principles (Gale 2001, p. 67). The general principles such as human good and the avoidance of harm are usually based on ethical dilemmas and several judgements.

The ethical action should support the individual involvement of major concerned parties and is generally relevant to the promotion of universal propagation of human rights. In order to meet the goals aimed at sustainable water management and also meet the intergenerational needs, it would be imperative to halt the use of science and technology for the purpose of arriving at short term goals at the expense of the long term benefits. This is in order to avert the long term risks of the negative ecological effects in the future. These principles should be used to reflect proper moral values with regard to water conservation and the will to improve on the practicalities of enhancing and actualizing the principles. It will assist in addressing the already delicate situation in Libya. The situation is mainly characterized by large scale depletion of natural resources and water shortages while the search for renewable water sources continues (Dimkic, Brauch & Kavanaugh 2008, p. 100). The irrigation development projects for the water resource development in Libya composed some of the major sectors for the international economic assistance and have been crucial in showing the economic results (Postel 2004). However, this international cooperation has been criticised due to its tendency to encourage irregularities, unaccountability, and corruption; thus, leading to questions on the basic moral and inconsistency issues.

As with the other social processes, the ethics of the water management is driven by the political preferences and ambitions and are usually based on the legalities where the views are rationalised; thus, creating the path for the establishment of the relevant laws and legislations. The process represents a *bottom-up* approach that involves the government legislature and has been seen to be time consuming and usually not that effective in terms of enforcement. It is based on some background ethics that are usually within different groupings. The background ethics are usually concerned with the issues within a community or people that inhabit particular dwellings (Arsov & Watt 2003, p. 52).

According to (Lstiburek 2006), the social norms are usually not stagnant, but they are an accurate representation of the social capital at the basic level that is evolving and may be affected by the external factors and stresses. On the difference of the prevailing ideas to the topic, it would be practical to check the absence of the ethics at the global level (Salem n/d., p. 52). There are other few issues that can be stated to have moral deficiencies in an assessment of the current social norms. It can be said that few poverty stricken countries are committed to eradicating domestic poverty. In these countries, the public spending is stated to favour the leading elite. These indications are based on recent research of the third world countries. The development in these countries has stalled due to inefficiencies and, for a greater part, corruption (Pearce 2004, p. 21). Other countries have been able to prove otherwise. For example, South Korea, previously wallowing in poverty, was able to turn the tables and make an outstanding recovery based on proper principles and accountability.

Water can be said to be indispensable for the existence of humanity. Therefore ethics should be applied by the governing bodies such as GWA to ensure that the distribution of water is not based on social class or any other form of hierarchy. This is due to the fact that there is no human with a greater need for the resource than another (Goosen & Shayya 2000, p. 155). It is a resource that is very essential and non-substitutable that needs to be used more efficiently. In the same dimension, food can be said to be an essential resource for the survival of the population while hunger can be said to be a result of the neglect of the global right to food, which is also non-substitutable (Sørensen 2008, p. 86). That is why the debate about the water management will also continue to rage on. This will mostly be the case especially in the countries that always face natural water scarcities such as Libya. The Jefara region is no exception and has constantly been under the spotlight because of poor water distribution. However, the water conservation efforts have been improving.

The availability of water is directly related to the public health and nutrition of a population; thus, the societal systems that govern the water bodies should be built on solid foundations, devoid of political interference, and monitored by the society. In the worst case scenario, if the farmers are not addressed, the country should brace itself for a serious food crisis in the near future. In essence, water is directly related to the human rights of the populace. The water management budgets in the countries facing acute water shortage like Libya should be fully committed to meeting the immediate priorities of the societal needs, agriculture included (Majumdar 2004, p. 52). With the time invested in the structural change and economy development, the country's policymakers will need to focus on the productive use of the available resources. This will involve passing the relevant laws that are needed to ensure that the resources are used according to a laid-out plan. With regard to the plan, they should be based on workable policies, not overly ambitious plans based on sheer optimism.

The plans should be made in conjunction with the NGOs and other related bodies, GWA Libya included. The plans should then be forwarded to the policymakers so as to be subjected to debate by the government. Therefore, only workable plans can be arrived at and duly implemented. With these policies in place, the various water bodies in Libya can be given specific mandates to manage the resources (OECD 2003, p. 61). However, the most serious impediment is that there are too many bodies that are credited with the issue of water management in Libya. As aforementioned, some of these bodies have overlapping mandates and this can always lead to management conflicts. What needs to be done is that the bodies have to be disbanded and replaced with one or two bodies that can address the water issues in Libya amicably.

On an optimistic note, there should be no cause to worry especially for the Jefara region as there have been proper investments in the water and land sectors. In addition to this, there have also been commendable reforms attributable to the heightened resource-user participation based on the traditional knowledge and professionalism. This has directly led to increased motivation for the cheaper but more effective water management schemes in the dry regions of Libya especially the Jefara region. The poor rural farmers have adapted to the conditions and resorted to rainwater harvesting and irrigation (Hildering 2004, p. 121). The social capital has also been invested in agriculture and cropland intensification. It is also being invested in the drinking water supplies storage including some large scale facilities that serve the irrigation purposes and livestock management.

3.9.1 Methodology and methods used in the area of research

Long, Reich and Gasiorowski (2002) state that the account of efficient water use and management follows a qualitative paradigm. This is because the study has no statistical data that would require a quantitative analysis (UOM 2004, p. 56). This is imperative as it would explore the reason behind specific decision-making processes. It is imperative if the assumptions would be articulated and reconstructed to enable proper comprehension of the water policies of Libya. The methods need to be in tandem with the theoretical perspectives on which they are based. The resultant effort to deconstruct these knowledge relationships from the solutions provided by the NGO bodies in conjunction with the AUJHJWSG and other authorities related to water will go a long way in providing a realistic foundation of the water policies in relation to the Libyan concept (CIA 2009).

A proper alternative would be to analyse the vast literature resources to get a conclusive methodology. For this analysis, it would be better to choose the critical theory as the fundamental perspective. However, this discussion was restricted to, at best, a partial and pragmatic overview of an issue with a moderate affinity that would require the attention of a large series of research investigations. From an alternative view, it appears that the water management processes are technically complex due to the fact that water is a flow resource. This is mainly attributable to the fact that it occurs within hydro logically-connected systems and any adjustments on any part of the system may inevitably lead to chain reactions that may affect its availability, quality, and its cost. Secondly, the privatisation of the water bodies as has been suggested by some critics as being the much needed catalyst for the sector reforms. However, under this scenario, we cannot easily foretell the outcomes due to the known complexity in the water issues which is beyond the basic level of human understanding or control as mentioned by Wallace and Wilkinson (2004) in relation to the complexity theory. The identification of the full cost of water to enable the effective policies regarding water management and economic efficiency has featured prominently in these critics' and authors' thinking such as Scott et al. (2003).

Assessing the derivatives of the complexities inherent in the water systems and other related issues such as the water and the immediate environment, water, and economy, it is difficult to get the prescriptive model to base any theory (Fisher, Huber-Lee & Amir 2005). Therefore, the analysis has to be done in groups or sets. For example, it would be imperative to subdivide the research into sub-links that would make the analysis simpler and more organised. For instance, there would be the category of institutional arrangement that would focus on Libya's water management bodies. Then, there would also be a category for the performance of the water irrigation system. The ecosystem would also form an imperative part of the research methodology. Finally, it would also be prudent to assess the conflicts arising from the water use.

The main reasoning behind this subdivision is that all groups have something to contribute towards the answering of the research question. The field research must be key to the answers for the sub-questions. It should also answer the central research query for the whole process (Sullivan 2008, p. 82). To achieve this, there will be specific research methodologies that can be assessed per proposal. The interview plan enables the planning of the flow measurements. However, the options may be open and the possibilities may be plenty. The methodology in such research area entails the structures and semi-structured interviews that give direct answers to many of the queries. This would also entail organizing visits to the water institutions; specifically, the AUJHJWSG (Phase II), and any other related bodies. Meetings are necessary and should be planned in advance so as to meet the right people at the right time. The process of document retrieval for the relevant agencies is recommended in order to get the accurate information (Amin 2004, p. 54). This information would be tallied against the data accrued from the other methodologies and converted into meaningful assessable information.

According to Benoit and Comeau (2005, p. 55), the practical part would entail assessment tours of the research areas' reservoirs, canals and irrigation systems. One activity that emerges out of the field practical exercise is daily report writing. The report usually in such cases contains analysis based on the daily activities (Leedy & Ormrod 2005) and will ultimately relate to the research question.

3.9.2 Conflicting opinions and discrepancies in previous research

There are several challenges that the policymakers face in their quest to reform and effectively manage the water sector in Libya. First and foremost is the financial crunch that the country faces constantly. On the other hand, poor institutional reforms have affected the country's performance when it comes to water management. Over the years, the policymakers have set out to improve the water management of the region through several means. Some of the measures include the irrigation benefits programmes and other related hydrology projects. However, some of these efforts have been hampered by the growing water demand across the competitive sectors and the drought issues.

The severe water shortages that have been caused by these problems have led to a great number of conflicts between the different categories of users including the industrial, agricultural and domestic users. Some of the emerging challenges that the Libyan policymakers have found particularly hard to contain include the management of the water infrastructure and also the water itself. Due to the poor management of water, the farmers and urban residents resorted to pumping out the groundwater in order to sustain their needs. This has also led to the declining levels in the water tables, which has further aggravated the salinity ingress. In order to properly investigate and address these issues, the policymakers commissioned research initiatives aimed at resolving the water issues. However, the results from these studies proved that much needed to be done in order to address the issues permanently.

The research, especially that commissioned by policymakers and the water governing bodies of Libya, has been accurate to some extent but has not been devoid of weaknesses. The main problem area has been the analysis of the capacity of the water management systems. This is in relation to the size of the communities per the datasets regarding the population statistics of the Libyan regions (Warner 2007, p. 122). The water collection systems may be adequate in the meantime in relation to the ratio of the water volume and the population. The research indicates that this water may last for years to come and cater for the future generations. However, there are several exceptions that have not been made that can overrule these suggestions. For instance, water of GMRP has been under constant threat from contamination from the sea water. This could jeopardise the entire water system as it will be rendered unusable in the long run if the contamination is dire (Kenney 2005).

What the reports from this research should have indicated is the statistics related to a scenario where the water sources are jeopardised. These provisions should be able to give an accurate overview of the situation. This could assist in the efforts of planning for water management and storage in the country. Therefore, there are issues that contemporary researches have to re-visit. For example, they have to review and analyse the amount of water and the climate in the relevant water catchment areas over a sustained period of time and develop proper water allocation decision processes from the same (Motta 2004, p. 71). This data should also be used to formulate the basic climate models for the Jefara region. They should also check to ensure that the data emanating from other water bodies are similar so as to have a single developable plan that will be manageable. This can be achieved through the incorporation of the climate information and the collaboration of the different water basin reports and hence, identifies the best practices that may be in accordance with the GWA, GMRP and JHJWS using both primary and secondary sources.

3.9.3 Questions raised in the area of research

The country cannot be faulted for the inefficiencies regarding the water use as commendable efforts have been made to streamline the management of the precious resource. The bodies credited with the water management initiatives have been able to step up to their mandate without major difficulties. They have been able to steer the water management responsibilities away from the political interference that hampered previous efforts.

In line with the issue of WUE, it would be better to address the concept of water conservation first. This is because the water cannot be used effectively if there are no conservation efforts. Good conservation efforts will ensure that water will be available for use, and efficiently for that matter. In line with the country's National Water Policy of provision of safe drinking water for all, Libya needs to recheck its policies of water management and distribution. The main emphasis should be placed on rainwater harvesting and conservation. This should be followed by the technological options that will be bent on ensuring that the water conservation measure will be viable even for the future generations.

The main queries that were subject to examination regarding WUE are mainly levelled at the issue of water conservation. For example, in line with the water management research, what methods should be employed to curtail the water shortage in the Jefara region? Under this broad analysis, it would be imperative if the question was split into several sub-queries that serve as components to the head query. For instance, should the region continue the prolonged use of the automated sprinkler? The Jefara region uses the automated sprinkler to manage its irrigation prospects and also in the general farming. Otman and Karlberg (2007) maintain that all this depends on the type of soil, and thus can be uncontrollable to an extent. In many cases such as the Jefara region, the issue boils down to the climate of the region and the area's landscape. In this scenario, the region is generally arid and devoid of reliable rainfall for a great stretch of time. Otman and Karlberg (2007) then go ahead and give a recommendation to the persistent query. They state that the sprinklers should mainly be turned in the driest months of the region. Some of the months that experience a great deal of drought include May. For periods like this, the water systems should be turned on approximately once every three days.

For the other relatively stable months like July and September, the water should be utilised once every four days (Barrio 2004, p. 49). For better months like October, once every six days would not be excessive. Barrio (2004) notes that despite the water policies and the mandate by GWA, the people of regions like the Jefara region should also take their own initiative and manage their water resources as they can only be accountable to themselves. The author advises the area's populace to use water sparingly; for instance, applying water to one spot during a 20-minute period of watering. The other question that got revealed from the research is on whether the water authorities and initiatives should make it their mandate to enforce rules that are aimed at conserving the water, for instance if the outdoor drinking fountains should be removed in the Jefara region (Biswas, Rached & Tortajada 2008, p. 90). The authors note that the fountains are an essential public service utility in Libya, and should not be closed down. They do not represent any realistic statistic when mapped on the water shortage curves or graphs. Hence Biswas, Rached and Tortajada (2008) add that this public utility should be maintained and the government should look for alternate means to manage or conserve water resources on a large scale.

The other question stems on the facts regarding the legalities of water wastage; for instance, the case where people are found to be mismanaging the resource, especially in the dry Jefara region. Biswas, Rached and Tortajada (2008) point out that there may be no formal ordinance on this matter, it would be best if the GWA was notified. This may eventually lead to the culprits being warned accordingly or notified about the issue. However, rather than be reactive, the water authorities can make better steps regarding the issue. The main issue that will need urgent resolution is the excessive pumping of the ground water in the Jefara Plain done to sustain the high population (Sahuquillo et al. 2005, p. 135).

Based on the research, a query that featured prominently was whether the water issues should be termed as drought given the fact that the country has witnessed worse years before. Simons (2007) notes that it still qualifies to be termed a crisis due to the population levels. The water resources are not infinite and the Jefara region may soon suffer serious consequences. This is because the area's population is still swelling and may reach to insurmountable levels (Simons 2007, p. 78). This eventually means that the total water supply is being subdivided into small amounts that can effectively serve more people. Simons (2007) then tackles the issue that has been worrying the area's residents. The issue whether the residential well should face restrictions is the issue in contention. The author notes that people in the region mainly rely on the ground water but the levels may drop to new lows. This means that the government would have to curtail the use of the groundwater sources for a while until the government sources are depleted. In essence, what Simons (2007) implies is that there is no need to utilise the well when the government can supply water from the GMRP and reservoirs.

The government, in conjunction with the NGOs, should implement policies that govern the use of the water sources. This will be done to ensure accountability in the utilisation of the scarce resources. Simons (2007) indicates that the policies should be used in governing all the water usage, not only the Jefara region, but also the entire country. It should also be used to handle the affluent neighbourhoods that lay claim to villas possessing large backyard pools and private golf courses (Vidal et al. 2001, p. 67).

The other questions that need to be addressed include the issue of the resident's initiatives to manage the shortcomings. Otman and Karlberg (2007) state that the residents should be more conservative and that they should devise simple means to manage the water shortages like rainwater harvesting.

The sub questions include the issue of the water institutional framework and the water management policies in Libya. There are active and commendable water policies in Libya that are followed to the letter to ensure an effective water distribution plan. The bodies that are charged with the water management include the GWA. The other pertinent issue is the improvement of WUE (Shapland 2003, p. 143). The water distribution, as addressed in this part of this report, has been regulated by the individual councils per region. The water being used by the farmers to irrigate their crops is monitored to ensure that the amount used complies with the set standards. This is to address the persistent water shortages in the area.

Many question marks revolve around the problems of water management policies. These queries initiated research on the challenges faced by the Libyan policymakers and may have negatively affected them in framing the water policies. Initially they do not have accurate data that they can use to formulate better policies. This is because of insufficient research leading to unreliable datasets (Nafziger, Stewart & Väyrynen 2000, p. 113). The farmers' opinions can definitely assist the policymakers make the right decisions regarding the water policies. They are the relevant people to derive information regarding the water scarcity and management as they happen to be the biggest consumers. Their opinions could be converted into meaningful data that can be used as a basis for research and the development of meaningful reports. These reports would shed more light on what needs to be done to step up the campaign for efficient water use.

3.10 Gaps in the literature

The literature contains a significant amount of scientific information relating to levels of available water, water supplies, rates of usage and rates of the decreasing in groundwater levels. Most cited studies point to the same issue, i.e. water scarcity problems. In framing this inquiry specifically to the Libyan context, water scarcity is already a problem in the country given its geographic nature and increasing demand for water. The prospect of jeopardising agriculture through future water conservation policies or initiatives needs to be carefully assessed as actions taken will directly affect farmers and their livelihoods. The potential impacts of potential policies or initiatives is largely absent in the literature.

The policymakers have been unable to formulate policies that could address the water management issues due to sub-standard research activities. These research initiatives have failed to detail proper conclusions that would assist in the implementation of the recommendations. The previous studies have had problems in the way the data and final analysis were handled. Most of the gaps identified have to do with the incomplete analysis of the various important variables and considerations. For example, the studies fail to indicate the financial constraints that are related to the water bodies' effective implementation of the water policies. The previous studies mainly focused on the recommendations and the suggestions made in order to streamline the processes involved. The other relevant issue is the constraints faced in the interrelation of the different water management bodies. As seen in the discrepancies of the previous studies, it is imperative to note that there are far too many water bodies in Libya. Therefore, the water policies can probably never accurately and fully reflect the water management problems (Earle, Jägerskog & Öjendal 2010, p. 50). There is inadequate collaboration between these bodies and as a result the country has been subjected to different statistics and advice.

The previous studies could have addressed this issue better and offered a solution that would ensure that there is proper coordination between the various bodies. The studies also failed to tackle the imbalances of the water distribution in the country. This could be attributed to the poor planning by the relevant councils that are charged with the water distribution (Ali 2010, p. 57). This mainly is a function of the location of the regions. For example, those regions that are close to the resources of

GMRP rarely have a problem with water shortages. The studies could have offered opinions as to whether the government should focus on the specific locations that will be suitable for the entire country. Furthermore, the studies could also have addressed the politics related to the water management in the region. However, the research report does indicate that there is some discrimination in the allocation of the water resources in the country. The elite are always given the topmost priority in the water networks (Figuères, Rockströ̈m & Tortajada 2003, p. 86). This indicates that the water bodies have some levels of political interference that may end up paralysing the operation of the water bodies and management organisations.

In line with this, the studies should have utilised knowledge management for decision making. The researchers should be able to disseminate and collect high quality data. This is because the quality of data regarding the water resources is poor to the extent that it is difficult to use it to achieve accurate baselines. The data can also not be used to make projections and setting targets in the implementation of the water projects (Wagner & Marsalek 2008, p. 59). However, the process of obtaining and analysing this data can be a formidable task and it can take significant time to achieve the desired results. There is also insufficient data on the local issues. The lack of information to do with the local water management processes is also a major problem. This type of data is usually very important as they usually connect to international structures and the complex relationships that they entail. This greatly impedes any meaningful outcome. For example, it would be extremely hard to extract the relevant data regarding the Jefara region of Libya without generalising the statistics (Savic et al. 2005).

As Rausser (2000) points out, the political economy is critical to the formation of sound water management and policy. As much of the literature in this field lacks an exploration of the conditions of the farmers, the degree to which policymakers factor in the interests of farmers as stakeholders should be explored. The literature does not examine the impact of water management and policy upon farmer attitudes toward water saving. It also does not examine the relationship between the goal of saving water and farmer viability and consequent water flow sustainability and farmer performance in the Jefara region in Libya. This highlights the need to fill the gap in the literature and supports further research in the Libyan context.

The recommendations would provide the relevant data to the policymakers who can analyse it and come up with a meaningful conclusion. The new Libyan government, non-profit organisations, and the private sector should collectively support the research initiatives so as to address issues that have something to do with the water quantity, quality, and rates (Koundouri 2006, p. 83). They should also come up with abundant information about the difference between the water rights of the agricultural producers and the water they utilise. The flow returning from the diverted water should also be scrutinised. This should also be done to check the appropriate quality of the reclaimed water for the various uses such as urban irrigation.

3.11 Summary

The reviewed literature reveals that the design of water policies, including groundwater resource management in transaction and negotiations, is influenced by internal political mechanisms and socio-cultural aspects in countries and territories. Policies relevant to farming tend to focus on how farms can use water sustainably, rather than on the response of the farmers towards water scarcity. The great efforts made in the providence of new water sources in Libya must be matched by urgent transformation from water supply management to water demand management to achieve economic sustainability.

Electricity rationing has been found to be a useful tool to improve WUE. On the other hand, the neo-liberal free market approach in water supply may not achieve the benefits it is expected in theory to bring to the poor. A rationing system could feasibly provide another option or be an alternative to the neo-liberal free market. In addition, many factors need to be considered in relation to water pricing in Libya, such as farmers' reactions, price costs and the maximum price advocated by The World Bank. Although the information indicates that WUE may not necessarily lead to greater profit, in Libyan case the literature reveals that the WUE and crop water productivity may increase with the same, if not more, agricultural productivity.

Inefficient water utilisation is a global problem, but population growth rate, deterioration of ground water resources and the lack of rainfall in most of the NENAR, in particular in Libya, have exacerbated the problem of water scarcity in the region. There have been no credible means to manage the utilisation of water reservoirs in Jefara region. This has led to the region only being able to harness 3% of the water supplies. A close examination of prevailing theories, ideas and opinions around the issue of water scarcity has revealed the difficulties in fully understanding the multifaceted and interdependent nature of water systems meaning that the knowledge that we possess of complex water systems can at best be provisional.

It can be seen that groundwater management and water policies are for the most part directed at water itself. Water scarcity has been the prevailing issue in Libya and the preoccupation of the government. Much research has focused on procuring new water sources for agricultural, industrial and domestic use. The four options mentioned previously have been explored in order to obtain additional supplies of water, the result being the establishment of the GMRP. This demonstrates that research has focussed on procuring new sources of water rather than on overall water sustainability. Therefore only part of the problem has been explored. The time has come to focus on framing a policy for sustainable water security.

4.0 CHAPTER FOUR: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

It can be seen from both the cited literature and other sources that farmers are the stakeholders most affected by water scarcity in Libya. Their response to the problem has generally been through “Band-Aid farming” practices rather than through reference to policies which take their views or needs into consideration. Hence, the development of the research questions is concerned with the ways in which farmers are affected by water scarcity and their relationship to economic hardship. This chapter seeks answers to the research questions raised and identified in the problem exploration phase (Bhattacherjee 2012). The reviewed literature demonstrates that water policies can be redundant and that water management strategies are more often focussed through economic and political lenses than on social considerations.

The research design is the general plan of how the research will go about answering the research questions (Saunders, Lewis & Thornhill 2009, p. 136). The strategies, techniques and approaches undertaken to achieve the goal of theory building are outlined in this chapter. In the context of the research problem, the research questions have been formulated to attain the research purpose, with a focus on the process of research design turning these questions into the research project (Robson 2002). The research methodology has been used to extract meaning from the data and information (Leedy & Ormrod 2005). Details related to obtaining ethical approval to conduct the research interviews are provided in this chapter. Components of the study population and the methods of sampling are introduced, with the analysis techniques presented in detail in the last section of the chapter.

4.2 Research design

4.2.1 Case study design

Many water policies in Libya are concerned with water itself, but policies relating to farmers in this context are limited. This could be addressed by a move from supply to demand. In their evaluation of the water crisis in Libya, Wheida and Verhoeven (2007a) recommend an urgent transformation from water supply management to water demand management to achieve economic sustainability in the country. The socioeconomic conditions of farmers, major stakeholders in water scarcity, need to be examined as well as the ways in which they are responding to the issue. While some effective solutions are being implemented, the issue remains as to how far farmer opinions and views on the management of their circumstances are utilised as valid sources in policymaking. However, it is also important to understand how policymakers face the issue in light of the challenges of water scarcity and farmer reactions. Thus farmers and policymakers are the units of analysis in this case study, with farmers represented by members related to agriculture in areas using the water of GMRP in JPR, and policymakers by the staff members of the authorities concerned with water issues, the AUJHJWSG, AIMG, GWA and MOA.

For exploratory research, the most suitable strategy was identified as a case study which would provide an opportunity to observe and analyse a phenomenon within its real life context that few have considered before (Saunders, Lewis & Thornhill 2009). An awareness of the variables in the context of this research would increase the ability to explore and understand the case study, and generate answers to the research questions. The case study strategy has considerable ability to generate answers to the ‘what?’ and ‘how?’ questions in research (Saunders, Lewis & Thornhill 2009), and to interpret the case for theory building (Bhattacherjee 2012).

4.2.1.1 Grounded theory building

The research targeted building the theory inductively from a base of observed patterns of events, behaviours, actions and interactions. This so-called “grounded theory building” is grounded in empirical observations (Bhattacherjee 2012). As Goulding (2002) points out, grounded theory calls for early data collection, analysis, further theoretical sampling and category saturation. The theory is developed from data generated by a series of observations, interviews and data (Saunders, Lewis & Thornhill 2009). The theory building process in this study is a grounded theory strategy as it is helpful for research to explain people’s behaviours and the emphasis is on developing and building theory (Saunders, Lewis & Thornhill 2009, p. 149). It is also helpful when current theories about a problem are either inadequate or nonexistent (Creswell 2008).

An inductive approach allowed the research to ponder observations which give way to an analysis of patterns. This eventually leads to the formulation of general principles and a tentative hypothesis (Babbie 2010). This study adopted an inductive and ethnographic approach as the research inquiry began with observations about the research problem, then moved to the rationalisation phase to make sense of the observations by logically connecting the different pieces of the puzzle with the objective of building a theory (Bhattacherjee 2012). This is consistent with Burney (2008) who points out that observations tend to be used for inductive arguments.

Ethnography is inductive, generates or builds local cultural theories on the perspectives of the people or explanations of how people think, believe, and behave that are situated in local time and space (LeCompte & Schensul 1999). The adoption of an ethnographic strategy necessitates the researcher being within the context in which a phenomenon occurs so as to gain insights about the particular context and better understand it (Saunders, Lewis & Thornhill 2009). The ethnographer therefore must select typical quotations that are characteristic of the situation or event described (Fetterman 2009).

4.2.1.2 Nature of the research

Given the nature of the research problems and the research questions identified, it is clear that this research is exploratory and ethnographic in nature. As such, this requires the researcher to develop an understanding of the attitudes, beliefs, opinions and motivations of respondents (Malhotra et al. 2006) with regard to framing sustainable water policy for agriculture in the JPR of Libya. Exploratory research can be directed at measuring the extent of the citizens' dissatisfaction (farmer dissatisfaction in this case) with governmental policies, understanding how such dissatisfaction affects them and the presumed causes behind such dissatisfaction (Bhattacherjee 2012). Given the flexible nature of exploratory research it allows interviewees to draw attention to related issues that may not have been considered by the researcher, as well as enabling exploration of the research problem without preconceptions about the findings and outcomes (Aaker et al. 2007). Descriptive research is directed at making careful observations and detailed documentation about the phenomenon of interest (Bhattacherjee 2012). Therefore the research will also be descriptive as it will describe the circumstances and characteristics of respondents (Zikmund 2003).

4.2.1.3 Research method and approaches

The qualitative research design is an appropriate method for conducting this study because the research purpose is to conduct an in-depth exploration of the issues surrounding WUE and policy in agriculture in the JPR of Libya. In choosing the most suitable research design for this study, the research questions, the steps undertaken for the resolution of the research questions, the implementation of these measures, and their end results were considered (Yin 2009). The strength of this method lies in its ability to provide complex textual descriptions of how people experience a given research issue (Merriam 1998). Through this method, the human side of a research problem is highlighted, providing insights into emotions, views, opinions, beliefs, and behaviours. An advantage of qualitative research is its use of open-ended questions that provide opportunity for key participants to freely express responses in their own terms rather than be constrained to fixed choices made by the researcher as is the case in quantitative research.

This research will require qualitative measures of farmers' characteristics and circumstances and policymakers' perceptions of AUJHJWSG. A qualitative approach will provide rich insights about the nature of the problem. Leedy and Ormrod (2005) point out that qualitative methods enable the discovery of problems existing within a phenomenon, as well as assisting with the interpretation of information, as they enable researchers to gain new insights and develop new concepts or theoretical perspectives about the phenomenon under study. A qualitative, inductive approach will improve understanding of the natural and social relationships of farmers with each other, their characteristics and circumstances, including language, culture, human institutions and subjective thoughts. The inductive approach will also provide insights into their relationship with the AUJHJWSG and its water policy practices. In qualitative, inductive research, the researcher examines the data for patterns and relationships, and develops theory or uses developed theories to explain the data (Morse, J. M. & Field, P.-A. 1995). Qualitative methods in the research will cover the social phenomena represented by farmers and the political economy approach represented by policymakers through participants' responses to interview questions.

This research examined the potential of influencing farmer attitudes by rational water policy and facilitating water sustainability in the JPR of Libya. It is an appropriate methodology for a real-life situation such as this where an understanding of people's personal experiences is required. In addition, given that previous research in Libya in this area is limited (Laamrani & Salih 2010), qualitative methods are more flexible in allowing better interaction with the participants based on good relationships and trust (Leedy & Ormrod 2005). Medema (n/d.) used a qualitative research approach that identifies the lived human experiences, to derive a more general, abstract theory of the process, actions and interactions grounded in the views of the participants of the study.

4.2.2 Research questions

This research seeks to deal with the challenges associated with the constructs of water resources management in the JPR of Libya. To attain the research purpose, the following question has been formulated in the context of the research problem:

- ✓ ***How can farmers and policymakers engage with each other to understand the key issues to facilitate more sustainable water policy?***

Addressing the research problem necessitates an examination of the current Libyan water institutional frameworks and water management policies. This will enable an exploration of the ability to improve WUE in agriculture in the JPR and provide insights into how water saving and a more efficient water policy framework could improve water sustainability in the Libyan agricultural sector. The challenges faced by Libyan policymakers in framing water policy and JPR's farmers' attitudes toward this framework will be examined with the objective of proving an integrated picture of water management policy strategies and frameworks. Therefore the following research questions (RQs) will be investigated:

RQ_1 What is the current state of water institutional frameworks, water infrastructure and water management policies in Libya?

RQ_2 What scope is there for improving WUE in agriculture and how will water price affect farmers' viability?

RQ_3 What are the challenges faced by Libyan policymakers in framing water policy?

RQ_4 How can farmers' opinions on water scarcity and WUE in irrigation assist policymakers in framing sustainable water policy?

4.2.3 Sustainability

The Brundtland Report (1987) defines sustainable development as follows*: "Meeting the needs of the present without compromising the ability of future generations to meet their own needs"*. Sustainable development aims to take the middle ground by serving the interests of humans without jeopardising the environment (Richardson 2002). It is oriented towards the future. A sustainable water resource system is therefore one designed and managed to meet the needs of people living in the future as well as those of us living today (UNESCO 2008). Sustainability is a philosophical concept and not a precise state of being, but the core of the Brundtland definition encompasses criteria which consider the long-term future as well as the present. As such it is more specific than much of the literature, for as Thompson and Sorvig (2007) point out, in general there is no agreed definition for sustainability despite the widespread use of the term.

Sustainability can therefore be considered a term of mercurial, elastic and relative matter with a certain level of ambiguity. When defining the sustainability of limited and non-renewable resources, such as groundwater in Libya, the following questions come to mind: sustainability for how long or to what extent? When future generations are mentioned, how many generations of future generations?

Furthermore, sustainability depends on a broad set of principles and variables that vary in importance and impact on social, economic and environmental development. According to DuBose (1994):

> *"No one element can by itself indicate sustainability; it is the nexus of relations between elements working in harmony that indicates sustainability like an equation for which an answer cannot be derived from one variable alone but requires the interaction of the variables for solution."*

In the case of water, sustainability can be understood, for example, in saying that the water amounts abstracted from aquifers in areas that depend on aquifers for water use and to meet current needs must not exceed the recharge amounts so as to meet the needs of future generations. However, when applied to non-renewable sources, the equation is not as precise, and when the variable of population growth is taken into account, the balance of the equation may be prejudiced over time.

In general, the premise that withdrawals should not exceed the recharge amounts in Libya in the JHJWSG is out of the question as it is in reference to non-renewable sources (fossil water) (European Commission 2009). The results of the study suggest that at the present time, achieving water sustainability in JPR of Libya can be only be done by working seriously on achieving use efficiency with the current available water and searching for new renewable resources such as desalination and the use of solar energy.

4.2.4 Conceptual model of the study

The conceptual model aids the synthesis of prior empirical findings and reconciliation of any contradictory findings, by exploring the contingent variables influencing the relationships between the constructs and the understanding of cause-effect relationships (Bhattacherjee 2012, p. 26) *(See Appendix D)*.

4.2.4.1 Concepts

Corbin and Strauss (2008) introduce the term of concepts as words that stand for grouping ideas, objects, events, and actions contained in data; they are interpretations and the products of analysis. The literature review, and the information gathered from the interviews and observation reveal there are a number of initial concepts that interact with each other in the development of water policies to provide sustainable water policy. Harmony in the interaction between these concepts means a greater quality of water policy formulation and thus increased opportunities of achieving water sustainability. As a consequence this study required development and identified the following vital concepts:

Water institutional framework and water infrastructure: The Institutional framework comprises all the institutions related to the processes of water management, as well as the decision-making mechanisms and the flow of work and limits of authority and responsibility in the area of research interest. It includes, in addition, all water infrastructure components, such as the wells and pumping stations, reservoirs and distribution networks.

Water management policies: All policies, reforms and amendments relating to water management since the beginning of the water flow from JHJWSG to the present date.

Challenges faced by policymakers in framing water policy: All the problems, obstacles and pressures, in whatever form, which prevent the achievement of the objectives of policymakers in framing and developing their policies in water management in the area of research interest.

Water use efficiency (WUE): The economic use of water through the use of available water in goods production which achieves the highest returns, or produces the targeted production, using the least possible amount of water.

Farmers' opinions on water scarcity and WUE: The cultural background, inherited and acquired, of farmers which affect information and opinions about water scarcity and WUE, whether stated in the interviews or appearing in agricultural practices.

Farmers' viability: The ability of farmers to make a profit, and develop and continue working in an agricultural activity in the light of the costs, with a continuous flow of water as part of the cost of production.

Sustainable water policy: A policy that achieves desired water security, ensures the farmers' viability and achieves the goals of policymakers on one hand and leads to a continuous flow of water for as long as possible on the other. In addition, a sustainable water policy invests part of the water revenues in the search for new water resources.

4.2.4.2 Constructs

For the purpose of research and to facilitate building the conceptual model, the identified concepts needed to be combined into constructs in order to capture and abstract them (Bhattacherjee 2012). Accordingly, the concepts have been grouped into three constructs: the constructs of policymakers, farmers and sustainability.

The construct associated with policymakers is a multi-dimensional construct as it consists of three underlying concepts: water institutional frameworks and water infrastructure; water management policies; and the challenges faced by policymakers in framing water policy. The concepts of this construct are the key factors that will provide information through interviews with managers and staff of the water authority and water policymaking specialists to provide information about their past experiences with the farmers, including farmers' attitudes and reactions to the changes in water policies. Policymakers will provide information about their perceptions and schemes for future policy as well as finding solutions to the sustainability of the water. The experiences of these interviewees will transfer to the research problem, allowing the researcher to investigate it in depth.

The farmer construct is a multi-dimensional construct encompassing three concepts as well: the scope of improving WUE; farmer viability; and farmer opinions on water scarcity and WUE. Farmers are the main respondents to provide information and insights related to these concepts. This information will be compared with the policymakers' point(s) of view. It will help in the development of better water policy frameworks to both accommodate the requirements of farmers and achieve the goal of the sustainability of the water.

Finally, sustainability is a uni-dimensional construct as it contains one concept which is sustainable water policy. Arriving at sustainable water policy is subject to the final information gathered from the database, reports and documents of AUJHJWSG, AIMG, GWA and MOA, and through interviews with specialists from policy makers and the farmers.

4.2.4.3 Variables

The measure of each concept is considered a variable. Goulding (2002) calls the variable "concept properties" and "concept dimensions". All variables playing their role in this study will be analysed at the individual level. This is consistent with Bhattacherjee (2012) who suggests that constructs are sometimes used interchangeably with variables. All variables will vary in measurement of their level of quality, efficiency and nature from low to high and negative to positive.

The conceptual model cycle begins with two independent variables; the water institutional frameworks and water infrastructure, and water management policies. Because the independent variables explain other variables of the conceptual model (Bhattacherjee 2012), measuring and determining the aspects of these two variables is the basis and starting point to drawing up any new water policy and achieving the goal of the research. Determining the level of efficiency and organisation of the institutional framework, the extent of ease of the work flow, the degree of clarity in decision making mechanisms and the qualifications of workers in institutions related to the organisation, management and distribution of water are measures of the first variable, in addition to the quality of infrastructure and water distribution networks.

Measuring the second variable in this research relies on the determination as to what extent sustainability has been taken into account in the stated policies and plans of AUJHJWSG, with knowledge of the problems likely to be encountered and the measures taken by the AUJHJWSG to avoid them. The field visits and access to the database of AUJHJWSG, AIMG, GWA and MOA, in addition to interviewing people with experience, whether in the institutions mentioned or farmers, will give a reliable indicator that can be strongly relied upon in answering the first research question.

Identifying the domains able to control farmer WUE through price partially answers the second research question. Thus, farmer viability is central to the research as a mediating variable, as it is at the same time described by the independent variables while itself explaining the dependent variable (Bhattacherjee 2012). Farmer viability cannot be ignored, as a successful water policy able to fulfil the sustainability goal cannot be achieved without taking this variable into account. A sustainable water policy cannot be visualised which is incompatible with farm profitability. Interviews with farmers around this topic are able to give an estimate of farm viability, as water price is an integral part of agricultural production costs.

Knowledge is needed of the possible and potential pressures on farms, including the extent of the impact, in order to achieve the goal of WUE through a rise in the price of water without substantially prejudicing farm viability. As this is a sensitive issue for farmers, care was needed to gather appropriate information both directly and indirectly from the farmers’ responses to the research questions. Farmer interviewees' answers should be compared with those from policymakers, so as to avoid emotional bias. This applies to all responses in the interviews (Bhattacherjee 2012).

The scope of improving WUE in irrigation, the challenges faced by policymakers in framing water policy and the farmers' opinions on water scarcity are represented as moderating variables. They affect a sustainable water policy positively or negatively. Bhattacherjee (2012) posits that moderating variables influence the relationship between independent and dependent variables.

The level of WUE in the region must first be identified and then the available scope to raise this level. It is possible to visualise that however high the level of efficiency, there is also a small area of potential to raise the level from time to time. Reducing the size of the challenges faced by policymakers is important in achieving sustainable water policy. These challenges as moderating variable differ from the farmer viability variable in that it is the policymakers who put forward the policies and direct them. They can afford a certain leeway in the level of these challenges and try to move to mitigate their impact. Answering partially the second question and the third, fourth and sub-questions related to them can achieve this goal. This variable combines all the challenges which may provide feedback to the policymakers to continually improve their policies. The extension of the farmer's realisation of the water scarcity problem puts limitations on sustainable water policy in the region. The more farmers realise the scale of the problem, the less the limitations and less the negative effects of this variable on the sustainability.

Through the experience and specialisation evident in the responses of policymakers and farmers, a comparison can be drawn between them to provide information able to develop research perceptions of the issues and expand the horizon to come up with a conceptual model for a sustainable water policy to achieve the goal of the research.

A sustainable water policy is the fruit of the best engagement and the interaction between the independent, mediating and moderating variables associated with the policymaker and farmer constructs. Accordingly, a sustainable water policy is considered the dependent variable in the conceptual model. The dependent variable is introduced and identified by the other variables (Bhattacherjee 2012), and the ideal situation for all the variables mentioned offers optimal sustainable water policy. The assessment and arrangement of the priorities of water and agriculture policy, in addition to economic, social, environmental and political challenges in general, put limitations on some variables more than others. Raising the efficiency of some variables and the sacrifice or acceptance of a lower level to some degree in others are sometimes necessary to achieve research goals. This research aimed to find the best combination of variables able to achieve the goal of sustainability.

4.2.4.4 Propositions

Bhattacherjee (2012) points out that propositions capture how the variables are related to each other, and are stated at the theoretical plane. The research propositions are tested by examining the corresponding relationship between measurable variables of the conceptual model (Bhattacherjee 2012) *(See Appendix D)*. The stated research propositions are as follows:

P_1 Although the development of infrastructure in the public and private sectors, including water institutional frameworks, tend towards centralisation, Libya is failing to achieve acceptable levels of performance in terms of water usage.

P_2 Substantial improvements could be made to increase WUE in agriculture and determine the level of assumed water price best able to achieve water policy and maintain the profitability of farmers and their viability.

P_3 Policymakers will face a number of challenges in terms of formulating effective water resource management strategies. Reduction of these challenges will help in the development of sustainable water policy.

P_4 Enhancing farmers' perceptions and attitudes towards water scarcity and WUE will increase their interaction with policymakers and their response to proposed management strategies.

Bhattacherjee (2012) indicates that logic is the basis for justifying propositions so as to provide meaning and relevance to the relationships between constructs and their patterns. This case study will later identify under what circumstances these constructs and relationships will work, and the limits of these conditions.

4.3 Research methodology

4.3.1 Data needs and information sources

The case study strategy necessitated using and triangulating multiple sources of data and information. Triangulation refers to the use of different data or information collection techniques within a study (Saunders, Lewis & Thornhill 2009). This study has employed various data and information collection techniques, including interviews, observation and documentary analysis. Interviews and observations have played a major role in information collection as a primary method, but secondary data has been gathered from databases, documents, reports and historical records of the AUJHJWSG, AIMG, GWA and MOA. Together, these secondary sources have provided precious information about current water policy and the current state of water institutional frameworks and water infrastructure in Libya, as well as revealing the landmarks and perceptions of the planned direction of future water policy *(See Appendix E)*.

4.3.1.1 Plan of the interviews

As a case study, the primary information has been collected through interviews (Leedy & Ormrod 2005). Both the policymakers and farmers provided this information through interviews that focussed on topics such as water management reforms and the likelihood of these reforms achieving the objectives of the policymakers framing the water policy, how farmers can be helped to improve WUE and how, ultimately, sustainable water policy can be achieved. Information in relation to the concepts associated with the policymaker construct was largely gathered through interviews with policymakers themselves. Interviews with policymakers, managers and staff associated with the water authorities provided their perspective as specialists. Information on the concepts associated with the farmers construct was gathered through interviews with farmers. Farmers provided a summary of their experiences with water policies that were determined by the policymakers. This did not negate the need to question both farmers and policymakers about specific issues and points of view many times.

The researcher used a semi-structured interview framework, a qualitative information collection strategy which enabled standard questions to be followed with individually designed questions to clarify and gain deeper insights into participant responses and reasoning. As Leedy and Ormrod (2005) indicate, this allowed exploration of all issues that emerged as significant and relevant to the research. As mentioned previously, open-ended questions were used to provide opportunity for key participants to freely express responses in their own terms rather than be constrained to fixed choices made by the researcher. Open-ended questions ensure that the answers have meaning and are culturally relevant. Likewise, the results are, to a certain extent, unforeseen by the researcher and provide a richer and explanatory perspective.

In addition to open-ended questions, close-ended questions also were used. Numerical and categorical questions were asked of participants to obtain personal information about responses such as age, marital status and education (UFS 2010). Background information such as farm size, number of employees and the type of production was obtained by these types of questions as well. The questions were careful regarding research bias and avoided general and ambiguous questions, and complex questions which could invite conflicting answers to one question, so as to minimise errors in the analysis. As much as possible, questions were phrased so as not to lead to particular answers or be emotionally charged (Cavana, Delahaye & Sekaran 2001).

To encourage co-operation with this research, participants were personally contacted on site to request an interview. Personal face to face contact was a priority for the research. Telephone contact in this context was found to be less effective than direct contact. As Cavana, Delahaye and Sekaran (2001) comment from experience, hanging up the phone is the best shortcut for a participant to evade a researcher. Most information from the interviews was collected using audio-recordings; note-taking was used for others.

The researcher personally contacted policymakers, managers and staff to ask for interviews, knocking on their doors at their places of work. Most agreed to conduct interviews at the time, with a few arranging to be interviewed later. For those whose jobs are characterised by field visits outside an administration building, the researcher interviewed them on site in the field. The researcher personally visited the farmers and conducted the interviews directly on their farms and fields. Maps and addresses supplied by the AUJHJWSG database were used to identify and locate farmers. In a few cases, because farmers were busy with their work during the first visit, they were interviewed during a later follow-up visit.

It was anticipated that the participants would have different opinions on the issue, as farmers are buyers of water and GMRP authorities the sellers. All things being equal, sellers want a higher price, and buyers want a lower price. Thus, as mentioned previously, there was a need to question both farmers and policymakers about specific issues and points of view. Knowledge of both points of view regarding the issue and the comparison of their differing perspectives, supported from documents and reports, have enabled the research to arrive at a comprehensive picture of the situation, and enriched the researcher’s insight. This approach is supported by Neuman (2006), who posits that a study which considers both points of view will come up with a complete picture for the researcher.

Going back and forth between the different groups of interviewees was required to gather further information about the perspective of the other party upon issues and points of view raised by the first party during the interviews and vice versa to identify common points and get to the areas of agreement between them (Bhattacherjee 2012). The objective use of this information was an important factor in coming up with sustainable water policy. In the social context this was critical, as a researcher must not let her/his personal biases and preconceptions interfere with her/his ability to present a fair and accurate analysis and interpretation of the facts (Bhattacherjee 2012).

To obtain useful answers to the research questions, and thus ultimately address the research problem, variables related to policymakers, managers, staff and farmers were translated into interview questions in order to collect information (Johnson & Onwuegbuzie 2004). The interviews with policymakers, managers and staff provided the reasoning behind policy implementations and changes. In addition, the interview method enabled an exploration of Libya’s ability to both develop water infrastructure and to find new sources of water for future generations through the investment of GMRP’s water revenue on water exploration and technology. Policymakers were asked about their level of satisfaction with current water policies, and to identify the problems and challenges faced in the decision-making and drawing up of water policies.

The research scope included an investigation and debate about the point of view of policymakers regarding possible reforms and the development of efficient water use in agriculture, and the assumed water price to best able to achieve water policy and maintain the profitability of farmers and their viability. Through the interview questions, the study sought to gain insights into the policymakers’ understanding of farmer problems and their vision to find solutions. As well, the questions were framed to discover to what extent farmers’ understanding of the problem of water scarcity and the importance of efficient water use helps policymakers to frame sustainable water policy. To this end, the interview questions examined policymaker policies against the results from the survey with farmers.

The conducted interviews with farmers canvassed their thoughts on the issues surrounding water. Their responses provided information useful to understand the extent and severity of farmer water scarcity problems, efficiency and related policies. Farmers also provided insights by their ideas on how best to alleviate the impact on their practices and livelihoods. The farmers were asked about local water management approaches, how they observe these efforts, and whether they considered them to be effective or not. The interviews and surveys will present an updated picture of the socioeconomic conditions of the JPR's farmers and how water scarcity affects their situation.

It was also useful to investigate how farmers change as the result of specific circumstances or interventions by policymakers. Information about farmer viability facilitated finding a basis from which to set water policy. It needed to be ascertained through the interview questions if farmers considered that any change in water policy would directly affect their viability, or whether a range of water saving measures as a result of the change in water policy could preserve or improve their viability. Such details, as well as information about water policies, economic and social factors, and the physical environment affecting the situation, enabled the researcher to more fully identify the context of the case (Leedy & Ormrod 2005).

The research carefully applied a number of practical and worthy suggestions made by Leedy and Ormrod (2005, p. 148) in conducting the interviews, such as: identifying the questions in advance; considering participants' cultural backgrounds which may influence their responses; recording the responses verbatim, keeping in mind that the responses will not necessarily deliver facts; hiding the personal reactions of the interviewer; and getting written permission.

4.3.1.2 Observation

Observation takes its form of specific historical and social conditions within anthropology and sociology (Dawson 2002), as a procedure for generating understanding and new knowledge about the way of life of the people associated with the study. Primary observation methods fitted well with the research objectives as a supplementary method of information collection in addition to the interviews. As the researcher had the same cultural background as the interviewees and was familiar with the studied community, he was able to easily gain access to it. As advised by Bhattacherjee (2012), and Leedy and Ormrod (2005), the researcher spent as much time as he could on the farmers' fields and the AUJHJWSG sites observing and interacting normally with the participants in the study.

From the outset, the researcher started taking notes using audio-recordings and a private diary for information taken down in shorthand briefly during observations. The shorthand information was redrafted and stored systematically in the evening of the same day, heeding advice from Dawson (2002) that recalling such shorthand information after a long period of time would render it pieces of hieroglyphs difficult to reassemble. The information collected through primary observation depended on the research questions and objectives and concentrated on observing the key participants and their activities, and the events and processes related to the research problem. This was the basis for the writing of a narrative account, helping to develop a framework of theory that helped in understanding and capturing the whole picture of the research problem (Saunders, Lewis & Thornhill 2009).

4.3.1.3 Databases, reports and documents

Secondary data is used most frequently as part of a case study and often used along with primary data (Saunders, Lewis & Thornhill 2009). In this case study, secondary qualitative data of organisational documentation was obtained from the database, reports and documents of the AUJHJWSG, AIMG, GWA and MOA. The internal and external reports, briefings, planning documents and schedules needed were collected and summarised as set out in Chapter Two. The secondary data included written materials such as books, public records, journal, magazine articles, diaries and pamphlets, as well as visual and graphic materials such as pictures, maps, films, CDs and television programmes.

The researcher was granted access to the archives of all the AUJHJWSG, AIMG, GWA and MOA's websites, database, records, reports and documents through their libraries and Informing and Documentation Departments. Collecting secondary data and conducting interviews and observations in most cases were done together; the interviews' questions and responses often referred to required documents, where they are and seeking access to them.

4.3.2 Ethical clearance

Conducting the interviews with the policymakers and the farmers required an approval from the Office of Research and Higher Degrees at the University of Southern Queensland (USQ). The purpose of this approval is to ensure that participants' rights, methodological requirements and dissemination responsibilities are all addressed satisfactorily (Hays, Murphy & Sinclair 2003). Prior to this, the USQ Fast Track Human Research Ethics Committee assessed the application of Human Research Ethics to the research and agreed that it met the requirements

(*National statement on ethical conduct in human research* 2007). The project was endorsed and full ethical approval granted under the Reference Number H11REA010 *(See Appendix F)*.

Complete information about the research was provided in a letter directed to the participants under the title "Participant Information" *(See Appendix G)*. This letter contained an invitation to participate in the research. Details of the researcher, the research topic and a brief description of the research idea was presented in this letter, as well as a statement of the participants' rights, the confidentiality of their information and all questions expected to be asked by them. A Consent Form was designed, *(See Appendix H)*, to obtain the participants' consent through their signature on it. This form contains a declaration of the participant that the "Participant Information" has been read and the participant is aware of all details of the research through a number of points listed on the form in advance. Once this form is signed by the participant, the interview becomes valid.

4.3.3 Population and sample

The unit of analysis refers to the unit of the investigation whether person, collective, or object targeted in the research (Bhattacherjee 2012). This study used the staff members of authorities related to water issues, the AUJHJWSG, AIMG, GWA and MOA on one side, and members related to agriculture in areas which use the water of GMRP in JPR on the other side, as the units of analysis. In this research, the category of members of the water authorities is designated as "policymakers" and the category of members related to agriculture as "farmers". As a result, the population of the sample can be divided into two groups. Group One includes staff members of authorities related to water which are policymakers, managers and staff in these authorities. Group Two includes members directly linked to works of farming, irrigation and supervision in the private agricultural sector, public agricultural sector and foreign investors in agriculture *(See Appendix E).*

Interviewees were targeted on the basis of their expertise. As such, for Group One a purposeful sampling approach was used to select a sample of key policymakers, managers and staff. The non-random purposeful sampling method enabled the researcher to select information-rich cases to learn a great deal about issues of the research (Patton 2002). The participants were people within the AUJHJWSG, AIMG, GWA and MOA working in the areas of drawing up water policies and dealing with the other group (farmers) with regard to water issues. Their identification was achieved through personal contact with key people in these authorities known to the researcher.

As there were only a relatively small number of people in these positions, approximately eighteen participants were selected for the interviews. This approach is consistent with Malhotra (2010) in that the elements to be included in a sample should be representative of the population of interest. The numbers of targeted participants were distributed significantly and relatively to some extent according to the number of employees in each administrative level. Four policymakers were selected, the Undersecretary of the MOA, the Head of AIMG, the Head of the AUJHJWSG and finally, one of members of the Management Committee of the AUJHJWSG. For the managers, five members were found to be a suitable number to provide the required information. To represent the staff, as a pyramid base of the authorities related to water issues, nine members were selected.

In Group Two, members related to agriculture, information was gathered from samples of interviewees working in farming, irrigation and supervision jobs in farms owned in the public and private sectors and by foreign investment. While 20% samples are suitable (Cavana, Delahaye & Sekaran 2001), in reality, face to face interviews with more than 300 participants as a sample of the mentioned sectors population were difficult to achieve in the study's time frame. Interviews are time-consuming both in travelling and interviewing each participant separately. Therefore, it was anticipated that conducting at least 40 interviews distributed proportionally between the three sectors, as explained later, should achieve a sufficient degree of confidence in the information gained and enable the researcher to draw worthwhile conclusions.

Purposeful sampling was found to be the best way to select the participants from the foreign investors in agriculture and the public agricultural sectors. Three main foreign companies are investing in farms equipped with the GMRP's water in the JPR, the area of study, the TechnoFarm International LTD, the Almutahida Company and the Andalusia Agritechnique Company. Given the importance of benefiting from the experiences of foreign investors in dealing with the water issues, a purposeful sample of 6 participants was selected. These participants represented two of the foreign investment companies TechnoFarm International LTD and Almutahida Company, as the Andalusia Agritechnique Company was not undertaking any works in Libya during the period of research information gathering.

There were just two public agricultural projects in JPR using the water of GMRP called Tarhouna Project with total area of 950H and Abu Aisha Project with total area of 3320H. These projects are managed by AUJHJWSG in agricultural investment, either directly or in partnership with local or foreign investors [17]. As the local investors were included in the private sector and the foreign investors separated in the foreign investment sector, the need for information was sufficient from both the head and the irrigation official in each project, in addition to follow-up visits and observation.

For the private sector, there are currently 1618 small private farms with a total area 6289H irrigated by GMRP's water in the study area (AUJHJWSG 2010b; WTNWR 2003). The greater part of this area is located around Garhabuli City, and had originally been divided into four almost equal regions, known as the first, second, third and fourth region, by the AUJHJWSG to facilitate its management so as to provide the city with water. A smaller area located in the Abu Shebah region is considered the fifth region for purpose of this study as it almost equals the others in size. In addition, there are a number of more than thirty private investors in the public agricultural projects both in partnership with AUJHJWSG in agricultural investment and for their private account. Their different experiences were important to this study. Therefore, the researcher considered them as another region in addition to the other five areas. Elements of each part were homogeneous enough to be stratum in sampling.

The total population elements in the six parts of the private sector are estimated at 1648 farms. The six parts (strata) are roughly equal in size. Thus, the best sampling technique for private sector was a stratified random sampling approach and equal samples were taken from each of the six strata. The homogeneous strata will ensure a good representation in the sample, consistent with (Leedy & Ormrod 2005) recommendation that stratified random sampling has the advantage of guaranteeing

[17] More details about these projects are in Chapter Two.

equal representation of each of the identified strata when those strata are roughly equal in size in the overall population as well. Each stratum will be studied alone and compared with each other (Lukas et al. 2004). The sample avoids bias as it represents the true distribution of the population and gives an equal chance to each member to be selected (Leedy & Ormrod 2005). The sample frame includes participants from each stratum according to the database of the MOA and AUJHJWSG, in conjunction with a map of the geographical area of the JPR (Leedy & Ormrod 2005; Malhotra et al. 2006).

The number of elements of the population in each sector reflected the number of interviews held, and ensured adequate representation from each sector. The nature of the culture of the people in the six strata in JPR and their strong interrelations with each other enabled the researcher to obtain a high response rate through the researcher's relationships with many people in the area. Hospitality is an important aspect of culture in Libya and visiting the farmers in their own places in effect created a moral duty; the hosts, the farmers, sought to serve their guests as best as they could. As anticipated, farmers in particular would not usually refuse to respond to the researcher's questions.

4.3.4 Analysis of interview responses, observation and data

The analysis initially began concurrently with data and information collection by classifying the data and reviewing, preparing and converting the audio-recordings and notes of information collected from the interviews and observations into word processed text, making links between the data and the information collected whenever possible. This was mostly done in the evening of the same day after the interview and observations had taken place, a procedure advised by Leedy and

Ormrod (2005). This influenced and improved the quality of later interviews and identified precisely any other secondary data needed.

Mixed techniques for analysing inductively text data and information were used in this study. The sentiment analysis in content analysis was used to capture policymakers' experience and farmers' opinion and attitude toward water scarcity (Bhattacherjee 2012). A narrative analysis was also needed as a complementary means to explore linkages, relationships and socially constructed explanations that naturally occur within narrative accounts to analyse the data and information (Saunders, Lewis & Thornhill 2009). The research conducted the analysis of interview responses collected from the interviews and observation in order to investigate the research problem in greater depth. Analysis of interview responses and observation in this research focused initially on simplifying and abstracting the information from interviews, and organising, compressing and combining the data. Miles and Huberman (1994) identify these steps as data reduction, data display and conclusion drawing and verification.

The case study strategy needed to use and triangulate multiple sources of data and information. Different data and information collection techniques were used in order to confirm the telling of the information (Saunders, Lewis & Thornhill 2009). The secondary data summarised and documented in Chapter Two was used as a means of triangulating findings based on other data and information, such as information collected through observations or interviews. Many separate pieces of information ideally should all point to the same conclusion (Leedy & Ormrod 2005). The summary of documentation helped in providing a list of the key points related to significant concepts in the case study themes and concepts such as water institutional frameworks, water infrastructure and water management policies in Libya. This summary was useful in the analysis of other concepts and referred to the sources of data and information. Secondary data provided a useful source to partially answer the research questions.

Information from the interviews was summarised in a word processed text maintaining both factual accuracy and the spirit of the interview in terms of what had been said and observed at the time. Facts about the case study, information and observations related to research problem and questions were drawn from the interviews and data, arranged and organised in a detailed logical order, and categorised into meaningful groups (Creswell 1998). Each group served a particular question of research. Each concept or category of data or information was examined separately for specific meaning and interpreted in relation to the case study. Corbin and Strauss's (2008) coding techniques were useful in this context, since open coding identified the characteristics of each concept, and enabled similar concepts to be grouped together in categories as constructs in a grounded theory.

Identifying categories helps cluster the data and information into meaningful groups (1998). The constructs "categories" and concepts "variables", already defined in this chapter, were labelled or named to define the intended category and variable so as to convey a specific meaning or description. This categorisation indicated significant issues, themes and causal relationships between them, and developed a deep focus in relation to the research questions and propositions. Strauss and Corbin (2008) describe this technique as axial coding, with selective coding leading on to the next stage in grounded theory.

In this study, selective coding was employed to identify the construct of sustainability the central category and to recognise and develop the relationships between it and other categories. The construct of sustainability was systematically and logically recognised and the relationships between the central category and other categories developed, with the categories' interrelationships forming the story line to describe "what happens" in regard to the research problem (Strauss & Corbin 1998). Data and information were interpreted and examined accurately to identify themes and patterns in the case study more broadly rather than focussing on a segment of the data or information.

Miles' (1994) matrices were useful to display reduced information drawn from the word processed text. The design placed the participants' names in the first defined column, with their ages, qualifications, specialisations and experiences in the four following columns. The first defined row contained the data and information variables. All other cells in the table were divided to two parts; the first dedicated to information, the second to observations. A little space in each part also referred to the source of information and observations, and related data. All relevant information and observations and links to any related data of each concept were entered selectively into the appropriate cells, recording the engagement of every single participant.

A couple of little squares were included above each cell, colour coded to highlight the different relationships in the data through the responses. The cells below the last row were specified for descriptive statistics. They show the statistical descriptions incorporating frequencies and percentages and illustrated the degree of agreement and difference in respondents' views about each concept. The last column was allocated for any general information that might be needed. Miles (1994) recommends this kind of format, arguing that it helps in the development of analytical thinking by representing data and information in limited and comprehensive visual forms *(See Appendix I)*.

To avoid any biases or prior expectations, the researcher suspended all his previous knowledge and information to ensure that the theory was based only on the data and information collected. The data and information were left to dictate the formulation of the theory (Bhattacherjee 2012). The information related to the ideas, attitudes, opinions, and interactions according to the categories summarised in the word processed text, and was examined and listed in the table to display its relationship with the concerned concept.

The rule of thumb for data and information entry and conclusion drawing followed Miles' (1994, p. 241) indications, and were the best to take all variables into account. Information was displayed in a great dense matrix as much as possible for a small percentage of the available information. Some direct quotes and paraphrases were also needed. Inclusion of any bit of information in any cell was coupled with the inclusion of a tag referring to its source to facilitate getting back to it when needed. The secondary data collected and summarised was classified according to the concepts of the study and each individual source was given a reference number. Each document was linked to specific piece of information or observation raised by any participant, referred to by the reference number in related cell of the matrix.

In some cases, the information and data which were missing or ambiguous associated with a certain respondent were shown in a related general information cell in the matrix. The use of numbers in ratings or scales included in the last row was coupled with phrases to clarify and further define their meaning. The display in this way enabled the identification of the patterns, conditions and interactions emerging from the data and information. It facilitated comparisons between responses given in the rows of the participants and cross the columns with each concept, thus enriching the exploration and analysis of the information. In addition, it helped in interpreting the data and information for the purposes of drawing and verifying conclusions.

Conclusion drawing and verification began with a quick scan of the matrix cells looking for any stereotyped or atypical relationships and matched, conflicting and extreme or bizarre responses. Highlighter pens, in similar colours to the colour coded squares of the table, were used to highlight these relationships and responses. Arrows were used as needed to indicate significant relationships. These were continually and carefully verified and revised during the analysis phase. Later, and due to the large size of the table, it was split into parts so that each part devoted to a participant in conjunction with the variables.

The initial conclusions were drawn through making comparisons and contrasts, and clustering and counting the identified patterns and relationships. These initial conclusions were checked back against the raw data and information, and revised, reverified and reconfirmed, then coupled with the writing of clear memos. Miles (1994) points out that writing is itself a form of analysis and the associated text is always needed. The suitable tactics of Miles (1994) that check findings by examining exceptions to early patterns and take a sceptical, demanding approach to emerging explanations were used in this study for drawing conclusions from matrix information.

Emerging a theory from the process of data and information collection, and analysis needed the use of grounded theory techniques to interpret recorded data and information. As an inductive technique, grounded theory was developed by Glaser and Strauss (1967) (Bhattacherjee 2012; Saunders, Lewis & Thornhill 2009). It uses a prescribed set of procedures for analysing information and constructing a conceptual model from them (Leedy & Ormrod 2005, p. 142). Drawing conclusion and generalisations construct the overall picture of the case study. Following Leedy and Ormrod's (2005) position, the generalisations made in this case study as a single case are tentative and must await further support from other studies - perhaps from additional case studies or experimental research.

The structural model developed explains the natural evolution of the problem and describes the cause and effect of certain interactions related to the problem. According to Leedy and Ormrod (2005) a theory describes how certain conditions lead to certain actions, how those actions lead to other actions in a typical sequence of events being laid out. Comparison between the relationships, patterns, conditions and interactions in categories is followed by interpretations to determine which themes occur most frequently, in what contexts and how they are related to each other, and this enables the delimiting and writing of the theory. Following Bhattacherjee (2012), the model was validated by comparison with raw data and information, and no contradictions were found. Finally, identifying the context of this case study helps those interested in this report to draw conclusions about its findings, and whether they may be generalised to other situations (Leedy & Ormrod 2005).

4.4 Summary

Given the nature of the research problem, an exploratory research strategy was found to be the most suitable for this case study. The argument for building the theory inductively, through observed patterns of events, behaviours, actions and interactions, was put forward through a series of observations, interviews and data. The qualitative research method was argued to be an appropriate method to explore and understand the reasons for conducting this study. Qualitative methods covered both the social phenomena represented by farmers and the political economy approach represented by policymakers in the responses to interview questions.

The study required the development and identification of seven core concepts whose interrelated harmony increased the opportunities of achieving water sustainability. These concepts were associated with three constructs: those of policymakers, farmers, and sustainability. The priorities of water and agriculture policy, in addition to the economic, social, environmental and political challenges, required raising the importance of some concepts and the acceptance of a lower level in others to some degree.

Interviews and observations have played a major role in the study as the primary method of information collection. The interviews were validated by obtaining ethical approval from the USQ, and the written and signed participants’ consent. Secondary data gathered from databases, documents, reports and the historical records of the AUJHJWSG, AIMG, GWA and MOA were used to complement and support the primary data. Access was granted to the archives of all these organisations’ websites, database, records, reports and documents through their libraries.

The sample population included the policymakers, managers and staff related to AUJHJWSG, AIMG, GWA and MOA, and members linked directly to farming, irrigation and supervision works in the private agricultural sector, the public agricultural sector and foreign investors in agriculture in JPR. A purposeful sampling approach was used to select a sample of key policymakers, managers and staff, and participants from the foreign investors in agriculture and the public agricultural sector. A stratified random sampling approach was identified as the best sampling technique for the private sector.

Data analysis followed the steps and techniques identified by Miles and Huberman (1994) for analysing inductively text data and information, moving from data and information reduction to data and information display and finally to conclusion drawing and verification. The conclusion was validated by comparison with the raw data and information. The next chapter will discuss the analysis and findings of the thesis.

5.0 CHAPTER FIVE: ANALYSIS AND DISCUSSION

5.1 Introduction

The analytical process involves the abstraction and interpretation of the information whereby interviews, observations and data are broken down to generate concepts clustered into descriptive categories, re-evaluated for their interrelationships and subsumed into higher order categories (Goulding 2002). This chapter aims to analyse the information and draw conclusions for the purpose of achieving the research objectives. Information collected from interviews and observations are classified, abstracted and interpreted, and compared to secondary data and the literature as the need arises.

The chapter’s structure is guided by the research questions and the objectives and is divided into eight sections. The introductory section deals with the context and purposes of the analysis, while the second section reviews the demographic and personal characteristics of the participants. The following four sections present the classification, analysis and discussion of the categories, themes and concepts identified in the observations and responses to each research question, with the assistance of graphics displaying the categories, themes and concepts related to each question. The seventh section displays the developed structural model which links and assesses the relationships between constructs and concepts, and establishes the best engagement between the policymakers and farmers in order to achieve sustainable water policy. The eighth section concludes the chapter with a summary of the research findings.

5.2 Demographic and personal characteristics of the research participants

This section provides an overview of the demographic and personal characteristics of the targeted participants as defined by their profession, age, educational qualifications, experience, and, in the case of farmers, if they worked full-time or part-time on their farms. As indicated in Chapter Four, the research sample was divided into two groups, policymakers and farmers. The policymaker group was drawn from the staff of the authorities related to water issues, the AUJHJWSG, AIMG, GWA and MOA, and subdivided into three categories: policymakers, managers, and staff members. Participants in the farmer group were directly involved in farming, irrigation and supervision work in four areas, local and foreign investment and the private and public agricultural sectors.

For the purposes of analysis, the respondents were each assigned to a category according to their role and given a reference number in order to ensure research objectivity and guard against possible personal biases of the interviewer. The information gathered could thus be considered in relation to the role and functions of the respondents rather than to them personally as individuals. *Table 5.1* shows the selected sample of participants and their different categories, numbered from 1 to 58.

Table 5.1: Sample size, showing the grouping and categories of the study participants

Group	Category	Reference Number	Number of Participants
Farmers	Local investors	1 - 5	5
	Private agricultural sector	6 - 30	25
	Foreign investors	31 - 36	6
	Public agricultural sector	37 - 40	4
Policymakers	Staff of authorities related to water	41 - 49	9
	Managers of authorities related to water	50 - 54	5
	Policymakers of authorities related to water	55 - 58	4

Where the interests of local investor and private sector interviewees coincided or where there were no significant differences between their responses to questions related to the same subject or idea, the researcher treated these two categories as one.

The age of the study participants ranged between 30 and 60, with the average age of the policymakers at 48 years and the farmers at 47. It must be noted that two of the farmers were 70 years old, extreme values for the sample. The age distribution for the study participants are shown in *Tables 5.2* and *5.3*.

Table 5.2: Age distribution of policymaker group

Ages	**Policymaker Group Members**
36 – 40	2
41 – 45	3
46 – 50	7
51 – 55	4
56 – 60	2
Total	**18**

Table 5.3: Age distribution of farmer group

Ages	**Farmer Group Members**
30 – 35	6
36 – 40	6
41 – 45	10
46 – 50	5
51 – 55	4
56 – 60	7
70	2
Total	**40**

A high proportion of young people were present in both groups, with the median ages of policymakers being 46 - 50 years and the farmers 41 – 45 years. From the interviews, they characteristically expressed an enthusiasm and willingness, on the one hand as policymakers to work successfully to achieve water management policies, and on the other as farmers to achieve viability through the application of those policies.

Almost 78% of the study participants from the policymaker group had qualifications directly related to water and agriculture (14 out of 18). While the percentage for a group needing specialised knowledge seems reasonable, however, no participant possessed qualifications higher than a Bachelor's degree. Nevertheless, according to the criteria for a purposeful sample, the selected sample is appropriate for the purposes of the study (Patton 2002). *Table 5.4* shows the distribution of these participants according to their educational qualifications.

Table 5.4: Educational Qualifications of Policymaker Participants

Qualification	**Number**	**Qualifications related to water and/or agriculture**
Masters Degree	0	N/A*
Bachelor Degree	15	12
College Diploma Degree	3	2
Vocational training	0	N/A
Secondary	0	N/A
Primary	0	N/A
Illiterate	0	N/A
Total	**18**	**14**

* Not applicable

Using secondary sources to complement the information gathered in the interviews, the study examined the profiles of policymakers, managers and staff in the archives of the authorities related to water and agriculture. The database revealed that the educational qualifications of a number of employees, in particular those of managers in sensitive positions directly related to water and agriculture, did not have any relationship either to water management or agriculture. For example, one manager was an army officer, and several others lacked even a college diploma degree and appeared unqualified for administrative work.

The information gathered through the study interviews, observations and inquiries and the researcher’s in-depth knowledge of the study environment indicate that the demographic and personal characteristics of the farmers in the research sample are in the main representative of the study population as a whole.

The interviews revealed that, similarly to the policymaker group, 80% of the farmers in the study (32 out of 40) possessed higher educational qualifications, although only 33% of these were related to water and agriculture (13 out of 40). In contrast to the policymakers, however, three of the farmers held a Master’s degree in agriculture. The distribution of the farmer group participants according to their educational qualifications can be seen in *Table 5.5*.

Table 5.5: Educational Qualifications of Farmer Participants

Qualification	Number	Qualifications related to water and/or agriculture
Masters Degree	3	3
Bachelor degree	11	6
College diploma degree	18	4
Vocational training	1	0
Secondary	3	0
Primary	1	0
Illiterate	3	0
Total	**40**	**13**

The policymaker group had an average of 23 years of experience. Although for a number of them this experience was not fully in the field of water management in AUJHJWSG, they had still been working in fields related to agriculture in general.

Table 5.6 shows the distribution of the experience in years of the policymaker participants in the study.

Table 5.6: Years of Experience of Policymaker Participants

Years of Experience	Number of Policymaker Participants
11 - 15	2
16 - 20	6
21 - 25	2
26 - 30	5
31 - 35	3
Total	**18**

An examination of farmer experience needs to take into account whether or not they are engaged in full or part-time farming. For the private owner farmers, in particular, the experience factor is affected by how much time they actually work or are able to work on their farms. The distribution for all farmers in the study sample is shown in *Table 5.7*.

Table 5.7: Farmer Participants' Years of Experience and Availability to Work on Farms

Division of experience	Number of Farmers	Full-time work in farming
1 - 5	1	0
6 - 10	6	2
11 - 15	5	3
16 - 20	7	2
21 - 25	4	3
26 - 30	9	5
31 - 35	5	2
36 - 40	1	0
41 - 45	0	0
46 - 50	0	0
51 - 55	2	2
Total	**40**	**19**

During a discussion about farmers' experience with the researcher after viewing the data in *Table 5.7*, the Manager of the Guidance Department in the MOA, Participant 41, commented:

> *Let's agree that the experience here, for private owner farmers, does not necessarily mean years of work in farming, while [instead] it means years of living on the farms as a residence, but these years may have been interspersed with periods of work in farming.*

To an extent, the sample data in *Table 5.7* supports this claim, as a substantial number of private owners were working full-time in other professions. Participant 26, a private owner, provided an explanation for the situation:

> *Most farmers are not full-time working in farming as a result of the failure of the agriculture sector in ensuring a sufficient income that reaches the aspirations of the farmers in achieving what they need of the necessities that cannot be gained by working in farming.*

Two of the participants from farmers' group had over fifty years experience in farming, while the rest of the group ranged between 5 and 40 years. Treating the experience of these two farmers as extreme values, the average length of experience for the other farmers was 22 years. Giving validity to this figure, the median value for the experience of all the farmers in the study sample was 21-25 years.

At first glance, the data in *Table 5.7* gives the impression that 48% of the farmers were working full-time in farming (19 out of 40). However, as eleven of these farmers were local and foreign investors with full-time farming a priority in order to make payments to the AUJHJWSG and to achieve viable returns on their investment, they should theoretically be excluded from the data. Private owner farmers, on the other hand, own and live on their own land, and as the farm is considered a fixed asset and they do not pay any taxes on it, they do not need to farm full-time, but can work at a better paying job and farm part-time or as time allows. It can be said, therefore, that only 28% (8 out of 29) of the farmer respondents were farming on a full-time basis.

It should be noted here that private owner farmers who work in other professions are not necessarily working part-time in their farms. Many of them do not work at all in farming and others only work at specific seasons or only under specific circumstances.

Before the discovery of oil, the Libyan economy was heavily dependent on agriculture (European Commission 2009). Farmers followed traditional practices and sustainable farming methods in relation to the technology available at the time. After the discovery of oil in 1959, the balance shifted in favour of oil (CW 2001a, 2001b), with the agricultural sector neglected and going through a great period of depression (European Commission 2009). Most indigenous farmers either left farming in favour of other more profitable occupations or disappeared from the sector through old age or death.

As the Libyan government seeks to revive the agricultural sector, the demographic and personal characteristics of farmers have changed greatly with the loss of a generation of traditional farmers. While the relatively young average age of current farmers is an advantage in terms of the knowledge and use of modern technologies and practices, it is an obstacle to long term commitment to agriculture. As a profession, farming does not meet the aspirations of young people in the prime of life for a viable and stable income to provide for their needs.

An indication that many of these farmers are not specialising in agriculture is evident in the data in *Table 5.5*, with 20 of the respondents undertaking vocational or tertiary education in areas other than agriculture as opposed to 13 gaining qualifications in the area. It also became apparent in the interviews that many farmers lacked sufficient experience in farming, as they had either inherited or bought farms in periods of recession in agriculture, and did not have an understanding of farming practices and fundamentals. Even where farmers had gained knowledge of traditional practices from the previous generation, this experience was not particularly helpful in keeping pace with the modern technologies and farming methods demanded at the present time in agriculture and irrigation. The increasing importance of oil revenues, the knowledge between the previous and current generation of farmers, and the inheritance system have all greatly impacted upon agriculture in Libya and exacerbated the problem of water in agriculture.

5.3 Categories, themes and concepts of responses to the first research question

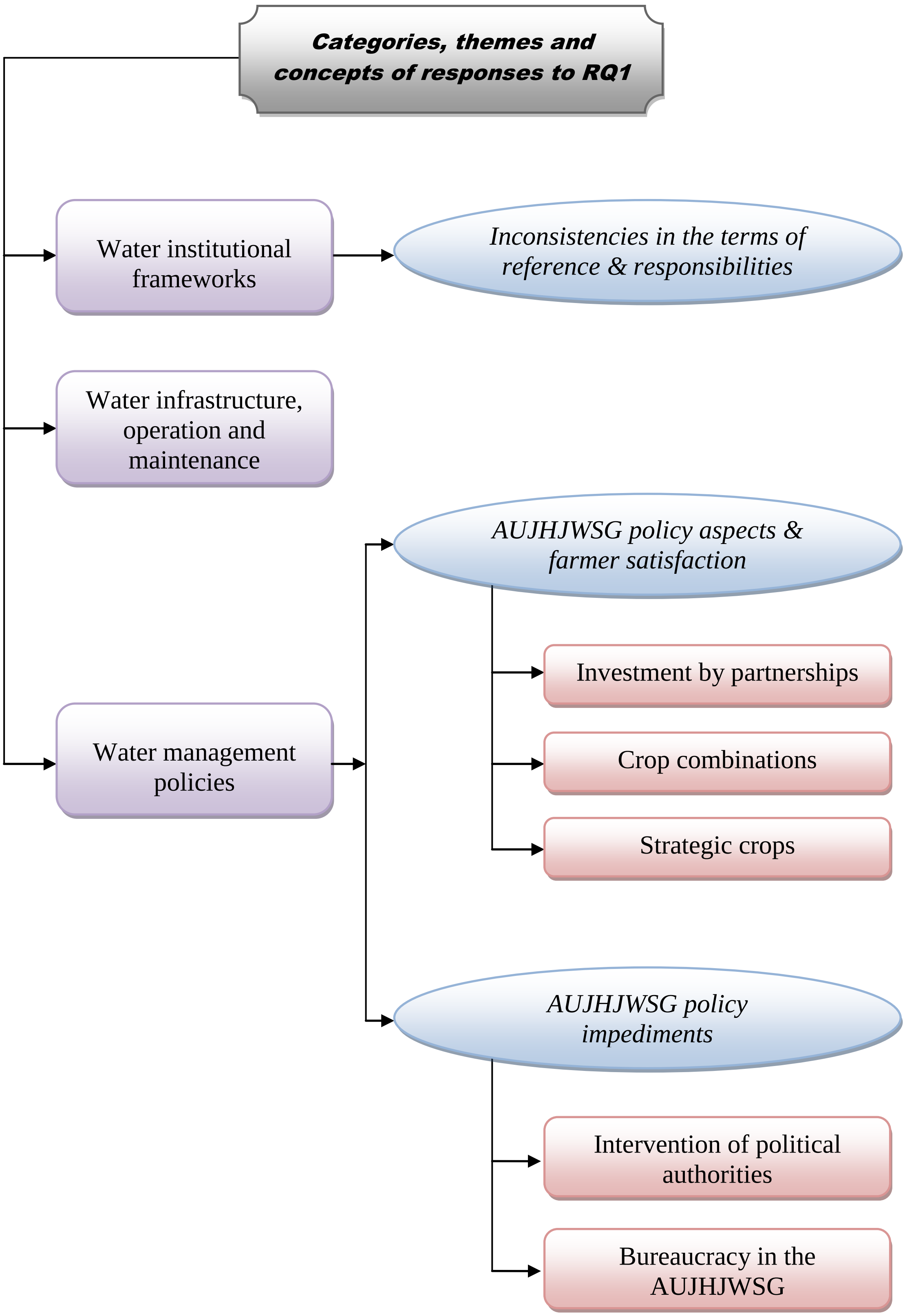
The first research question is centred on the water institutional frameworks, infrastructure, operation and maintenance, and related features of water management policies in Libya. The focus area establishes the institutional context through the examination of databases, reports, and documents of AUJHJWSG, AIMG, GWA and MOA and uses qualitative data gathered from interviews with water stakeholders to evaluate the set of natural and organizational activities supporting water resources management (ASCE 2009).

Information from secondary sources relevant to the first question is presented in Chapter Two of the research and is taken from the databases, reports, and documents of AUJHJWSG, AIMG, GWA and MOA. In this context, the research asked participants in the interviews to respond to several questions related to water institutional frameworks, infrastructure and water management policies. Respondents were given the opportunity to present their personal opinion, point of view and evaluation of water institutional frameworks and associated infrastructure to identify problems with water management policies. The central question was as follows:

- What is your opinion and evaluation of the institutional frameworks and infrastructure of the water sector, and water management policies in Libya in general and in particular AUJHJWSG?

An examination of the participants' responses enabled their grouping into a number of categories, themes and concepts. These are presented in *Figure 5.1*.

Figure 5.1: Categories, themes and concepts of responses to the first research question



Hydrosocial Contract acts as the basis for institutional development, and determines what the public deems fair and legitimate to which policymakers react, such as the desire for ecological sustainability (Turton 2000). The majority of the respondents agreed that there are inconsistencies in the terms of reference and responsibilities of the institutions associated directly or indirectly with water management, such as the AUJHJWSG, AIMG, GWA, MOA and other relevant institutions. The situation is considered to have been aggravated by negative political interference, often through the restructuring of institutional frameworks from one period to another without sufficient research or consultation. A MOA staff member (Participant 41) commented:

> *There is a big problem in the water institutional frameworks, which always leads to failure of water and agricultural policies. It is the inconsistency in the terms of reference and responsibilities of these institutions sometimes. In addition to the lack of interrelating and concentrating their efforts in one direction to support plans and policies of AUJHJWSG ... Departments and even ministries often being merged together and separating others repeatedly which was always confusing AUJHJWSG and other relevant institutions' policies.*

The Oxford report (2008) supports this comment that there were several problems that arose from the issue of having many bodies governing the management of water resources. To some extent this is usual according to Complexity Theory. The institutional and strategic uncertainties and unknowns are usually witnessed in issues to do with water management (Wallace & Wilkinson 2004).

Most respondents indicated that the stability of the water institutional departments and ministries was essential. The terms of reference and responsibilities should be clearly and accurately distinguished, and published to provide accessible guidelines to inform the roles, responsibilities and actions of all staff and managers and policy makers. This does not conflict with the view that drawing up some aspects of public policy requires the participation of those institutions convened to achieve the overall objectives of the agriculture sector and the state. Some countries such as Egypt, Jordan and Morocco have established high-level national planning and coordination entities to combine the voices of those key ministries that have direct and indirect impact on water (Dayem & Odeh 2008). Tiihonen (2004) considers Effective Institutions as one of the good governance keys in "The enabling environment for good governance" model.

The following table *(Table 5.8)* summaries the views of all interviewees in relation to the proposition that there are inconsistencies in the terms of reference and responsibilities of the water governance institutions:

Table 5.8: Interviewee acceptance of the proposition that there are inconsistencies in the terms of reference and responsibilities of the water governance institutions

Group	Members	Agreed	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	18	72%	2	8%	5	20%
Local investors	5	0	0%	0	0%	5	100%
Foreign investors	6	0	0%	0	0%	6	100%
Farmers of public sector	4	2	50%	0	0%	2	50%
Staff	9	7	78%	1	11%	1	11%
Managers	5	2	40%	0	0%	3	60%
Policymakers	4	1	25%	1	25%	2	50%
Total	**58**	**30**	**52%**	**4**	**7%**	**24**	**41%**

Respondents were divided in their opinions about the water infrastructure and its operation and maintenance. Three main viewpoints can be identified. In the first, 25 respondents from all the groups interviewed considered the infrastructure to be excellent, modern and up to date. Their distribution is shown in *Table 5.9*.

Table 5.9: The view that the water infrastructure is excellent, modern and up to date

Group	Members	Agreed	%
Local investors and private sector	30	8	27%
Foreign investors	6	5	83%
Farmers of public sector	4	4	100%
Staff	9	6	67%
Managers	5	1	20%
Policymakers	4	1	25%
Total	**58**	**25**	**43%**

For example, a respondent from the private sector (Participant 15) said:

> *Generally, the infrastructure is very excellent, flexible in controlling the flow of water and enables of following policy of organizing of scheduled irrigation by hours among farmers during the day and night.*

Another participant from the staff expressed the opinion that:

> *AUJHJWSG achieve its work through a huge and modern infrastructure of wells, distribution networks, reservoirs, power stations and carefully specified and studied pumping stations with 3 bar power to each farm gate. All linked to the control system and associated to AIMG in addition to the roads' paving, car parks, lighting and....*

A Senior Executive Director in the AIMG (Participant 57) further commented:

> *Water infrastructure was much earlier than its time that it provided the water since 1996, but consumers and investors were not ready for investment at that time.*

The GMRP report (2011) is consistent with this statement that although the current production capacity of the GMRP is about 4 mm^3 / day, it produces only 1.6 mm^3 / day due to lack of readiness of subsystems and some agricultural projects.

21 respondents took another viewpoint, considering the water infrastructure to be good but having problems in operations and maintenance. These participants were of the opinion that the irregular flow of water and the lack of constant maintenance schedules for the network limit the efficiency of the planning process for agriculture and irrigation organisation, and that the problem affected both the yield and agricultural work in general. Ferragina, Marra and Quagliarotti (2002) are in agreement that despite the development of infrastructure in the public and private sectors, Libya is failing to achieve acceptable levels of performance. The following table *(Table 5.10)* shows the distribution of these respondents around this viewpoint:

Table 5.10: The view that the water infrastructure is good but with operational and maintenance problems

Group	Members	Agreed	%
Local investors and private sector	30	15	50%
Foreign investors	6	1	17%
Farmers of public sector	4	0	0%
Staff	9	2	22%
Managers	5	2	40%
Policymakers	4	1	25%
Total	**58**	**21**	**36%**

In this regard, a policy maker (Participant 55) stated:

> *There is a problem in the operation and the lack of automatic control systems to control the flow of water supplies for its allocation to each farmer. Construction of such systems needs millions of dinars as well*

> *as fears that it would be vulnerable to tampering and sabotage, as happened to some other equipment previously. That is due to the lack of the security and awareness of the public interest.*

The remaining interviewees did not express or declare an opinion about the infrastructure, apart from one respondent (Participant 53) from the managers' group who held a negative view of the water infrastructure. He commented:

> *The infrastructure is not good and improperly designed and distributing of its water has got major problems in some areas in the imbalance of water pressure, addition to interruptions and the operating problems.*

The AUJHJWSG, as a public sector, has two different water investment plans *(see section 2.10.2 Chapter Two)*. Manager and policy maker interviewees were unanimous that the AUJHJWSG's investment policy of partnership with private companies as investors is viable and has achieved a success much greater than that of the water sale policy to privately owned farms, both in terms of returns on investment in agriculture as well as in terms of raising the WUE. This is due to the availability of capital and expertise in the agriculture business, as well as marketing. An interviewee (Participant 57) from the group of policy makers agreed with this position, saying:

> *Local and foreign investors have more ability in competition in the field of agriculture than private owners. Policy of investment by partnership proved its success and viability even by certificates of specialized international organizations through agricultural projects, such as the Abu Aisha and Tarhunah [18].*

Tiihonen (2004) finds that public-private partnership is an important factor in the enabling environment for good governance.

[18] For more information about these projects see Chapter Two.

In investment by partnership projects, AUJHJWSG imposes certain conditions on the investors which cannot be imposed on private owners. For example, it includes the terms of procurement of modern irrigation techniques and the commitment for timing the irrigation during the day and the night as well as the crop combination and other related matters. Termination of the contract with the investor as punishment for violations of AUJHJWSG's policy conditions is considered the best deterrent to ensure that only committed partnerships remain. This has led to the exit of a large number of investors from the competition. Participant 1, a local investor, commented:

> *When we started working in the AUJHJWSG's projects, large number of investors had undertaken the investment. Over time the number reduced to less than half because of the infraction of the provisions of contracts and lack of the ability in competition.*

Conditions that can be imposed on investors cannot be imposed on private owners for several reasons. Respondents drew attention to some of these, such as the lack of capital, specialisation and the ability to be competitive in marketing. It is difficult for farmers to successfully compete with other investors in marketing and procuring modern irrigation techniques or to afford paying for water. The AUJHJWSG is thus unable to raise the WUE of farmers and to generate fair returns from the sale of water to them. Farmers are undeterred by the threat of depriving them of water while drawing on the limited water resources of private wells still remain an option to them. A manager (Participant 51) emphasised this point:

> *The problem with private owners that there is no clear policy for dealing with them until now, where the most waste, inefficient use of water and evasion of payment of the value of water comes from this segment of the farmers.*

Most of the local and foreign investor interviewees as well as a number of respondents from the water-related authorities *(see Table 5.11)* expressed satisfaction with the AUJHJWSG model of investment partnerships. The continuing participation of these investors for many years while the others withdrew from the competition is the evidence of this satisfaction.

Table 5.11: Approval of the AUJHJWSG model of investment partnerships

Group	Members	Agreed	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	7	28%	0	0%	18	72%
Local investors	5	4	80%	1	20%	0	0%
Foreign investors	6	6	100%	0	0%	0	0%
Farmers of public sector	4	2	50%	1	25%	1	25%
Staff	9	7	78%	0	0%	2	22%
Managers	5	3	60%	0	0%	2	40%
Policymakers	4	2	50%	0	0%	2	50%
Total	**58**	**31**	**53%**	**2**	**3%**	**25**	**43%**

In this regard, a public sector interviewee (Participant 37) and foreign investor (Participant 33) agreed that:

> *The work or the investment in agriculture with AUJHJWSG is very profitable even though it could be better than that, but requires capital, the specialisation, devoting time and organized action.*

Some respondents drew attention to negative aspects impeding the success rate in investment projects and discouraging investment, thus limiting the success of AUJHJWSG policies and objectives. The most important of these were identified as the unsatisfactory level of WUE, bureaucratic, administrative and financial problems and operating and maintenance problems. There is a weakness and often an absence of stringency in the application of the policies and the efficient collection for water value from private owners. According to a staff interviewee (Participant 44):

> *Problems always occur in the application of policies, not in the policies itself. The AUJHJWSG is dealing with human beings, private owners, often with a low level of education, without specialisation and not eligible. This makes them not understand the AUJHJWSG's policies. These policies encourage them to invest their allocated quantities of water in crops proportion with these quantities and get the highest returns of them. Therefore, we see them later are unable to achieve a satisfactory level of WUE and thus they be unable to pay for water value.*

A lack of specialisation and eligibility can be identified as significant factors impacting upon the ability of farmers to achieve acceptable levels of WUE. On the other hand, farmers accuse the AUJHJWSG staff of mismanagement and incompetency in the application of farmer related policies. Participant 12, for example, a private owner farmer, commented:

> *There is a big administrative laxity in the AUJHJWSG. It lacks the control and oversight to the farmers and the field follow-up and taking readings of the meters and making comparisons in order to facilitate the discovery of any inefficient water use, waste or fraud in obtaining water (illegally), if any.*

Contrary to the view of most local and foreign investor respondents, most private owner farmers do not show any satisfaction with AUJHJWSG policies, with a number of these interviewees believing that there is mismanagement in water and agriculture sectors in general. Some even expressed the opinion that there are no water and agricultural policies in Libya to encourage or support farmers. A private owner (Participant 9), for example, commented:

> *The AUJHJWSG does not include the involvement of the farmers and their concerns in drawing the policies. It works in isolation from farmers, where they connect the water and interest and demanding*

> *payment for water value only. They do not pay any attention to the agricultural guidance and financial support and marketing policy in the country.*

In contrast, however, another private owner (Participant 23) held a different opinion:

> *As I am an agronomist and have 28 years experience in agriculture, I understand all policies carried out by the AUJHJWSG. I think it is very suitable for farmer success on the one hand and appropriate to raise the WUE on the other.*

The following table *(Table 5.12)* shows the percentages of agreement and disagreement in relation to AUJHJWSG policies among the participants from different fields.

Table 5.12: Satisfaction with AUJHJWSG water policies

Group	Members	Agreed	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	4	16%	18	72%	3	12%
Local investors	5	3	60%	2	40%	1	20%
Foreign investors	6	6	100%	0	0%	0	0%
Farmers of public sector	4	2	50%	1	25%	1	25%
Staff	9	4	44%	3	33%	2	22%
Managers	5	1	20%	1	20%	3	60%
Policymakers	4	3	75%	0	0%	1	25%
Total	**58**	**23**	**40%**	**25**	**43%**	**11**	**19%**

One AUJHJWSG policy imposes certain crop combinations on farmers, focussing on crops with low water consumption and high returns in terms of food value or economic returns for both farmers and the country. The key policy objectives are:

- ✓ The goal of raising the WUE.
- ✓ The goal of not compromising (prejudice) the farmer’s viability.
- ✓ The goal of the controlling the market and prices.

This policy is recommended by the NCBMM (1994), water users should be encouraged to take bold steps to conserve water by changing their crop combinations. Commenting on the policy, one local investor (Participant 5) said:

> *Crop combinations policy has been imposed previously by the Ministry of Agriculture and has succeeded to some extent, but due to lack of follow-up farmers no longer abide by it.*

Most staff interviewees believe that the AUJHJWSG should adopt a crop combination policy to exploit the water and the land in an appropriate manner compatible with the goal of raising WUE. One staff member (Participant 42) commented:

> *For optimal exploitation of water it can grow crops that need a lot of water in the wetlands (clay lands retains moisture for a long time) while planting trees and plants which are drought-tolerant in the dry lands.*

A similar point of view comes from a farmer holding a Diploma in Agriculture (Participant 20), who sees a need to take the quantities of virtual water in agricultural products into consideration when imposing a certain crop combination, with crops consuming more water than if they are imported at a lower cost being excluded. In theory, this is a common idea among the most highly qualified interviewees in relation to raising WUE levels. The view is supported by the UN (2006) position that taking into account the virtual water trade reduces the pressure on the country water resources, and according to (Hammaad 2009), it partially helps restore the water balance in Libya. Participants generally differed in their opinions of the policy of imposing crop combination and its impact on farmer viability, however, 30 out of the 58 participants supported the policy *(see Table 5.13)*. One staff member (Participant 46) concluded that:

> *Farmers must adapt their crop combinations in line with the AUJHJWSG's policy, in accordance with the objectives and strategies of the country and in line and consistent with the goal of raising the WUE.*

One of the local investors (Participant 3) agreed:

> *An organisation agricultural policy is required for crops and products consume less water and more important to the country. This needs developing an integrated plan and a timetable consistent with the seasons of products that should be grown and compel farmers to follow it.*

Amongst those supporting the crop combination policy, 12 of the interviewees gave only qualified support, seeing a corresponding need for market and price controls, supervision, monitoring, follow-ups, agricultural guidance by AUJHJWSG and compensation in cases of loss. Participant 9, a private owner summarised this position:

> *A certain crop combination cannot be imposed without considering the market. I look forward to what maximises my profits through what the market needs. Taking into account the market of the agricultural requirements and controlling the market of the agricultural productions are very useful for the farmers and the market, contributing to water conservation and encouraging the farmers for the useful collective work.*

In contrast, the 18 opponents of the crop combination policy *(see Table 5.13)* argue that it is not feasible where farmers are obliged to pay for the use of water. If crops consume a lot of water, farmers will pay a lot of money for water value and consequently turn towards crops giving greater financial benefits. The farmer (Participant 25) who best expressed this view said:

> *I do not accept the policy of imposing a crop combination as long as I pay for water. Paying for water means I bought their water, so why should they impose the crop we should consume the water with? Also*

> *they cannot obligate me not to cultivate a particular product to achieve greater profits at the lowest possible cost.*

It should be said here that all the AUJHJWSG and MOA opponents to this policy do not see that it is a wrong policy as much as they see that the farmers are not yet at a level that would allow them to apply it at this stage. Participant 53 expressed this by saying:

> *Policy of crop combinations cannot be successful at this stage by virtue of the farmer's illiteracy and the lack of qualifications and awareness.*

When AUJHJWSG or MOA take the responsibility to control and organise the market, the crop combination policy, or specialisation in agriculture, becomes important. It bans infraction of the agricultural productions market balance through the assessment of agricultural production needs and then imposing it in a crop combination for each season. Participant 47 expressed the opinion that:

> *The Ministry of Agriculture should intervene to draw a sound marketing policy and controls the market in terms of imposing crop combinations. This policy, in addition to water conservation, should control the market balance of the agricultural productions needs, thus control (adjust) their prices.*

The following table *(Table 5.13)* shows the distribution of the supporters and opponents of the crop combination policy:

Table 5.13: Satisfaction with the crop combination policy

Group	Members	Agreed	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	10	40%	13	52%	2	8%
Local investors	5	4	80%	1	20%	0	0%
Foreign investors	6	6	100%	0	0%	0	0%
Farmers of public sector	4	1	25%	0	0%	3	75%
Staff	9	5	56%	3	33%	1	11%
Managers	5	3	60%	1	20%	1	20%
Policymakers	4	1	25%	0	0%	3	75%
Total	**58**	**30**	**52%**	**18**	**31%**	**10**	**17%**

The concept of strategic crops has previously been proposed as a basis for crop combination models. The Gaddafi government, for example, considered wheat and barley as strategic crops to ensure food security in Libya.

In the opinion of an agronomist from the public sector with experience of 26 years in the field of irrigation (Participant 39), however:

> *It is better to produce tomatoes, as an example, with less amount of used water to be exported, then the government can import wheat and barley (at a lower price than the cost of locally produced) from countries, which do not suffer from water scarcity as the case in Libya. Here, the tomatoes will be the strategic crop that achieves the equation by virtue of logic and not wheat or barley.*

The agronomist’s viewpoint is supported by Dayem and Odeh (2008) position that farmers should cultivate crops of high productivity and high added value to allow the country to import basic food products while guaranteeing the availability of necessary funding to pay for such imports in a sustainable manner.

The policies of the previous regime and its political interventions in water governance have been negatively influential factors in water and agriculture management policies in Libya. To some extent, this is a common aspect of water governance in Arab countries but it is more prominent in Libya. According to Tiihonen's (2004) Enabling Environment for Good Governance Model, political will is one of the keys to good governance. In contrast to the strong political will shown in Singapore that has led to remarkable progress in efficient water management (Xie 2006), the economic patterns and political interference seen in Libya and other Arab countries has often imposed restrictions on policies and potential solutions to water problems (Bucknall 2007).

The substantial political support given to publicising the success of its mega-project, the GMRP and the AUJHJWSG in the media, was essentially propaganda to support the politics of the Gaddafi regime at home in Libya and abroad. Gaddafi was represented as the saviour of North Africa by bringing water from the depths of the desert to address the area's acute water scarcity issues. The support for construction of the project aside, previous political interventions in water governance are considered to have had consistently negative impacts, as for example, in the failure of the collection policy for water value as a result of government interventions to exempt farmers from the payment. A manager (Participant 50) recalled:

> *Many times, directives were coming from the top of the pyramid of power to exempt farmers from paying for water value, on the occasion, for example, celebrate the anniversary of Gaddafi's coming to the govern in Libya, and other events and occasions ... even we sometimes hear from farmers, when we try to put pressure on farmers to pay off their debts, who says (who brought us the water, "Gaddafi" will give us it free). It is a type of threat that they will complain to Gaddafi.*

Participant 43, an AUJHJWSG's staff member, referred to further negative interference, recounting that:

> *Gaddafi ordered to extend the water of GMRP to the desert arid lands and unfit for cultivation to establish agricultural projects around his hometown of Sirt. As a result, these projects have failed and wasted lots of water and money in useless way.*

Many of the interview participants made mention of the way in which viewpoints, directives and regulations were imposed by the political authorities under Gaddafi without any deep understanding or study of the relevant information and issues. Any discussion or objections were summarily rejected by the government, creating a confusing situation for the AUJHJWSG and adversely affecting its management and policies. In addition, there was a state of secrecy imposed on information and data related to the GMRP and the AUJHJWSG, further disadvantaging the latter's policy formulation and implementation abilities. The impact is described in the following statement by one of the staff members (Participant 48):

> *The political authority was imposing a state of secrecy and isolation on AUJHJWSG and GMRP, reservation on the data and information and not allowing for researchers and scholars in the field of water to access to any information ... Also imposing a state of no-objection to any of its interferences, its policies or its orders the AUJHJWSG even if they were whether wrong, confusing or contradictory with AUJHJWSG's plans.*

There was some consensus amongst the participants, particularly from those associated with the water management authorities, about the negative impact of interference from political authorities. Farmers were mostly neutral or do not feel the negative impact of the intervention of political authority power, because it was often imposing a case of confusion and administrative chaos, which enables the farmers to manoeuvre and get rid of the burdens and obligations towards management.

The following table *(Table 5.14)* shows the distribution of the views of participants from the different groups in this case:

Table 5.14: The negative impact of interference from political authorities

Group	**Members**	**Agreed**	**%**	**Disagreed**	**%**	**Neutral**	**%**
Local investors and private sector	30	0	0%	4	13%	26	87%
Foreign investors	6	1	17%	0	0%	5	83%
Farmers of public sector	4	2	50%	1	25%	1	25%
Staff	9	6	67%	0	0%	3	33%
Managers	5	3	60%	0	0%	2	40%
Policymakers	4	3	75%	0	0%	1	25%
Total	**58**	**15**	**26%**	**5**	**9%**	**38**	**66%**

Many farmers and investors expressed their worries and feelings of vexation with the AUJHJWSG management bureaucracy. The speed of work in the investment sector, whether local or foreign, does not align with the performance of water management personnel. There are always problems in the day-to-day decision-making in the bureaucracy. As investors pay production expenses with their own money and profits return to them, they see a need to take quick and decisive decisions because delays would harm their interests. In contrast, the AUJHJWSG is a government managed and funded bureaucracy, with employees receiving fixed salaries and having little incentive to consider profits in their decision-making. The differing aims are at the root of the problems some respondents face in regard to the AUJHJWSG, and in particular investors. A foreign investor interviewee (Participant 31) stated:

> *The main problem that we face with the AUJHJWSG is the bureaucracy. Decision-making takes a number of steps and requires a number of time-consuming requirements. Time is very important in agriculture. For example, the planting season does not afford any delay or wait.*

This point of view is supported by Saleth and Dinar (2004) that bureaucratic allocation and management in Arab countries is unable to sustainably meet the requirements and challenges of this new era of water scarcity.

All local and foreign investors and a number of farmers in the private sector are in agreement that a lack of flexibility, the bureaucracy and disruptive investment laws are problematic aspects of the AUJHJWSG. There are no quick and successful treatment for problems and responses to any complaints by the AUJHJWSG. The bureaucratic routine normally delays business but some of the problems in agriculture cannot realistically be delayed. One member of the public sector (Participant 38) commented:

> *When some lesion or blight, as an example, was discovered in the crop, the investor or farmer in the private sector immediately buys the medicine and use it on the same day. But in the public sector this will require submitting an application to the purchases department. This department in its turn will collects three offers and conduct a tender ... and so on.*

With no partnership relationship between private owners and the AUJHJWSG, collaboration is limited or linked only to water. Therefore, private owners typically expressed less frustration with bureaucracy. The following table *(Table 5.15)* shows the distribution of the interviewees in regard to bureaucracy and its impact in water management:

Table 5.15: The negative impact of bureaucracy in water management

Group	Members	Agreed	%
Farmers (private owners)	25	4	16%
Local investors	5	5	100%
Foreign investors	6	6	100%
Farmers of public sector	4	1	25%
Staff	9	0	0%
Managers	5	0	0%
Policymakers	4	0	0%
Total	**58**	**16**	**28%**

In regard to the first research question, results suggest that there are inconsistencies in the terms of reference and responsibilities of institutions associated with water. 52% of the respondents were of the opinion that there are inconsistencies which negatively affect the management of the water sector in Libya. While 4% did not agree with this view, however, 41% took a neutral stance.

In general, both foreign and local investors have no relationship with any other institution in the Libyan water sector other than that with the AUJHJWSG through signed contracts. This goes some way to explaining their neutral stance on the question of inconsistencies in institutional frameworks *(see Table 5.8)*, as foreign and local investors are able to exploit AUJHJWSG land and water, directly whether by rent or partnership. While some respondents from each of the other groups also took a neutral position, they did not make any negative observations in relation to the subject, which suggests that if there are inconsistencies in the terms of reference and responsibilities, it does not concern them or affect their work.

Although the research identified some problems in operation and maintenance, the infrastructure is generally considered to be of high quality. 77% of the interviewees emphasised the excellent condition and development of the infrastructure. 44% of the respondents (34% of the entire sample), however, pointed out problems in the programming of operations, stoppage schedules and maintenance.

The research reveals that imposing specific crop combinations and the concept of virtual water on investors in the AUJHJWSG framework has the potential to achieve raised WUE goals without impacting upon the investors' profitability and viability. The AUJHJWSG role in controlling the market and prices, however, has been largely unsuccessful. The concept of imposing crop combinations needs to be implemented within a wider and clearly stated policy which includes all farmers, even private owners. Such a policy lies outside the powers of the AUJHJWSG and would be the responsibility of the MOA. Implementation of the concept of strategic cropping to achieve food security in its present form, however, could be at the expense of water security.

While 10 out of the 11 local and foreign investor interviewed favoured the crop combination policy, 13 out of the 25 private owners opposed it. Significantly, private owner acceptance of the policy was conditional on market support of agricultural requirements, and control of the agricultural production market and prices. Overall, 17% of the interviewees have a neutral position, 52% are in favour of a crop combination policy, with 40% of these favouring it with conditions.

The best water investment model in AUJHJWSG's policies is the investment by partnership with investors as registered companies. This model of investment achieves the best results in terms of returns and the level of WUE. AUJHJWSG's ownership of land and water gives it a margin of manoeuvrability and the ability to impose conditions on investors, factors not available to other investment models in Libya.

Examining *Table 5.11*, it seems at first glance that only 53% of respondents are of the opinion that the policy of investment by partnership is the best investment model; the actual percentage, however, is much higher. Private owner farmers were not familiar with the model because this policy has never applied to them and they thus had little knowledge of it. Despite their predominately neutral position, they did not oppose the model, and 7 of them expressed support for it. This group apart, the percentage of supporters for the investment model is 73% (24 out of 33 participants).

Overall, with the exception of the policy of investment by partnership, the AUJHJWSG management policies do not meet with any significant levels of acceptance and satisfaction by farmers or even by a number of employees and managers themselves. While 9 out of 11 of the local and foreign investors by partnership were satisfied with the AUJHJWSG's policy, only 30% of the other respondents (14 out of 47) were of a similar opinion. The majority expressed dissatisfaction with the policy.

Intervention of political authority has had a significant negative impact on water governance. It has befuddled AUJHJWSG's policies, and other sectors related to water and the agriculture. Although the research results seem to indicate that only 26% of participants agree with this statement, this conclusion is inaccurate. The direct correlation between the political interventions and the AUJHJWSG and its policies means that the focus should be on the views of participants from the groups associated with the water-related authorities, the staff, managers and policy makers. The opinion of 12 out of the 18 respondents (66%) that political interferences have had a negative impact provides a more accurate indication of the situation. In addition, the relative weight in the results of the number neutral farmers (32 out of 40), essentially the beneficiaries of such political interventions, impairs the credibility of this indicator, and it thus can be considered misleading.

The research results indicate problems with the bureaucracy related to decision-making in the AUJHJWSG, especially with regard to agricultural work requirements and daily work details. This negatively affects both local and or foreign investors, and consequently all investors (100%) complained about the bureaucracy. In contrast, 3 out of 4 farmers in the public sector were largely unaffected by the problem. Unsurprisingly, all participants associated with water authority and receiving fixed salaries for routine administrative work, were of the opinion that bureaucracy did not have any negative impacts on water management.

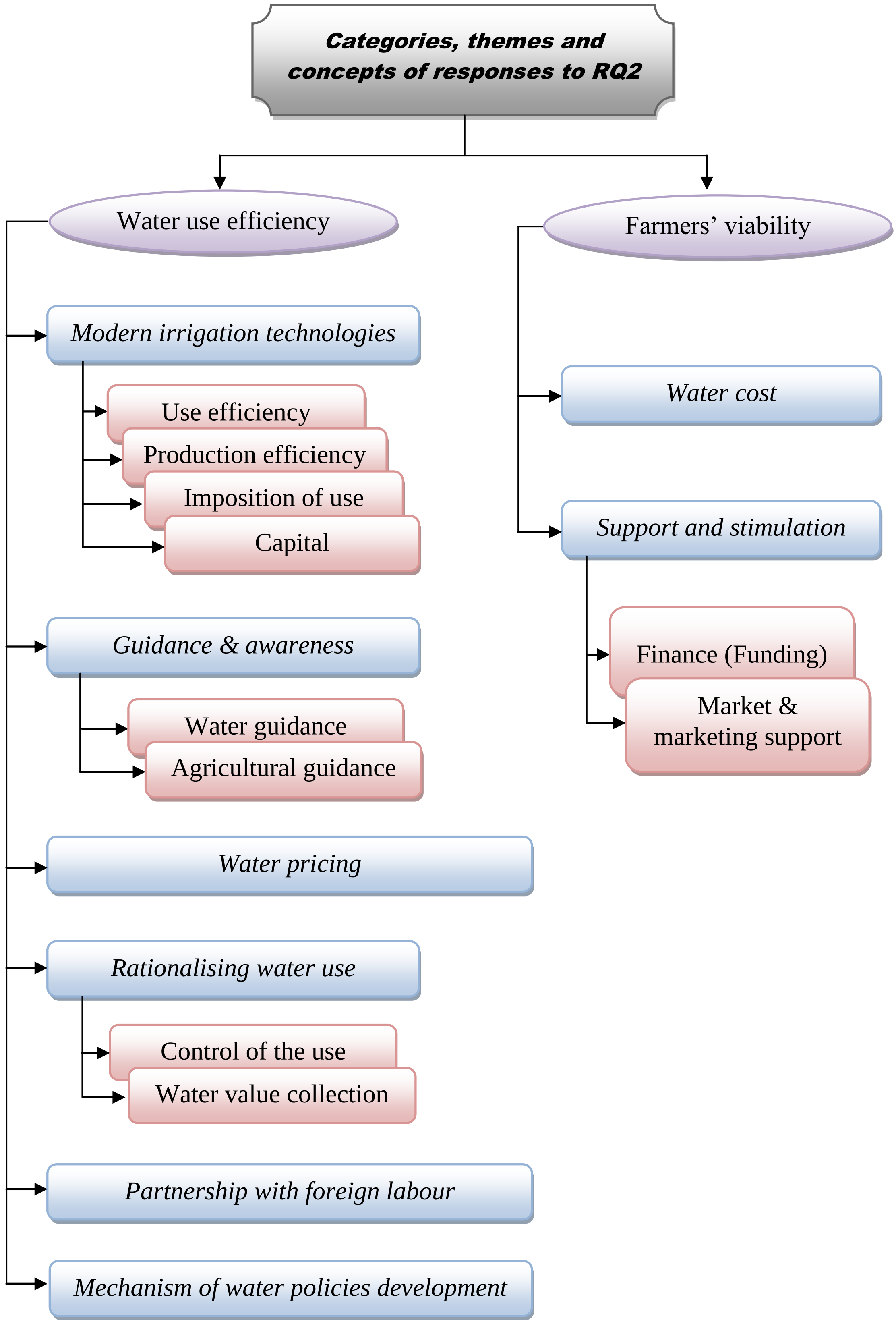
5.4 Categories, themes and concepts of responses to the second research question

Farmers are important stakeholders in Libyan agriculture and their interests and economic viability need to be taken into account when considering the potential for improving water sustainability in the sector. The second research question explores the possibilities of improving WUE in agriculture, both in general and more specifically by a water pricing mechanism, while maintaining or improving farm profitability. In this context, the research participants were asked to present their personal opinions on the impact of more water efficient practices and technologies on farmer viability. The central question was as follows:

- Is there any opportunity to improve WUE in agriculture without a negative effect on farmer viability? If yes, how? If no, why?

To facilitate analysis of the qualitative data gathered from respondents, information has been grouped around two key themes, WUE and farmer viability, with a number of categories identified within each theme. *Figure 5.2* presents these categories, themes and concepts.

Figure 5.2: Categories, themes and concepts identified in responses to the second research question



Almost all the respondents, both the farmers and authorities related to water, agreed on the necessity of using modern irrigation techniques, such as drip irrigation, to achieve the goal of improved WUE. Their attitude is reflected in Parris' (2010) observation that the adoption of drip irrigation, low pressure sprinkler systems and other water saving technologies and practices for WUE are becoming more widespread. Bouzid (1996) had previously noted such a tendency with the adoption of water saving technologies in Syria with modern irrigation technology and preparing and implementing training programs for farmers and technicians on modern irrigation and farming techniques. Similarly in Australia, ATSE (2012) acknowledges the importance of implementing modern technological developments to improve the WUE:

> *Scientific and technological innovation will drive increased efficiency, increased productivity and reduction in the environmental impact of the water sector and will underpin sustainable water management into the future.*

Some of the advantages of modern technologies identified by interviewees were a reduction in the amount of water used and an increase in crop production, up to double that of the same crops irrigated by conventional methods. Participant 52, a manager specialised in soil and water and with 32 years experience, observed:

> *Modern irrigation technologies have focused on roots of the plant, thereby reducing the wastage in irrigation that falls away from the plant. They reduce the irrigation time itself and reduce the rate of evaporation of water.*

This is consistent with TC's (2013) observation that drip irrigation simultaneously improves plant vigour by delivering water and nutrients directly to the plant roots and avoiding unnecessary wetting of plant leaves. Respondents identified many instances of water wastage and inefficiency using old technology. Each time conventional irrigation sprinkler systems are moved from one place to another, for example, there is a loss of the water remaining in the pipes. In addition, damage to pipelines and other associated factors are significant expenses to farmers, limiting production efficiency. Participant 33, a foreign investor, drew attention to the ways in which modern technology, in particular drip irrigation, could improve production efficiency:

> *Drip irrigation technique increases production efficiency by saving the farmer's effort and time, and the number of employees in the field. It reduces the water cost by reducing the used water quantities... Reducing the quantity of used water limits the growth of weeds between the plants, the proliferation of harmful insects and thus the spread of disease in the crops.*

The comments are given weight by TC's (2013) view that when drip irrigation is used properly, it can provide great benefits such as: increased revenue from increased yields; increased revenue from increased quality; decreased costs of water, labour, energy, fertilizer and pesticide; and improved environmental quality. Participant 1, a local investor, supported this view, saying:

> *An investor who uses drip irrigation technology is very successful and his use of water is in the lower limits. There is evidence that all investors do not have debts with the AUJHJWSG for water use. I, for example - my WUE reaches the ratio of 75 - 97% because I have been using the programmed drip irrigation and providing the plants with their water needs without any increase or decrease.*

The situation was confirmed by Participant 51, an AUJHJWSG staff member:

> *We do not have any problems in the collection of the returns of the water usage with investors because they adhere to the policies of the AUJHJWSG, especially with regard to the use of modern techniques in irrigation.*

61% of the interviewees from the authorities related to water and 45% of those from foreign and local investors agreed that the water management policies should mandate the use of modern irrigation systems to raise the WUE and that this should be made clear in contracts with investors. Participant 36, a foreign investor, supported the AUJHJWSG's right to mandate modern irrigation techniques, but had reservations about crop production restrictions:

> *AUJHJWSG has the right to mandate the use of modern techniques in irrigation but should not interfere in the crop combinations of the farmers ... Farmers who do not have access to these techniques should not sign a contract with the AUJHJWSG and not exploit the water.*

Respondents were divided about the idea of providing financial support and / or subsidies to farmers to enable them to adopt water saving technologies and modern irrigation techniques. Participant 36, for example, was not in favour of providing any support, but in contrast, Participant 39, a public sector farmer, thought that water policy should include financial support to enable farmers to purchase modern irrigation systems, with the proviso that their use was strictly controlled.

Participant 33, a foreign investor, was of the opinion that privately owned farms lacked modern irrigation technology and techniques because of the large capital outlay needed, which many of these farmers could not afford. 21 out of the 25 private owner respondents acknowledged this. They agreed that the use of modern technologies should be mandated, but thought that compliance should be accompanied by financial support. Salman and Mualla (2008), and Dayem and Odeh (2008) are in agreement that water usage in irrigation is wasteful because incentives for farmers to adopt modern, water-conserving technologies are mostly inadequate. They suggest that the Arab countries could adopt a subsidy policy to support irrigators in their possession of water saving technologies.

Some respondents expressed another point of view. Private owner farmers already possess conventional irrigation equipment, and although the technology is outdated, inefficient and wasteful of water, it is a historical cost (already paid cost). Modern irrigation techniques are seen as an additional cost which many private owner farmers cannot afford. There is also a view that the new technologies may not yield the desired results, and do not have enough advantages over conventional irrigation equipment to justify the capital outlay and associated risks, such as bank loans, to purchase them, unless the government could provide farmers with some financial support. In this context, Participant 31, a foreign investor, questioned the perceived need for new irrigation technologies on private farms:

> *[I don't know] ... why the owners of private farms care about using modern techniques in irrigation which cost them a lot while they are not aware of or do not notice the difference when these techniques are used. They do not know how much water will be saved and thus how much money they will save.*

In conducting the interviews, the researcher observed that because they had access to capital, most investors already used modern irrigation techniques and either did not need or request support. For private owner farmers, however, the situation was very different. Their lack of modern irrigation techniques underscores their need for support and funding. This is evident in *Table 5.16*, which shows that while all the private owner farmers interviewed were in favour of modern irrigation techniques being mandated in water policy, 84% of them advocated for some form of financial support to purchase these new technologies.

Table 5.16: The view that modern irrigation techniques should be mandated in water policy

Group	Members	Agreed	%	Agreed with terms (support & funding)	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	2	8%	21	84%	0	0%	1	4%
Local investors	5	0	0%	2	40%	2	40%	2	40%
Foreign investors	6	3	50%	1	17%	1	17%	1	17%
Farmers (public sector)	4	0	0%	2	50%	0	0%	2	50%
Staff	9	6	67%	2	22%	0	0%	1	11%
Managers	5	3	60%	1	20%	1	20%	0	0%
Policymakers	4	2	50%	1	25%	0	0%	1	25%
Total	**58**	**16**	**28%**	**30**	**52%**	**4**	**7%**	**8**	**14%**

A manager, Participant 54, summed up the situation:

> *Modern techniques in irrigation should be used to reduce the cost of water as a factor in farmers' expenses and thus raise the WUE … to meet AUJHJWSG's objectives.*

This is consistent with TC's (2013) view that whether the motivation is improved profitability or better resource use, the utilisation of drip irrigation clearly makes sense.

Agricultural guidance to farmers is offered through the extension and advisory services of the Libyan MOA. This department plays a major role in disseminating technical knowledge and information through the media, lectures and workshops, as well as establishing small guidance farms, models of drip irrigation systems, and providing training and education to raise awareness of the importance of water in light of its scarcity. It provides guidance about more water efficient agricultural practices to farmers in all aspects of planting, irrigation, care of plants, fertilisation, disease and pest control, the rationing and maintenance of water supplies and efficient water use. In the course of the interviews, the researcher noted that all the respondents, in particular the private owners, acknowledged the importance of agricultural guidance and education in improving the WUE in agriculture. Participant 9, a private owner, said:

> *It is necessary to educate the farmer in the field of water conservation about how to maintain it [water supply], and support and encourage him to take advantages of the use of modern irrigation technologies instead of traditional equipment.*

The Libyan government has long been aware of the need for education and training. An important aspect of the national strategy for the management of water resources in Libya [19] was the setting up of advisory bodies, education and information awareness programs to sensitise people to the value of water for life (LG 1999).

Participant 42, from the agricultural guidance department, agreed:

> *It is necessary to guide, teach and convince the farmer that drip irrigation, for example, leads to saving water for the future generations and actualise the sustainability... It reduces or saves a substantial part of the water cost for farmers in particular as an expense of production costs, and also increases the production sometimes … but not the production costs (not on production account) …*

Agricultural guidance and education cannot be separated from water guidance and education. For example, guiding the farmer to find out how much water the plant needs is an agricultural piece of information but it also educates the farmer about how to save water by providing the plant only with its water needs, thus increasing the WUE. Educating farmers about effective plant care, fertilisation and disease and pest controls increases production efficiency and thus raises the rate of return on the water unit included in production costs. Participant 31, a foreign investor, commented:

> *Producing the commodity which consumes a lower proportion of water yields greater returns for farmers; on one hand through the decrease in the cost of water as a result in the decrease in quantity, and on the other hand, at times the product is of high value in the market... Farmers should be helped to understand these facts through the agricultural guidance.*

Participant 47, a staff member, went further:

> *It should be made compulsory for farmers to consult an agricultural guide to oversee their fields and get training courses in addition to the media role.*

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[19] Details of this strategy are in Chapter Two.

The 2007 AUJHJWSG report (2007) acknowledges the farmers need for agricultural guidance and education and training to implement modern and efficient agriculture methods and practice. However, despite the agricultural guidance offered by the MOA, most respondents were dissatisfied with the availability and effectiveness of the department’s services. Many of the interviewees from the private sector, in particular the private owners, complained about an absence of guidance from either the MOA or AUJHJWSG. For example, Participant 17, an illiterate private owner, said:

> *The absence of guidance is a big problem for us. We cannot afford the expenses of private consultations; they cost us a lot of money.*

Participant 43, from the AUJHJWSG staff, partly agreed:

> *There is no sufficient agricultural guidance for farmers. It is necessary, but it is not a speciality of AUJHJWSG. In this regard, the government should intervene.*

In contrast, the respondents from the agricultural guidance department put much of the responsibility back onto the farmers for their inaction and failure to follow advice; however it was also acknowledged that this could be due to financial inability or farming being a part-time occupation. The director of agricultural guidance at the MOA (Participant 41) placed part of the responsibility on higher administrative level officials, saying:

> *Officials in the higher levels do not recognize the role of agricultural guidance and education as a means for the success of agriculture and water conservation.*

A majority of the interviewees agreed with the proposition that there was a need for agricultural guidance as a factor in raising agricultural production efficiency, and thus ultimately, WUE. This is shown in *Table 5.17*.

Table 5.17: The view that there is a need for agricultural guidance to raise agricultural production efficiency, and thus the WUE

Group	Members	Agreed	%
Farmers (private owners)	25	22	88%
Local investors	5	2	40%
Foreign investors	6	2	33%
Farmers of public sector	4	4	100%
Staff	9	7	78%
Managers	5	4	80%
Policymakers	4	2	50%
Total	58	43	74%

The remaining respondents did not disagree with the importance of agricultural guidance, but were more interested in other aspects of the central question raised in the interviews and did not discuss it in detail.

The principle of using the pricing mechanism as a tool to raise the WUE is based on the premise that farmers generally do not see the importance of water as a resource and value it only through the money they pay for it. For the farmer, maximising profits comes from the added value to production costs. If the cost of water were to be seen as an essential and substantial part of production costs, it would create competition amongst farmers to reduce this cost and thus maximise profit. In this case, genuine and committed farmers will continue production and pay for water, but those less serious would leave the sector. Participant 37, from the public sector, commented:

> *Raising water prices and putting in a strict system for water value collection makes the farmer seek to reduce the water cost through organising the irrigation, in terms of the timing and the quantity needed by the plant, reducing water wastage and possessing modern irrigation techniques.*

This view contrasts with findings from case studies in the Yellow River basin of northern China and in Tunisia, where the effect of water pricing on water use behaviour was intrinsically weak (Frija et al. 2009; Yang, Zhang & Zehnder 2003). As mentioned in Chapter Two of this research, despite the objections of some policymakers, the water price used in agriculture in Libya is at present subsidised by the AIMG. Participant 50, a manager, claimed:

> *Subsidising the water price is a major cause of water wastage. Farmer must be charged at least the price of real water costs. Thus, farmers will be fully aware of the value of this water and exploit it to best use.*

Scott et al. (2003) and CPPAP's Report (2003) are in agreement with the position that the price of water must reflect the full cost of water so that water will not be wasted. Participant 57, a policymaker, commented further:

> *An absence of economic logic in favour of social factors and [maintaining] the standard of living costs in Libya necessitated subsidising the water price. Releasing the price to market mechanisms is impossible according to the current standard of living in Libya, despite its necessity!*

The wells on privately owned farms are strong competitors to GMRP water. Up to a certain limit, the AUJHJWSG would not be able to raise the price of cubic metre of water more than the cost of cubic metre of water withdrawn from private wells. As farmers bore the wells themselves, the water itself is effectively free in the private agricultural sector (Wheida & Verhoeven 2007a; Zidan 2007). Participant 7, a private owner, thought that the AUJHJWSG water price and private well water costs were almost the same, however other respondents believed that AUJHJWSG water is cheaper. As shown in *Table 5.18*, while 17 of the 58 respondents were in favour of using the pricing mechanism as a tool to raise the WUE, 15 believed there should be conditions for its implementation. Certain conditions were identified as being of particular importance:

- ✓ The set water pricing should be well thought out, rational and accessible for procuring and collection.
- ✓ The prices of agricultural requirements and supplies should be fixed and subsidised and a good sale price guaranteed for farmer produce.
- ✓ There should be an expansion in the granting of soft loans to enable farmers to buy and use modern irrigation techniques.
- ✓ Agricultural guidance and education should be available for farmers.

Participant 21 commented:

> *The use of a pricing mechanism alone in raising the WUE, at the present time without subsidy from the government for farmers, is considered as imposing additional taxes, not a cost of production costs. It burdens the farmers and ultimately makes them perhaps move away from agriculture entirely.*

Participant 57, a policymaker, commented further:

> *An absence of economic logic in favour of social factors and [maintaining] the standard of living costs in Libya necessitated subsidising the water price. Releasing the price to market mechanisms is impossible according to the current standard of living in Libya, despite its necessity!*

Participant 50, a manager, proposed setting two different prices for the water to raise WUE. One price would be subsidised and conditional on the implementation of certain policies, such as the crop combination and the use of modern irrigation techniques. The other price would not be subsidised, but farmers would be unrestricted by any policies and able to benefit from the water in the way that suited them. Participant 11 similarly proposed the application of a sliding scale of water collection prices with varying conditions, a suggestion broadly favoured by four other interviewees. Wheida and Verhoeven (2007a) advocate achieving this by increasing block tariffs.

Table 5.18: The view that a pricing mechanism could be used as an effective tool to raise the WUE in the agricultural sector

Group	Members	Agreed	%	Agreed with terms	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	5	20%	7	28%	3	12%	10	40%
Local investors	5	0	0%	1	20%	1	20%	3	60%
Foreign investors	6	2	33%	4	67%	0	0%	0	0%
Farmers in the public sector	4	2	50%	1	25%	1	25%	0	0%
Staff	9	2	22%	0	0%	2	22%	5	56%
Managers	5	4	80%	1	20%	0	0%	0	0%
Policymakers	4	2	50%	1	25%	0	0%	1	25%
Total	**58**	**17**	**29%**	**15**	**26%**	**7**	**12%**	**19**	**33%**

In contrast, 7 of the 58 respondents were not in favour of using a pricing mechanism as a tool to raise the WUE, arguing that such a policy would be damaging to both the agricultural sector and the Libyan economy. They did not believe that it could achieve the goal of raising the WUE. Participant 28, a private owner, stated:

> *Pricing mechanism as a tool to raise the WUE is a wrong policy from its roots, and should not be used as a pressure card on farmers to reduce or limit the water wastage and to raise the WUE.*

As Speelman et al. (2009) point out, increases in water prices to manage water demand involve some risks in relation to farmer cooperation. The interviewees opposing the policy drew attention to a number of negative effects that it could have:

- ✓ Raising the price of water would lead to a rise in the price of product in the market.
- ✓ There would be fraud and evasion of payment for water.
- ✓ Raising the water price would be at the expense of agriculture, with farmers not able to absorb the increase in price and consequently either using private well water or abandoning agriculture for another occupation.
- ✓ A disinclination on the part of farmers to incur greater expenses in agriculture would lead to missed opportunities for investment in fertile land and potential profits.
- ✓ The disinclination to engage in agriculture would lead to a lack of returns for water investment by the government. The great expense of establishing the GMRP had as its objective the development of the agricultural sector.

In this context, Participant 21 thought there were better alternatives to a water price mechanism:

> *Agricultural guidance, subsidy, awareness and the focus on the use of modern techniques in irrigation remain the best mechanisms of raising the WUE.*

Despite the strong opinions of some interviewees, however, as *Table 5.18* shows, 19 of the 58 respondents took a neutral stance regarding the use of a pricing mechanism as a tool to raise the WUE. They were of the opinion that the proposal needed comprehensive study and research, saying it is impossible to determine an appropriate water price and to measure the impact of price changes, without taking into account or controlling the other factors associated with agricultural operations, such as the production costs and product selling prices, as well as the competition from private wells. Participant 31 a foreign investor, commented:

> *Determining the successful extent of a pricing mechanism in water conservation depends on the control of the agricultural supplies market and the farmers' production market.*

A number of respondents favoured the implementation of different strategies which they considered to be important factors in improving and raising the WUE in the JPR. The research identified several common factors:

- ✓ A rescheduling of irrigation times, rather than during the day when there are high temperatures and a high water evaporation rate. The practice of irrigating at noon, in particular, should be eliminated.
- ✓ Regulating the supply of water to plants, so they received only what they needed and no more, even where drip irrigation was used. Participant 33, an agronomist with 35 years experience and a foreign investor, observed:

> *The absence of rationing water use damages the crops because it leads to washing away of the soil, thus taking the fertilisers to depths not benefiting the plants ... Most farmers are not aware of these facts and are using water in a way that gives more harm than benefit.*

- ✓ Avoiding planting crops needing high water quantities and using water more efficiently to cultivate high-value crops as much as possible. Participant 31, a foreign investor, said:

> *It is better to use the water in planting crops with high value and low water use such as fruits, olives and vegetables, and maintaining the import of crops with high water needs such as grain and corn, because their import will be cheaper.*

- ✓ An expansion in production by raising the hectare productivity instead of expansion by increasing the number of hectares. This is consistent with Dayem and Odeh (2008) position that efforts should be made to raise the WUE and production inputs and achieve higher revenue per unit of agricultural area and per unit of water.

The value of this strategy has been recognised in Libya since 1996, when a national committee re-evaluating the water situation, recommended reducing water use by re-orienting the agricultural policies to improve WUE (Miludi n/d.; Salem 2007). In drawing attention to these factors, a number of respondents from the local and foreign investors, the public sector and the authorities related to water emphasised an associated need to control the use of water so as to achieve a rise in the WUE. Participant 53, a manager, asserted:

> *[We] ... must be following a control policy over the farmers in water use. Farmer should be restricted to specific programs under the supervision of specialists and qualified experts, each according to his specialisation in water and agriculture.*

None of the interviewees, either farmers or investors, opposed the need to apply a strict policy to ration water use, acknowledging that farmers and people generally are not inclined to conserve the water and raise its use efficiency without payment, controls and accountability. The absence of a proper system giving value to the procurement and collection of water use exacerbates the problem of water wastage and a low WUE. A local investor, Participant 5, observed:

> *The AUJHJWSG policies are good, but the problem is the absence of the strict application for these policies, especially the efficient collection of used water value ... If I do not pay for water, I may forget the water flows, or even as a result of laziness, may let it flow double the required time.*

This observation concurs with the CPPAP (2003) view that while a strict charge for water use is recognised as one of the effective means to reduce water wastage, such a policy has not been implemented satisfactorily in Libya. Although no one objects to the principle of strict control and collection for water use, the majority of private owners put forward conditions for the application of such policies.

A farmer, Participant 9, was of the opinion that:

> *The volatility of market prices for supplies and market prices for farmers' products limits farmers' activities, and distracts their focus from water conservation and adherence to the AUJHJWSG's policies, such as the crop combination policy.*

Some of the defects of the water value collection system as seen by Participant 15 are the irregular frequency of the water value collection times and the absence of reasonable periodic collection. These result in an accumulation of debts for the farmers and thus decrease their ability to pay. *Table 5.19* demonstrates the participants' responses to two factors separately so as to achieve a rise in the WUE; the need to control the use of water; and to apply a strict policy to ration water use.

Table 5.19: Interviewee agreement for a need for control and rigour in the collection

Group	Members	Control	%	Collection	%
Farmers (private owners)	25	11	44%	9	36%
Local investors	5	2	40%	4	80%
Foreign investors	6	4	67%	4	67%
Farmers in the public sector	4	2	50%	4	100%
Staff	9	5	56%	7	78%
Managers	5	5	100%	5	100%
Policymakers	4	4	100%	3	75%
Total	**58**	**33**	**57%**	**36**	**62%**

Many private owners work with foreign labour from neighbouring countries in partnership sharing the production output by up to half. The farm owner provides the land, water, medicines, seeds, equipment while the foreign worker's share is his effort in farming the land. Participant 22, in this regard, remarked:

> *There are no real farmers in Libya. There is a complete reliance on foreign labour from neighbouring countries in farming. Private farms in Libya are either neglected and not under production, or in the hands of foreign workers.*

A common opinion amongst the interviewees from all groups was that foreign labour is a major cause of water wastage in Libya. Because foreign workers come from countries that do not suffer from the problem of water scarcity, as is the case in Libya, it was felt that they did not appreciate the critical importance and size of the water problem in the country, and, as a result, did not care about the WUE, the quality of production and soil regeneration. Participant 2, a local investor, commented:

> *Foreign workers do not care about the quantities of used water because they do not pay for it. According to the agreement, the water and land always fall within the share of the farm owner in the partnership.*

A number of investors and farmers agreed with the principle of imposing policies on farmers, but saw a lack of flexibility and the non-involvement of stakeholders in drawing up these policies as major causes in their failure. This is congruous with Parris (2010) who believes that developing stakeholder involvement is crucial to improve water governance issues. If sustainable use of water resources is to be achieved, taking account of stakeholders' experiences and views is integral to the development of sustainable policies for water management (Allan et al. 2010). A foreign investor, Participant 31, came to the same conclusion:

> *Policymakers must be present with farmers in the fields, in supply markets and produce markets. They should share their concerns, discuss their problems, and explore their experiences and opinions to solve these problems before putting forth any policy.*

Allan et al.'s (2010) research and discussions, with stakeholders in the Tagus River region in Spain, point to the importance of stakeholder participation in influencing the development of water policy in the absence of effective formal procedures. The study revealed that while many policy makers in the region felt that there was a lack of stakeholder engagement, the stakeholders themselves often complained of paternalistic decision making that failed to properly reflect their views. Following on from these findings, the Spanish Hydrological Confederation is making efforts to increase genuine stakeholder participation, and similar steps are being taken in Portugal (Allan et al. 2010).

Dayem and Odeh (2008) similarly support the value of stakeholder participation in developing water policy frameworks. In their view, it is important to take into account the needs, values, and opinions of those affected by water policies and to involve them in planning and design, holding that increased participation of stakeholders would lead to genuine water governance improvements.

This position is apparent in many approaches for modelling sustainability with the recognition that public stakeholders and their political representatives and institutions must also contribute in evaluating designs and operating policies for efficient and sustainable water management (Wouters & Rieu-Clarke 2001). For Tiihonen (2004), Stakeholders participation is an important governance key in an enabling environment for good governance.

Four private owner respondents agreed, saying that the AUJHJWSG policymakers needed to have first-hand experience for a year at least with the farmers' situation, to enable them to fully understand the problems causing water wastage and a low WUE, as well as evasion and non-payment for used water value. The observation of the activities of a sample of farmers from land preparation and planting to the sale of the product in the marketplace would also enable better tracking of cost and the selling price trends. This kind of experience would be invaluable in helping determine a fair price of water for both sides of the debate, the policymakers and farmers, and enable the development of a comprehensive and efficient policy to raise the WUE in Libyan agriculture.

Water policies need to be developed with the cooperation of all relevant authorities, such as the AIMG, GWA, MOA, Ministry of Planning, agricultural research centres, food industries and other stakeholders. Water policies should not be developed or implemented in isolation from other government policies, but should be included in the context of the overall planning in the economic sector of the country. Water governance should take into account that all complex social-economic interrelationships and interactions are related to each other and no one agent, group, or sector has all the knowledge and facts required to set policy, make decisions, or take actions (Kooiman 2003). Supporting this view, Participant 58, a policymaker and Undersecretary of the MOA, said:

> *Water policy independent of other policies associated with water, agriculture and farmers will not be successful in any way. Water policy must be integrated into a larger policy which includes the pricing policy of the market (both supply and produce), subsidy policy, training and agricultural and water guidance.*

When developing water policies in relation to water beneficiaries, a distinction should be made between those private owner farmers having private wells on their farms and those who do not. Any policy which does not take this into account will strengthen the competitive position of the first party at the expense of the second. Participant 6, a private owner, remarked:

> *The owners of the private wells are advantaged over us twice. They have a spare source each so no one of them is susceptible to the problems in the water flow while this happens with AUJHJWSG's water. The second is as they benefit from the groundwater for free while it is a common commodity and public ownership.*

Lahlou and Attia (2005) take the position that water pricing should reflect the scarcity of water, discourage wasteful use, and promote water-saving behaviour. Using these parameters, this research has found that the extent of interviewee satisfaction with water price as a cost and the extent of their contentment with using a pricing mechanism to raise the WUE to be good qualitative indicators to examine the impact of water price on farmer viability. As mentioned in Chapter Two, the price of a cubic metre of AUJHJWSG water for agricultural use is 0.060 LYD. To examine to what extent this water price is appropriate for agricultural use, the research participants' responses were distributed into four groups: those who deem it appropriate; those who believes it appropriate if certain conditions are fulfilled; those of the opinion that the current price is expensive and not appropriate; and those with a neutral stance.

An examination of the responses of the water authorities' staff, managers and policymakers, all beneficiaries from the sale of water, shows that 12 of the 18 interviewees believed the current water price to be appropriate, although some deemed it should be raised in the future. 10 of the 15 investors (both local and foreign) and public sector farmers also agreed that the price was appropriate. The unanimous agreement of these participants seen in the analysis of first question further confirms and provides evidence of the success of the policy of investment by partnership. Participant 46, a staff member, observed:

> *Water price and its value collection from local and foreign investors are going very well and [there are] no problems in procuring in AUJHJWSG's projects. But the problem remains with the rest of the private owner farmers. Although the water price is mainly subsidised, there are obstacles and problems in repayment until today.*

In contrast, however, private owner farmers offer evidence of failure in the investment of AUJHJWSG's water, as also shown in the analysis of the first question. Only 4 of the 25 private owner respondents consider the current price to be appropriate. Participant 11, for example, a private owner, said:

> *Water price for the cubic metre is very suitable for farmers especially by comparison to the cost of cubic metre from the private wells ... There is a possibility and a great opportunity for investment in agriculture at this price especially in case of using modern irrigation techniques.*

12 of the 25 respondents considered the water price as appropriate, but only if certain conditions related to markets and marketing were achieved. They were of the opinion that it was only possible to afford the current water price if farmers were supported

through market price instability, both for agricultural produce and supplies. In addition, they thought technical support should be provided through agricultural guidance and education, as well as financial support to procure modern irrigation techniques. This would give farmers several alternatives to develop their production plans, and to know the cost of what each product needed in agricultural supplies, including water. Being able to compare supply costs with the product selling price would make the farmer advance steadily towards the optimal alternative for production and achieve success. Participant 9, a private owner, commented:

> *Supporting the market of agricultural supplies and setting prices in the agricultural produce market would allow farmers to be able to pay even more than 0.060 LYD. This enables the farmers to put out an integrated production plan through feasibility studies for what they will produce, conduct their accounts, comparisons and other...*

Only 5 of all interviewees believed that the current price is not suitable for the farmers if the rest of the production costs are taken into account, and market prices are compared. Participant 30, a private owner, said that his private well provides him with water at less cost than AUJHJWSG's water price. Participant 54, a manager, referred to the reactions of some farmers to the set water price and their reluctance to pay for consumption, saying:

> *Inability for repayment makes some farmers intentionally tamper with the water metre to stop or disable it to reduce the total amount to be repaid.*

Table 5.20 shows the distribution of interviewees' opinions about the appropriateness of the current water price for both farmers and the AUJHJWSG.

Table 5.20: The view that the current water price of 0.060 LYD/m^3 is appropriate

Group	Members	Agreed	%	Agreed with terms	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	4	16%	12	48%	2	8%	7	28%
Local investors	5	4	80%	0	0%	1	20%	0	0%
Foreign investors	6	3	50%	0	0%	0	0%	3	50%
Farmers in the public sector	4	3	75%	0	0%	0	0%	1	25%
Staff	9	8	89%	1	11%	0	0%	0	0%
Managers	5	3	60%	0	0%	2	40%	0	0%
Policymakers	4	1	25%	0	0%	0	0%	3	75%
Total	**58**	**26**	**45%**	**13**	**22%**	**5**	**9%**	**14**	**24%**

14 of the 58 respondents took a neutral stance in regard to the appropriateness of the current water price. They did not in fact object to the price, but felt that in-depth studies were needed to determine whether it is appropriate for farmers or not, as it is difficult to differentiate the impact of the water price costs on farmer viability from the impact of the other costs of production, the selling price of the agricultural product and the competition from private wells. This is due to the sharp fluctuations in these costs and prices in the agricultural supplies market and the farmer produce market. Supporting this position, Participant 48, a staff member, said:

> *No one at the current time can determine whether the price of 0.060 LYD is a reasonable price for water in agricultural use or not, even in the highest administration levels in the government.*

In this context, Ferragina, Marra and Quagliarotti (2002) point out that developing countries commonly fail to evaluate water prices versus each of the supply costs and the scarcity value of water.

In the interviews, 18 of the 25 private owner farmers and 9 of the 18 authorities related to water favoured the need to develop a policy to finance farmers by loans or partnerships. It was broadly assumed that farmers in general were poor and lacked money for capital outlays, and therefore could not afford the cost of developing their farms and agricultural works. It was felt that they are unable to own or extend the modern irrigation networks which are able to reduce both the used water quantity and the water costs and consequently help raise the WUE. By government action to ensure the development of the agriculture sector through support for farmers, the AUJHJWSG could feasibly achieve the goal of water conservation and bring returns to its investment in water. This is consistent with Dayem and Odeh (2008) view that water usage in irrigation in Arab countries is wasteful because incentives for farmers to adopt modern, water-conserving technologies are mostly inadequate.

A system of financial support would involve offering loans to farmers for the modernisation of their irrigation nets, the purchase of modern technologies and access to production needs and supplies. As well, the farmers would sign binding contracts with AUJHJWSG to obtain water under strict conditions. Many respondents felt that without such a policy, the AUJHJWSG could not succeed in raising the WUE. Participant 48, a AUJHJWSG staff member, said for example:

> *Without funding by loans, the farmers will continue to use water by conventional tools which cause a lot of water waste, as well as an inability to achieve success in agriculture and thus an inability to pay for water value. For [this reason] we find them currently trying to evade payment in various ways.*

The 2007 AUJHJWSG Report (2007) acknowledged that one of the reasons for farmer non-payment for water use in full is the failure to achieve good economic returns. Prior to this, the NCBMM plan (1994) had recommended that farmers be financially compensated to change their current practices as policies for raising prices for water use are implemented.

The AUJHJWSG (2007) put forward the view that farmers require grants and soft loans to achieve high economic returns. 2 of 11 investor respondents, however, opposed the idea of giving loans to farmers, believing that the offer would be so attractive that farmers who were unqualified, inexperienced, uninterested or only working part-time in agriculture would take out loans, thus wasting the funds aimed at developing agriculture. In addition, as private owners are competitors for investors, the market would be confused. These interviewees felt that a policy of farmer loans would not achieve either the goal of raising the WUE or that of agricultural development. Participant 26, a private owner farmer who was not opposed to the idea of giving loans, nevertheless agreed with this position from a historical perspective, observing:

> *The Agricultural Bank has previously provided loans to a number of farmers. However, due to a lack of expertise, specialisation, awareness, agricultural guidance, support of the market and marketing, farmers lost the money and were even unable to refund these loans to the bank.*

Other respondents, however, supported the idea of funding farmers and favoured a system of funding through partnerships or model farms. Building on the success of the partnership experience with the local and foreign investors, the AUJHJWSG could formulate a water investment policy on the basis of investment contracts with private owner farmers. These contracts could ensure the optimal utilisation of both farms and water. Participant 54, a manager, commented:

> *The model of partnership in projects of AUJHJWSG can be generalised to include private owners. Water can be computed in the AUJHJWSG's share and the land in the farmer's share. Then they can sign an agreement on the rest of the elements of production and the proportion of income distribution by any manner they agree upon.*

Participant 6, a private owner, believed that this model would be better for the simple farmer than the cash loans that they are often unable to invest due to a lack of expertise and specialisation. The following table *(Table 5.21)* shows the varying views of respondents about funding.

Table 5.21: The view that farmers should be given financial support

Group	Members	Agreed	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	18	72%	0	0%	7	28%
Local investors	5	0	0%	1	20%	4	80%
Foreign investors	6	0	0%	1	17%	5	83%
Farmers in the public sector	4	2	50%	0	0%	2	50%
Staff	9	4	44%	0	0%	5	56%
Managers	5	3	60%	0	0%	2	40%
Policymakers	4	2	50%	0	0%	2	50%
Total	**58**	**29**	**50%**	**2**	**3%**	**27**	**47%**

To facilitate analysis of interviewees' thoughts on the topics of "Supporting the market" and "Supporting marketing", the researcher provided definitions for these terms:

- Supporting the market:

The market in this research means the market of agricultural supplies needed by farmers in the production process, for example, agricultural machinery and equipment, improved seeds, fertilizers, medicines, pesticides, and agricultural guidance, awareness and training. Supporting the market means controlling it in terms of the suitable price and quality, as well as validity. These supplies should be protected from sharp fluctuations and not be left to speculators in the market. The support may also include providing these supplies at subsidised prices. For agricultural machinery and equipment they might be leased by symbolic sums at subsidised prices, for example from associations or agricultural companies, instead of their purchase being a financial burden and an additional cost for farmers.

- Supporting marketing:

Supporting marketing here refers to the marketing of agricultural products produced by farmers in the consumer market. It also means ensuring a minimum price for the product in the market that achieves a degree of satisfaction for the farmers. In addition, other alternatives and channels should be provided for the marketing of agricultural products, such as exports, the establishment of food industries to manufacture agricultural products and setting up canning and preserved food industries. Supporting the marketing also includes building the warehouses and providing the huge refrigerators / cool rooms leased to farmers to store their production in the cases of oversupply in the market, until another period or seasons of the year, when they can better market it.

For many of the respondents, supporting the market and marketing were the most important topics discussed in the interviews. According to Bjornlund (2003), efficient market mechanisms need to be developed and constantly adapted to meet changing demand within the social and environmental constraints of irrigation communities. 43 of the 58 interviewees were of the opinion that there was a real need to support both the market and the marketing. They were in agreement that AUJHJWSG could not develop a successful policy for water management in isolation from a government role to assist farmers through support of the market and marketing. For Saleth and Dinar (2004), insulation the water economy from market forces would be inappropriate.

Such a role would not only increase farmers' understanding of the market forces, but by fixing and stabilising production costs through market and marketing support would give farmers confidence to get a fair price for their crop production and to develop a successful production plan consistent in line with the policies of the MOA and AUJHJWSG. Commenting on the market, a private owner farmer, Participant 30, said:

> *The instability of the prices of agricultural supplies makes the farmer uncertain and not sure of their production fate. Production costs of the crop may rise to be a loss. Farmers are always hesitant to take risks and may leave the occupation for another activity.*

In relation to marketing, Participant 31, a foreign investor, observed:

> *The marketing problem is of the biggest problems in agriculture in Libya. For example, the farmer works for more than six months and does not know in advance at which price they will sell their production - this is crazy. But, for example, [having] the AUJHJWSG or the MOA determine a guaranteed minimum price makes the farmer's decisions more feasible.*

The interviewees in favour of supporting the market and marketing believed it would enable the mandating of public policies, such as pricing mechanism use, certain crop combinations and the exclusion of water-consuming crops, which could achieve the objectives of raising the WUE, as well as maximising and raising returns from the use of water and land. This viewpoint concurs with Shideed, Oweis and Osman (2003) recommendation that demand management should be put in place to control water use through measures affecting voluntary behaviour, such as market mechanisms and financial incentives. Participant 27, a private owner farmer said:

> *If a strong and integrated public water policy would be put forward by the AUJHJWSG and MOA for all farmers in parallel with a policy for supporting the market and marketing, farmers certainly would abide by it.*

In this context, a foreign investor, Participant 31, commented:

> *In Saudi Arabia, the government has guaranteed a good price for grain to farmers, thus within three years the government has achieved self-sufficiency with the grain.*

Table 5.22 shows the distribution of respondents' opinions about market and marketing support.

Table 5.22: The view that the market and marketing should be supported

Group	Members	Agreed	%	Disagreed	%	Neutral	%
Farmers (private owners)	25	21	84%	0	0%	4	16%
Local investors	5	4	80%	0	0%	1	20%
Foreign investors	6	4	67%	0	0%	2	33%
Farmers in the public sector	4	2	50%	0	0%	2	50%
Staff	9	6	67%	0	0%	3	33%
Managers	5	4	80%	0	0%	1	20%
Policymakers	4	2	50%	0	0%	2	50%
Total	**58**	**43**	**74%**	**0**	**0%**	**15**	**26%**

Results generated from the responses to the second question suggest that there is great importance attached to the use of modern irrigation techniques to raise the WUE. 61% of the participants related to water authorities believed there was a need to mandate the use of modern irrigation techniques. 65% of farmers in the public and private sector and investors agreed that it was essential for farmers to own and use these technologies, but favoured a system of farmer support with strict conditions. Agricultural guidance and education were considered the most important factors for improving the WUE in agriculture. 74% of interviewees agreed there was a need to provide agricultural guidance and education as components of raising the efficiency of agricultural production and thus the WUE.

The use of the pricing mechanism alone at this stage will not achieve the goal of raising the WUE. The use of this mechanism is limited, however, while water is available from private wells. The AUJHJWSG cannot raise the water price more than the cost of extracting the cubic metre of water from private wells. 55% of the interviewees (17+15 of the 58 participants) were in favour of using a pricing mechanism to raise the WUE, albeit with some conditions. 33% did not oppose such a mechanism, but were reluctant to give a firm opinion until concerns about controlling the supply market and marketing were addressed.

The control of farmer activities and strict water value collection were seen to play an important role in rationalising water use. The general view was that farmers would not raise their WUE without monetary payment, control and accountability for their water use. 67% of the respondents other than the private owners thought that farmers should be actively monitored, with 82% emphasising a need to apply strict policies for water value collection on the farmers. In contrast, most private owner farmers were not in favour of control and a water value collection mechanism, unless certain conditions were met.

Foreign labour was identified as a cause of water wastage in Libya, as it was felt that foreign workers do not feel any responsibility to reduce excessive water use. AUJHJWSG water policies aiming to raise the WUE should also monitor and place controls on this labour force.

The success of any water policy is dependent on farmer participation and the cooperation of all concerned authorities related to water. Water policies must be put in the context of the overall planning in the economic sector of the country. In principle, the current price of 0.060 LYD per cubic metre of water for agricultural use is considered appropriate and not affecting farmer viability. 67% of the respondents other than the private owner farmers thought that price could be used as the basis to construct a feasible pricing mechanism to raise the WUE. While 9% of the private owner farmers did not agree with this opinion, 48% (12 out of 25) of these respondents did agree, but with conditions related to the market of agricultural supplies and marketing.

There is an urgent need to develop plans to support private owner farmers financially, either by loans or partnerships, and these plans should be an essential part of the general water policy. Funding support would ensure the development of farms and extension of modern irrigation nets in order to raise the WUE and reduce the water cost to the farmers, thus ensuring their viability. 72% of private owner respondents were in favour of funding, especially through loans, and 50% of the water authorities respondents.

In addition, any AUJHJWSG policy should be based on support for farmers through supporting the market and marketing. 74% of all interviewees believed that fixing and stabilising production costs in the agricultural supply market and receiving a fair price in marketing agricultural products would ensure the viability and profitability of the farmer. This would facilitate the task of the AUJHJWSG in the development of a successful policy for water management.

5.5 Categories, themes and concepts of responses to the third research question

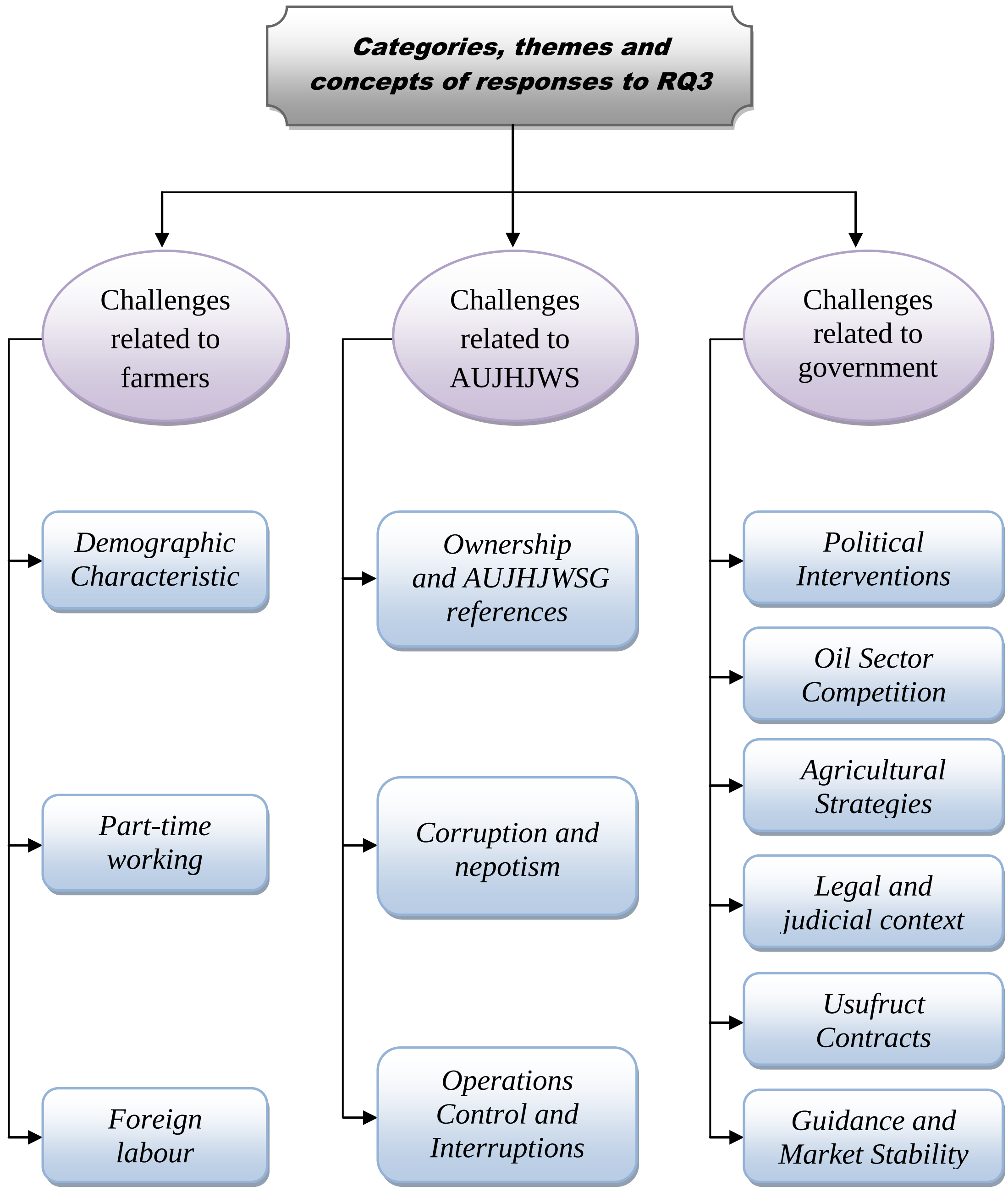
An important aspect of the research is to identify the challenges and problems facing policymakers in framing policies to achieve water sustainability. The third research question therefore explores the past experiences of water authority staff, managers and policymakers in relation to the development and implementation of water policies. In addition, the question examines farming activities both on farms and in the markets, in order to identify the work environment and place the responses within the context of farmer reactions and agricultural practices.

Secondary information relevant to the research question presented in Chapter Two was obtained from databases, reports and documents of water-related authorities. It provides an overview of important experiences, problems and failures associated with water management policies in Libya. Primary information has been collected through a series of related questions posed to the staff, managers and policy-makers of water related authorities participating in the research interviews. The initial and key question was as follows:

- In light of your previous experience in the development of water policies and the results of your work in this field, what problems, obstacles and challenges have you encountered in the application of these policies?

The information obtained from personal interviews shows that there are a number of real and substantial challenges threatening the success of any water policy in Libya and in the research area in particular. These challenges can be grouped into three categories, those associated with the government, the AUJHJWSG and the farmers. These categories, each with distinctive themes and concepts, are presented in *Figure 5.3*.

Figure 5.3: Categories, themes and concepts identified in responses to the third research question



A major challenge facing policymakers in their dealings with farmers and the successful implementation of water policy lies in the demographic characteristics of farmers. As indicated by an examination of both the literature and the educational levels and types of qualifications held by the sample of farmers participating in the research, many Libyan farmers lack the specialization with limited technical and management expertise in agriculture. The water authority interviewees generally were of the opinion that farmers' limited educational levels, qualifications and specialisation in agriculture, and their lack of real experience and agricultural knowledge do not allow them to keep pace and take advantage with modern advancements and the desired development in the country.

In this context, Participant 9, a private owner farmer, identified a lack of farming experience as a significant problem:

> *The lack of specialists or even professionals with experience in farming among the farmers is a major problem for agriculture and water [management] in Libya. It is a major challenge in the development of policies that must be overcome.*

Some respondents from the water-related authorities expressed the opinion that because most farmers lacked sophisticated technical knowledge and management expertise, they were unable to implement mechanisation and the use of modern techniques in agriculture and irrigation, measures which would allow them to raise their productivity per hectare, reduce the amount and cost of water and achieve the AUJHJWSG objective of raising the WUE. Some private owner farmers and investors shared this opinion, with Participant 24 commenting:

> *The simplicity, ignorance and poverty of farmers and their lack of specialisation, knowledge and experience ... creates a need [for them] to understand the policies and have the ability to apply them.*

Participant 20 similarly drew attention to the lack of farmer knowledge:

> *The current low awareness of farmers in considering water as a public good makes them believe that it is not necessary to pay for it and it is OK to evade it.*

Many of the water-related authority respondents identified an associated problem with many farmers working only part-time, using agricultural land for recreational purposes rather than being committed to raising productivity and water efficiency levels. Working full-time in other professions and engaged in activities rather than farming, these farmers appeared to place little importance on water conservation and management strategies. Participant 26, a private owner farmer, could not see the situation changing until the problem of insecurity in the farming sector was resolved:

> *Full-time working in agriculture is very important... but full-time working in agriculture requires farmers' confidence in achieving acceptable returns which can compensate them for work in other jobs. This cannot be achieved without a wise and integrated policy, commencing with direct material support or subsidies, and [followed by] programs supporting agricultural supplies, agricultural guidance and education awareness, and ending with marketing [support].*

This is consistent with Wheida and Verhoeven (2007b) comments that raising the price of water could reduce returns from investment in agriculture and result in movement to other sectors. Respondents from water-related authorities were in agreement that the lack of full-time working in agriculture is a major impediment to both AUJHJWSG's work and policies and a substantial challenge for agriculture and policymakers. Part-time farmers either ignore their lands, thus negatively affects agricultural development and the country's economy, or lease or share-farm with foreign labour, which also negatively affects the WUE [(20)]. In this context, a LG (1999) study found that farmers' reluctance to work in agriculture led to a reliance on foreign labour which contributed to increased water consumption, raised production costs and lack of stability in the sector. Participant 44 from the water-related authorities said:

[(20)] The analysis of the second research question provides more information about the use of foreign labour in Libyan agriculture.

> *One of the challenges in dealing with farmers who do not work in agriculture is that they have been leaving their lands to [be worked by] foreign workers... When agricultural guides visit farms [they] do not find anyone except foreign workers who do not bear any responsibility in the implementation of agricultural and water policies.*

Another significant challenge related to the AUJHJWSG is the ownership and reference of itself to the government as a public sector institution. Without any incentives to do so, the AUJHJWSG and water-related authority employees are not encouraged to actively go beyond their routine work roles to ensure water conservation. In this context, Bucknall (2007) says that the water policies and organisations in most NENAR countries are still not fully achieving their intended goals because the existing regime of subsidies does not encourage growth of organisational capacity.

Participant 48, a staff member, remarked:

> *Those who apply the policies are government employees accustomed to get a fixed salary by the end of each month. Thus there is no motivation and no encouragement to make additional efforts to ensure the success of these policies.*

Some AUJHJWSG interviewees made reference to corruption and nepotism in terms of recruitment and incentives and training. The researcher's examination of the qualifications of the managers and staff in the AUJHJWSG database appears to provide some evidence to support these allegations. The specialisation of a number of employees in sensitive positions directly related to water policy, in particular managers, had no connection to water management or to agriculture. To improve governance, Bucknall (2007) sees a need for the problems of political interference in staffing policies facing water institutions in the NENAR to be addressed. According to Dayem and Odeh (2008) priority should be given to institutional and regulatory reforms within the water governance agenda in Arab countries. The interviewees also drew attention to another aspect of administrative corruption, the exploitation of the AUJHJWSG's assets, supplies and goods. Participant 51, a manager, asserted that:

> *Some of staff in the AUJHJWSG exploit its agricultural projects capabilities such as the equipment, seedlings, fertilizers and other [support] for the self-employed, in favour of relatives or friends without any payment.*

Similar concerns had been raised in a LG study (1999) which found a lack of respect for the water legislation of governance with priority given to maintenance of social ties.

The AUJHJWSG's inability to control water pumping operations and adjust the interruption schedules are another challenge to water management. The AUJHJWSG receives the waters from AIMG and distributes them on the farms. The interruptions occurring in AIMG itself without notice to the AUJHJWSG and the sudden breakdowns occurring within the scope of AUJHJWSG's work itself [(21)] have created major problems for AUJHJWSG. Although an important role of the water body is to ensure water flow without interruption for farmers, except in accordance with specified schedules that take the needs of farmers' irrigation programs into account, the AUJHJWSG is finding it difficult to gain control over the unexpected breakdowns and sudden interruptions. To deal with similar problems, the Egyptian government established a Holding Company in 2004 with autonomous authority to operate through companies responsible for operation and maintenance of the networks (Dayem & Odeh 2008). Participant 41, the manager of the Guidance Department in the MOA, observed:

[(21)] See the operation and maintenance in analysis of the first research question.

> *One of the obstacles that has thwarted the idea of guidance farms is the inability of AUJHJWSG to take responsibility for interruptions and failures in the flow of water.*

Political intervention in water issues was considered another challenge for the AUJHJWSG in water management [22]. A number of manager and policymaker respondents were of the opinion that political authority interfered negatively in water management, as for example, interfering to cancel the debts of some farmers, and ordering changes in designs and plans of water distribution already implemented for many years. Characteristically, these interventions are for the benefit of specific individuals or regions, rather than for the benefit of the whole country and the effective and efficient utilisation of water in agriculture. Political interference was considered to have caused significant financial losses and confusion for the AUJHJWSG in water management and negatively affected raising the WUE. The effect of such interventions on staff and farmers has been a loss in their sense of responsibility towards any facility or economic resource in addition to the water source. In this context, Participant 54, manager, commented:

> *The citizen in general acts with any resource as [though] it belongs to the political authority ... and water is no exception. Thus citizens do not feel any responsibility towards the water resource as it is something that does not belong to them. The citizen believes that the resource should be benefited from in any way and does not care about it or the environment, or the country or future generations.*

Some respondents, as for example Participant 55, a policymaker, believed that competition from the oil sector with the agricultural sector is a real challenge to water management in agriculture. Participant 20, a private owner farmer, agreed, saying:

[22] See the intervention of political authority in analysis of the first research question.

> *The government does not give any importance to the water and agriculture sectors for the very simple reason that the price of a barrel of oil exceeds $100. So agriculture sector was neglected and as a result less attention has been given to the water management.*

Data from the European Commission (2009) and CW (2001a, 2001b) affirm the declining importance of agriculture. Until the early 1960s, agriculture contributed about 30% of the Libyan GDP, but by 2007, oil was contributing 71% of GDP and agriculture's contribution had reduced to just 2%.

Another challenge for the AUJHJWSG is its inability to develop a policy in isolation from the policies of the MOA and the government. Participant 44 said:

> *There is no a strategic agricultural policy in Libya [that] can be built upon to develop successful sub-policies such as water policy.*

Given the complex social and economic relationships and interactions between social stakeholders in all water-related sectors, Kooiman (2003), advocates that all elements and groups and sectors should be involved in policy-making to achieve success. This is consistent with Complexity Theory where a complex system includes numerous elements which interact and spontaneously organise themselves into elaborate structures over time (Valle Jr 2000).

According to Allan et al. (2010) there are two levels at which a legal framework is able to support sustainable water management: the law itself and the appropriate provisions enabling effective interpretation and implementation. Simply putting laws in place is of little worth if they are not supported by effective implementation systems (Allan et al. 2010). While Libyan legislative actions on water have been decisive, covering many water resources aspects in detail (Wheida & Verhoeven 2007a), the lack of an effective system of implementing and enforcing water related legislation has emerged as a significant challenge for the AUJHJWSG. Several manager respondents in the research voiced the opinion that a stronger judicial system was needed, as loopholes in existing legislation did not allow the AUJHJWSG to prosecute offenders contravening their policies and contracts or damaging or abusing their facilities.

Recognising the need for effective legal implementation systems, the Libyan government prioritised the modernisation and development of valid water legislation and the activation of its role as one of the national strategy aspects for Water Resources Management 2000-2025 (LG 1999). Legislative reform was considered necessary to discourage violations of water policy regulations and contract conditions and give better protection to AUJHJWSG's property, installations and assets, such as the networks, pumping stations, water tanks, and water meters. Participant 52, a manager, commented:

> *AUJHJWSG does not have the legal authority to arrest the vandals and [water] abusers and imprison them. Therefore, although the AUJHJWSG staff see the irregularities and tampering they cannot intervene; thus they resort to the judiciary, but the judiciary does not bring them justice. As a result, AUJHJWSG cannot mandate any arbitrated policy for water management in agriculture.*

Participant 53, a manager, observed that for over 30 years farmers in Libya had become accustomed to not paying any taxes for work in agriculture and the use of water, and had not been punished for any offense committed against the environment. Farmers, in his opinion, therefore did not take the problem of water scarcity seriously. To compound the situation, AUJHJWSG's policies lacked effective sanctions for contract violations. Lacking effective legislation and strict accountability, contract conditions and farmer pledges did not constitute a deterrent to offenders.

Participant 12, a private owner, held a similar opinion:

> *The existence of a strict law, restricting all farmers by applying the policies and contracts, leads to the success of water policy in Libya. But if the law has been broken or the contracts have been violated by some farmers without accountability it provides others with the justification for non-compliance, which leads to the failure of all policies.*

Weakness and laxity in the application of the law has led to an inability to protect the facilities, equipment and network of AUJHJWSG from tampering and vandalism by some farmers who do not agree with the AUJHJWSG's policy and seek either to thwart the implementation of a certain policy or to evade payment for water. In Bucknall's (2007) opinion, policies and organisations in most NENAR countries are not fully achieving their intended goals because of enforcement weaknesses caused by economic constraints and political interferences. Dayem and Odeh (2008) recommend improving the legal framework and the rule of law for good water governance.

Many interviewees from management and staff as well as private owners drew attention to the problems caused by illegal withdrawals of water from the AUJHJWSG public network for use in agriculture. Technically harmful to the network, these unregulated withdrawals cause a decline in water pressure for the other farms, creating an additional burden for the AUJHJWSG in their responsibility to provide a constant rate of flow to farms. Participant 51saw a need to resolve this problem:

> *The government must provide adequate security to protect the AUJHJWSG's properties, water and agricultural policies and apply penalties for violations.*

Another significant problem identified by respondents was the failure of the AUJHJWSG to enter into contracts of water exploitation with farmers benefitting from farm use through usufruct contracts and not by ownership [(23)]. These farmers were not able to provide the necessary documents to enter into contracts with the AUJHJWSG, due to the uncertainty and the social restrictions surrounding the ownership of these farms. AUJHJWSG contracts are similarly affected by the claims of the original owners to retrieve confiscated farms and the subdivision of farms through inheritance. Participant 53, a manager from managers, observed:

> *Important policymakers' challenges in the AUJHJWSG are the social problems resulting from uncertainty about land ownership whether in the AUJHJWSG's projects such as Tarhouna and Abu Aisha projects, or in what is known as usufruct contracts such as the Garhabuli project.*

The challenge posed by the dwarfing of farms through inheritance, in particular, has led to a deterioration in the water situation by increasing the number of drilled wells and low efficiency levels associated with the missed economic opportunity of farming larger areas LG (1999).

A number of private owner farmers believe the support and guidance available at the current time is insufficient for them to achieve success in farming. Participant 43, a staff member, took a different view, saying that if farmers can be reassured about marketing and agricultural supplies policies their activities could be substantially controlled and viable. In addition, the AUJHJWSG could enforce collection policies for water value and thus raise the WUE [(24)]. The challenge, however, lies in the market, marketing support and the agricultural guidance effectively being outside the

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[(23)] Neglected lands confiscated by Government, held by agricultural projects and re-delivered to other beneficiaries by utilisation contracts forever subject to Law 123, see Chapter Two.
[(24)] See the "support & stimulation" and "Guidance & awareness" in analysis of the second research question.

terms of reference and responsibilities of the AUJHJWSG. Participant 56, a policymaker, commented:

> *It [the AUJHJWSG] cannot direct farmers control them and develop a successful policy to deal with them without supporting them first in the market and marketing, and these are situated beyond the ability and powers of the AUJHJWSG, especially with private owner farmers.*

The data and information gathered by the third research question suggests there are a number of real challenges facing policymakers in framing water policy. Three kinds of challenges can be identified linked to the major stakeholders: the farmers, the AUJHJWSG and the government.

A major challenge facing policymakers is the demographic characteristics of the farmers and their lack of qualifications, specialisation and expertise in the field of agriculture. The situation is aggravated by a lack of full time work by farmers in agriculture and the use of foreign labour to run farms.

A major challenge associated with AUJHJWSG is the lack of motivation among the staff and managers to improve the implementation of water policies. Insufficient pay, administrative corruption and nepotism in recruitment, incentives and training, impact negatively on the AUJHJWSG's ability to successfully implement its policies. In addition, the AUJHJWSG has to some extent been incapable of adequately controlling operational and maintenance programs, and has not taken responsibility for stoppage problems or breakdowns in contracts with farmers.

Research respondents identified a raft of challenges associated with the government that have influenced the direction, development and application of the AUJHJWSG's policies, with the water body lacking the powers to question or override political decision making. The intervention of political authority in the AUJHJWSG's work, particularly common in the former Gaddafi regime, has been a major challenge. Political expediency and continuous passive intervention have resulted in both staff and farmers losing a sense of responsibility towards the problem of water scarcity and the WUE. In addition, as a consequence of the neglect of the agricultural sector in favour of the oil sector, there is an absence of a strong agricultural strategy that can be relied upon to develop successful water policies.

Further challenges flow from the AUJHJWSG not finding adequate support in the judiciary to achieve security for its properties and preserve its rights under contracts with farmers. In addition, the problems of exploited farms under usufruct contracts and farm size reductions as a consequence of inheritance present significant obstacles to water investment. A major challenge also lies in providing the guidance and direct and indirect support urgently needed by farmers, as these all fall outside the capacity and powers of the AUJHJWSG.

5.6 Categories, themes and concepts of responses to the fourth research question

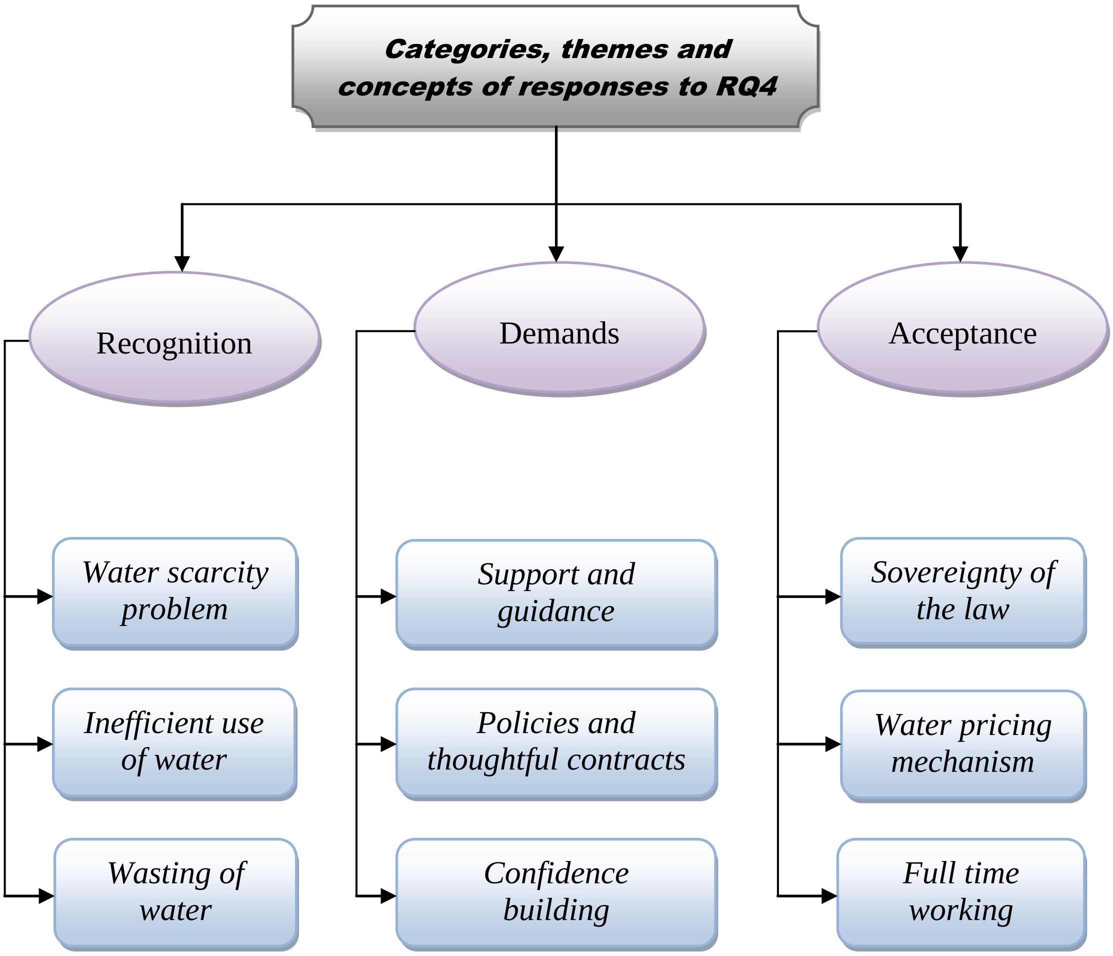
The fourth research question and associated sub-questions explore the extent to which the interviewees are aware of water scarcity and WUE problems in the research area. The question, in addition, examines the effect of farming practices, possible solutions and factors important to ensure water sustainability.

The responses to the fourth research question will be helpful in developing a framework for a sustainable water policy. The opinions and viewpoints of both policymakers and farmers need be taken into consideration in framing effective policy to sustain water and raise the WUE. On this basis, the central question and sub-questions were as follows:

- In your opinion, what is the size of the water scarcity problem and its use efficiency in Libya, particularly in the JPR? Do you think that farmers are a part of the problem? If yes, how? And how they can be part of the solution? If not, what factors do you consider would help sustain water in the JPR?

The interviewees' responses can be grouped into three main categories: recognition, demands, and acceptance. The categories and their associated themes are shown in *Figure 5.4*.

Figure 5.4: Categories, themes and concepts of responses to the fourth research question



All the farmer interviewees recognised the problem of water scarcity in Libya and its use inefficiency, as well as the issue of wastage and loss in the use of water. They affirmed that they had suffered greatly from lack of water in the past and do so currently. These farmers believed that the problem is getting worse because of the lack of rain feeding the aquifers, the main water resource in Libya, and this is consistent with (CW 2001b). Participant 27, a farmer from the Garhabuli area, commented:

> *We are well aware of the water scarcity problem with the evidence a simple comparison between the year of '56 when the water was [found] at a depth of only 36 metres, and now [in 2012] is at a depth of over 200 meters.*

Being aware of the water scarcity problem, however, does not mean that farmers comply with or adhere to water conservation measures. Differences emerged between farmer respondents as to the extent of their feelings of individual responsibility towards the problem. Participant 29, a private owner, remarked:

> *All are aware of the water scarcity problem in the country, but competition in agriculture, income achievement and the absence of wise policies by the government cause them [the farmers] to not care about this problem.*

Participant 37, a public sector farmer, added:

> *Each farmer sees others [who] do not care about the water scarcity problem, so they do not have any motivation to care about it, and wonder why I should do so? Why me?*

Inefficient use of water and its squandered use is a problem no less important than water scarcity problem in Libya. Through observation and the discussion with the research participants, it was noted that there was a consensus on the lack of efficiency in water use. There was also consensus that the worst aspect was the wastage of water, even though the respondents differed in the reasons offered to explain why this occurred. Participant 13, a private owner, commented:

> *The extravagance, wasting and inefficient use of water currently is a problem overtake water scarcity problem in itself.*

The farmers interviewed in the research were well aware of the water scarcity problem but considered there were no viable options available to help solve this problem or to use the water in a better way under the current conditions of farming, market and marketing. In this context, Participants 13 and 30, both private owners, indicated there was a need for farmer support from the government. They praised the support given to farmers in other countries, especially those close to Libya such as Egypt and Tunisia, which contrasted with the lack of support in Libya.

As indicated in the analysis of the second question, farmers urge funding and support of market and marketing, and see agricultural guidance as essential to achieve the policy goals set by policy makers. Participant 14 questioned the inaction of the Libyan government in these matters:

> *All the world's governments, even the developed and water-rich countries, support the farmers... So, why does our government not do so?*

Participant 47, a staff member, supported this position from the perspective of policymakers:

> *When farmers are assured of marketing policy of the agricultural productions and market policy of the agricultural requirements, they can be controlled significantly.*

The farmers interviewed believed their interests and farming conditions needed to be taken into account in policymaking. They felt they should be involved in the framing of water management policies on a clear basis through contracts, which were fair, applicable and sensitive to farmers' rights and did not limit their viability. In these contracts, the AUJHJWSG should undertake to supply the water in accordance with required quantities and specified times, and be liable for failures to do so, thus encouraging farmers to comply with policies and contracts.

Participant 22, a private owner, and Participant 55, a policymaker, as well as a number of farmers, agreed that there was a need to build trust between the farmer and the AUJHJWSG on the one hand, and the farmer and the MOA on the other hand. This is consistent with Dayem and Odeh (2008) view that legislative frameworks should be improved by moving towards greater accountability, transparency, and rule of law. Farmers should be certain that their rights are guaranteed, but at the same time, the farmers should fulfil their responsibilities and obligations toward the AUJHJWSG and MOA. Participant 24, a private owner, outlined the preferred outcome:

> *A well thoughtful and documented contracts policy could be developed with farmers that would preserve the rights of all parties. Such contracts should include the price, the detailed terms on all penalties and compensations, for and against all parties, and other items to create confidence and an appropriate work environment for farmers.*

Staff and manager interviewees took a different perspective to farmers on the sovereignty of the law in the application of water policies. They believed there was a necessity for strict legislation to mandate the implementation of water policies in Libya in order to achieve their goals. Farmers on the other hand were of the opinion that the sovereignty of the law should have its base in the development of general, strong and integrated water policies by the AUJHJWSG and the MOA. Such policies should be implemented in conjunction with a support policy for all farmers, providing both financial support and support of the market and marketing. Participant 12, a private owner, observed:

> *It cannot be relied on [that] the farmers will consider the water scarcity problem themselves, but they must be pushed to do so through support, guidance and education, and then by strong provisions in the law and severe penalties for offenders.*

Analysis of the second research question revealed that farmer respondents did not reject the principle of using water pricing mechanism to improve the WUE. However, while they were generally open to the framing of a sustainable water policy in this context, some farmers were in favour of implementation only under certain conditions to safeguard farmer viability.

Information from the third research question also indicated the lack of farmer full-time work came as a result of a lack of support and a lack of confidence in achieving satisfactory returns for farmers from agricultural activities, particularly after the oil sector boom and the neglect of the agriculture sector. Participant 26, a private owner, commented that full-time farming requires the farmers' confidence in achieving acceptable returns which can compensate them for lost returns from any other work or profession. This cannot be achieved except by a wise and integrated policy which includes direct financial support, support of the market of the agricultural requirements and support of the marketing of the agricultural production for farmers. Many farmers are in favour of these conditions which would enable farmers to work full-time in agriculture and invest in their farms themselves without any partnership with foreign labour.

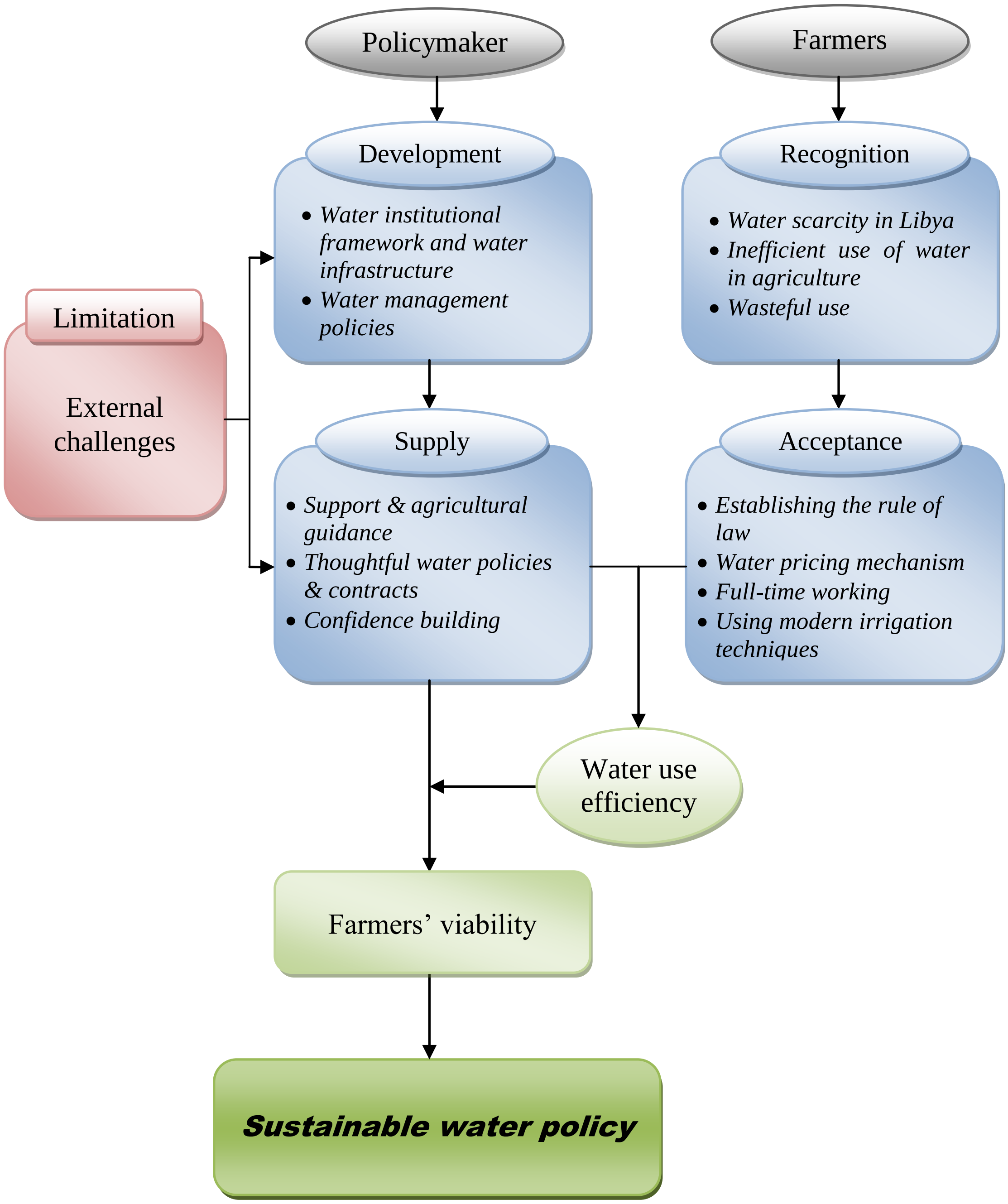
In relation to the fourth research question, the results suggest that the opinions and viewpoints of farmers helpful in framing a sustainable water policy pass through three stages. The first stage is the recognition of the problem of water scarcity and its inefficient use. It is well known that the identification of a problem and the recognition of it is one of the most important factors in the solution. In the second phase, farmers make some demands to ensure their viability and identify conditions for their compliance with water policy. Farmer responses indicate that the achievement of demands and conditions would allow farmers to be part of the solution to the problem, although they are reluctant to admit that they are part of the problem. The most important of these conditions are financial support and support of the market and marketing. Other conditions important for farmers are: integrated agricultural and watery policies; fair contracts for water use; and strategies and programs to build trust between the farmers and the authorities related to water. The third phase is one of acceptance and approval of farmers to play an active part in the general framework of a sustainable water policy. By providing farmers with a favourable environment for their agricultural activities, and meeting the conditions required by them, the sovereignty of the law will be consolidated and pave the way for the use of the pricing mechanism. These factors would encourage farmers to conserve water in their farming and raise the WUE as a means to achieve the sustainability of water.

5.7 Structural model

A key outcome of this study is the development of a draft model for sustainable water security in agriculture in the Jefara Region of Libya. The best model for sustainable water security in the research area would ideally be realised through the attainment of the maximum level of WUE. This cannot be achieved in isolation, but needs to take farmer viability into consideration. In other words, while increased WUE is the goal of sustainable water policy for the AUJHJWSG, it must also be an important means for farmers to achieve success. The desired water policy has to convince the farmer that his viability will only fully be achieved by raising the WUE.

The research results in conjunction with information obtained from interviews, databases, reports, documents, field observations and official memos in relation to the main research question indicate that the concepts of WUE and farmer viability are important variables in the study. Their achievement, however, is reliant on taking into account a combination of relationships between the other variables represented in the study concepts *(See Figure 5.5: Structural Model)*.

Figure 5.5: Structural model



The engagement and interaction between the constructs of the policymakers and the farmers in the first level of the proposed structural model comes inductively through two categories termed *development* and *recognition* for the purposes of this study. The development category flows from the position of the policymakers and includes the independent variables of the water institutional framework and infrastructure, and water management policies. On the other side, the recognition category encompasses the moderating variable “farmers’ opinions on water scarcity”.

The responsibility for integration of the development category, as a first step towards achieving WUE by maximising the return of the used water unit, rests with the policymakers. In addition to the existing infrastructure, development of the institutional framework for water management is required to accurately determine the responsibilities and clearly define the terms of reference. To eliminate bureaucracy and administrative corruption, the personal interests of the AUJHJWSG staff should be linked to the success of AUJHJWSG’s policies. This could be achieved, for example, by giving the staff a percentage of the collection of water revenues or a share in the profits of AUJHJWSG’s agricultural projects. The research has also identified improving water management policies, raising the efficiency of operations, and improved programming of interruptions and maintenance as important elements able to have a positive impact on the farmer viability at this level.

The role of farmers at this level comes through their opinions in relation to current water issues and their awareness of the water scarcity problem, water inefficiencies and wastage, elements identified as important co-factors in raising WUE in the JPR. The positive reactions of farmers and the degree of their willingness to maintain water sustainability, however, could be increased by the availability of certain elements that theoretically would be provided by the policymakers at the second level of the model.

The second level consists of two categories which in this study can be termed as *supply* and *acceptance*. There is a mutual and reciprocal relationship between these two categories, with each category affecting and being affected by the other category. The supply category encompasses those basic and important elements able to positively influence farmer viability, with the most important being financial support, market and marketing support, and agricultural guidance. This support may include partnership contracts with private owner farmers. In drawing up an integrated water and agricultural policy, the involvement of farmers in developing policy, fair contracts of water use and building trust between farmers and the AUJHJWSG are elements of no less importance in enabling farmer viability.

The acceptance category consists of a set of important elements which should be existent, and would provide farmers with security, in their work practices and accepted as a natural extension of their positive interaction and engagement with policymakers. The most important of these elements is establishing a culture of the rule of law, which would lead to farmers complying with its provisions in the implementation of water policies and to abide by the terms of contracts with AUJHJWSG, in other words, making the law really work.

If a water supply could be reliably provided for farmers, the implementation of a well-thought out water pricing mechanism could be considered. Feasibly, it should achieve the optimal economic use of water resources in agriculture by way of farmer reactions to changes in water prices. The goal of a water pricing mechanism is to give relative importance to the factor of water costs for farmers in comparison to production cost factors; this could be achieved either by raising water prices or supporting production. This would encourage the farmer to produce crops that would achieve the goal of maximising agricultural returns and, in addition, implicitly maximising the return value of water unit. Under this mechanism, water as a cost becomes a compression factor on farmers to reduce production costs, and thus an influential factor in competition and farmer viability. As a result, the reduction of these costs through raising the WUE becomes the means to achieve this goal. Farmers full-time work giving them more time to manage their farms, better control of the foreign labour force and the use of modern irrigation techniques are necessary and complementary elements in the acceptance category to capture and control the variable of WUE.

At the third level, the best engagement and interaction between the policymakers and the farmers in the context of supply and acceptance would yield the maximum WUE. The effort by policymakers to provide supply elements to farmers directly assists the achievement of farmer viability, and therefore the achievement of the AUJHJWSG goals. WUE would be raised indirectly via the engagement and interaction of both parties with the acceptance category. Thus it can be said that farmer viability and its associated co-factors are the means to achieve the goal of AUJHJWSG of raising the WUE. At the same time, the WUE becomes a means by which farmers are able to achieve their goals of viability and competitiveness.

Finally, although the proposed model could greatly assist in overcoming the challenges associated with farmers, as well as the internal challenges related to AUJHJWSG, its success remains limited in the face of the government-related external challenges faced by policymakers which fall outside the powers of the

AUJHJWSG and impact directly on water policy. These challenges are inversely linked to the success of the model, and consequently, wherever it is possible to reduce them, greater success would result. With the exception of these external challenges, however, the research results and analysis support the proposed model as being able to effectively facilitate the development of an efficient water policy for sustainable water security in agriculture in the Jefara region of Libya.

5.8 Summary

A review of participant characteristics indicates that a high proportion of young people were present in both groups of participants. The majority of the farmers in the sample and number of managers in sensitive positions possessed qualifications which did not have any relationship either to water management or agriculture. Most farmers farmed part-time or as time allowed and many of them did not work at all in the farming sector.

Inconsistencies in the terms of reference and responsibilities were a prominent aspect of the water institutional frameworks. AUJHJWSG policies were clearly impeded by the intervention of political authorities and the bureaucracy. Raising the WUE requires the insertion of modern technologies into irrigation, guidance and education for the farmers and recognition that farmer viability is dependent on financial support and stimulation. While the AUJHJWSG to a substantial extent can deal with the internal challenges faced by policymakers and to some extent deal with the challenges associated with the farmers, the external challenges associated with the government remain outside the control of AUJHJWSG. There is a clear recognition by farmers of the significance of water scarcity, however they state demands and identify conditions for their compliance with water policy to ensure their viability.

Farmers are willing to approve and play an active part in the general framework of a sustainable water policy if these demands and conditions are adequately met.

The essence of the structural model is the achievement of the difficult equation to syncretise raising WUE and maintaining farmer viability. Overcoming this dilemma lies in making WUE a cofactor and not an impediment for farmers to achieve success.

6.0 CHAPTER SIX: CONCLUSION

6.1 Introduction

The sixth chapter concludes the journey of this study. The focus has been to come up with possible water policy strategies to be able to attain the research objectives and achieve sustainable water security in agriculture in the JPR of Libya. Accordingly, the chapter summarises the results of the study, discusses the related themes and concludes the thesis.

Chapter Six begins with a brief overview of the study. Main results that led to the construction of the proposed structural model in this study are summarized according to the research questions. The distinct contributions of this study to literature and practice are then presented, and followed by the recognised limitations related to data collection, analysis methods and the research results. As suggested by the findings, practical implications in the field of the research and a number of recommendations and possible directions given for future research and investigation.

6.2 Overview of the study

A shortage of water affects the entire national economy of any country in the domestic, industrial, agricultural and environmental sectors (FAO 1993). The acute water problem in Libya threatens all aspects of life (GPC 2003). The unregulated withdrawing of groundwater in Libya for agricultural use has led to serious problems: a decline in groundwater levels, degradation in its quality, and a limit to its continuity in the future (European Commission 2009; FAO 2006). Given that the agricultural sector is the largest user of water in Libya (Zidan 2007) the current inefficiencies in water use mean that important steps must be taken to improve WUE (Lawgali 2008). A growing demand for water due to rapid population growth has exacerbated the problem of water in Libya and has further drawn attention to water sustainability as a priority issue for the country (Fedra 2004; UNPD 1994).

The efficient use of water resources in order to achieve sustainable water has become a priority for Libyans policymakers and, increasingly, an important field of research. Water management policies have also become an important issue for the farmers who depend on water as a basic need in the production process and thus a basic need to achieve a viable income. This study explores the relationship between the farmer attitudes and the perceptions of policymakers in the authorities related to water management in JPR. It examines the impact of this relationship on the development and application of water policy. The research results will help develop a framework for water policy able to improve the performance of farmers in JPR and ensure the sustainability of water flow.

The study identified seven main theoretical concepts which interact with each other and affect the development of water policies in Libya: the institutional framework and water infrastructure, water management policies, challenges faced by policymakers, WUE, farmer opinions, farmer viability and the interrelationship of these key areas. Corbin and Strauss (2008) see such concepts as helpful in classifying the attitudes, ideas, goals and events revealed in the data collected. Consideration of their effective interrelationship and interaction could lead to the formulation of the best sustainable water policy in the agricultural sector in Libya [(25)].

[(25)] See the “concepts” developed for this study in Chapter Four.

The first concept is the institutional framework and water infrastructure. Successive Libyan governments established a number of institutions that play a direct role in the development and implementation of water projects and policies. These institutions include the GWA, the Authorities of Implementation and Management and Water Utilisation of the GMRP, the GCWD, the GWSSC and the General Environment Authority [(26)], the MOA, the General Environment Authority, The Agricultural Research Centre and the Ministry of Planning (Oxford 2008) [(27)]. Although these institutions are independent and have separate responsibilities, they intertwine and overlap at times in their actions and policies (Al-Samarrai & Al-Mejribi n/d.).

Despite the setting up of water development infrastructure, there are still shortcomings in the performance of these institutions in the management and operation of the water infrastructure facilities (Ferragina, Marra & Quagliarotti 2002). The literature shows that efficiency in the water institutional framework and infrastructure as an independent variable has a directly proportional effect on sustainable water policy (dependent variable). As one increases, so will the other and vice versa.

Independently affecting sustainable water policy, water management policies are the second concept in this study, with a focus on the impact of water management policies on water scarcity and WUE. In Libya, efforts are being made in two directions: first, in order to ensure the sources of water supply (supply management), and second, to manage these supplies (demand management). Ensuring the sources of the water supply is outside the scope of this research. The literature indicates that Libya has failed to develop an effective strategy policy for water management to

[(26)] See "Water institutional frameworks" Chapter Two.
[(27)] See "Water institutional frameworks and water infrastructure" Chapter Three.

ensure sustainability of the water supply (Ferragina, Marra & Quagliarotti 2002). As a result of overlapping roles and inconsistencies in the terms of reference and responsibilities related to water management institutions, these institutions have lost control over water management and policies development (Al-Samarrai & Al-Mejribi n/d.).

The third concept in this study centres on the challenges faced by policymakers in framing water policy in relation to water scarcity and WUE. Investigating this concept and measuring the impact of these challenges in framing a water policy have been considered a moderating variable in this study. Reducing the size of the political, environmental, social and economic challenges faced by policymakers is an important and urgent need so as to achieve sustainable water policy (Laamrani & Salih 2010).

WUE is the fourth concept considered in this study. WUE in irrigation is represented as moderating variable, with a directly proportional affect sustainable on water policy, both positively or negatively (Oweis & Hachum 2012). The literature indicates there is a possibility to increase WUE while maintaining the same agricultural productivity (Alghariani n/d.).

Farmers' opinions in relation to water scarcity and WUE are the fifth concept in this study. Farmers are the most relevant stakeholders who can provide information about the research problem through interviews. This requires developing an understanding of the attitudes, beliefs, opinions and motivations of the respondents (Malhotra et al. 2006). The literature review highlights the importance of identifying and investigating farmers' ideas and opinions regarding water scarcity and WUE (Laamrani & Salih 2010). This concept is able to act as a moderating variable to know and measure the impact of farmers' attitudes and opinions on policymakers' policies, helping them make proper, correct and effective decisions to achieve a sustainable water policy [28].

The sixth concept in this study is the farmers' viability. The growing regulatory control of agricultural inputs has a negative impact on farmers' viability through increased farm costs and restricted management practices (Davidson 2005). This study has used this concept as a mediating variable to measure the impact of changes in water price, as a cost of farm costs, on the farmers' profitability. This measurement helps in determining the extent to which water price can move so that it achieves two goals, somewhat contradictory, in order to accomplish a sustainable water policy: that of raising the WUE and that of maintaining farmer viability.

To successfully develop sustainability in water policy, in-depth research of the related barriers and the relevant mitigation approaches is desired (Huang & Xia 2001). The best engagement and interaction between the six mentioned concepts generate the seventh concept. Sustainable water policy as a dependent variable in this study is the fruit of this engagement and interaction, already introduced and identified by the other variables (Bhattacherjee 2012).

The exploratory nature of research requires understanding the attitudes, beliefs, opinions and incentives of the units of analysis (Malhotra et al. 2006), which in this study are the farmers and water policymakers, in order to frame a sustainable water policy for agriculture in the JPR of Libya. Conducting this research required the use of a qualitative inductive approach to explore the issues began with observations,

[28] See "Nature of the research" Chapter Four.

interpretation of the information and the gaining new insights involved in the research topic (Bhattacherjee 2012; Leedy & Ormrod 2005).

The main primary sources of information for this study are interviews and observations. Semi-structured interview with the policymakers and farmers provided this information through questions associated with the mentioned concepts or variables. The policymakers, managers and staff associated with the water authorities provided their perspective as specialists, while farmers provided a summary of their experiences with the water policies determined by the policymakers. Observation concentrated on the key participants and their activities, and the events and processes related to the research problem. Secondary qualitative data was obtained from the database, reports and documents of the AUJHJWSG, AIMG, GWA and MOA.

6.3 Summary of main results

The objective of the main research question is to facilitate the development of a more sustainable water policy in Libya while taking into account the interests of the major stakeholders, farmers and policymakers. To gain an understanding of the key issues, it was necessary to investigate the level of engagement between farmers and policymakers in formulating water policy. Four associated sub-questions were therefore investigated, exploring the current water policy situation, the scope for improving water efficiency, the challenges facing policymakers and the feasibility of increased farmer involvement in framing water policy development. The initial conceptual model for the research suggested that the best level of engagement between the stakeholders would result in the best sustainable water policy.

The first sub-question examined the current state of the water institutional frameworks, water infrastructure and water management policies in Libya. Although there are inconsistencies in the terms of reference and responsibilities of the institutions associated with water management and problems in programming operations, interruptions and maintenance schedules, Libya has developed a sophisticated water infrastructure around the GMRP which can be relied upon to meet the demands of the agricultural sector. However, significant and often inconsistent political and bureaucratic interventions in policy have meant that Libya's AUJHJWSG has achieved varying levels of success in water management. The model of investment by partnership with local and foreign investors has achieved the best results in terms of the imposition of particular cropping combinations and raising the level of WUE. Investment by partnership has created opportunities for fair competition among investors in capital, experience and knowledge in the agricultural field, realising the rule of "pacta sunt servanda [(29)]". However, other aspects of AUJHJWSG water policy are considered much less successful and are poorly rated not only by farmers but by many of staff members as well.

The second sub-research question explores the scope of improving the WUE in agriculture and the impact of the price of water on farmer viability. The research information gathered indicates that there are a number of factors potentially able to bring about a substantial development in WUE in the agricultural sector. The use of modern irrigation techniques, farmer guidance and education, the organisation and control of foreign labour, increased farmer participation in policy-making and cooperation between all the water-related authorities were identified as major factors which could significantly assist improve policy and contribute to success in raising the WUE.

[(29)] Parties always resort to the signed contracts that govern the actions of each party and ensure their rights and state clearly their duties.

Encouraging farmers to participate in the development of sustainable water policies where their concerns are taken into account and their rights ensured would be the first step in improving the WUE. Although a water pricing mechanism would achieve the goal of raising WUE, its use alone is a double-edged sword. While on the one hand, it is a rational and practical tool enabling efficient and equitable water fee collection, on the other hand it could place a heavy financial burden on farmers resulting either in water payment evasion or a movement away from agriculture. Strict collection according to the prevailing price of water, however, remains sufficient at this stage. The general water policy should include plans to finance private owner farmers either by loans or partnerships. Supporting the market and marketing also would ensure the viability and profitability of farmers and improve WUE.

The third sub-research question investigates the challenges faced by policy makers in the setting and implementation of water policies. An analysis of the results identified three levels of challenges in terms of their source, farmers, the AUJHJWSG and the government. At the first level, the challenges came from the farmers' lack of qualifications, specialisation and experience, lack of full time working in agriculture and farms worked by foreign labourers were all factors contributing to the obstruction of AUJHJWSG policies. At the second level, challenges arose from the lack of incentive for AUJHJWSG staff to make more effort in the successful application of water policies, as well as from administrative corruption and operational, programming and maintenance inefficiencies. At the third level, the challenges stemmed from issues related to government pressure on policymakers in the AUJHJWSG. A major challenge is the negative interference of political authority and neglect of the agricultural sector in favour of the oil sector. The lack of a clear agricultural strategy and the absence of clear legal and judicial guidelines limit the ability of policymakers to develop successful policies for water. These challenges, in addition to others concerning usufruct contracts, a lack of agricultural guidance and the fluctuation of the market, form compression factors in terms of formulating effective water resource management strategies.

The fourth sub-research question explores farmer opinions on water scarcity and WUE in irrigation could assist policymakers in framing a sustainable water policy. Analysis of the research results reveals that there is a great awareness among farmers of the problem of water scarcity in Libya and its wastage and inefficient use in agriculture, however, the degree of farmer commitment to water conservation and payment for its use is poor.

In the interviews, farmers drew attention to a number of important factors they considered essential for their viability and which needed to be taken into account by policymakers to formulate any successful water policy. Financial assistance, market and marketing support, agricultural guidance, integrated agricultural and water policies, fair contracts of water use and programs to build trust between the farmers and the water authorities were all identified as significant factors able to raise the degree of interaction between policymakers and farmers and contribute to the development of sustainable water policy. For farmers, the most important aspects of a successful policy to increase WUE as a means to achieve sustainable water would be the establishment of the rule of law, the implementation of a water pricing mechanism, access to modern irrigation technology and the viability of a full time commitment to work in agriculture.

6.4 Contributions of the study

This study has enhanced understanding of the acute water crisis in Libya, a problem with complex social, economic and environmental dimensions which threatens the country's water and food security. Water scarcity is the single most significant issue facing Libya at the beginning of the Twenty-first Century.

The research make several contributions to a consideration of the issue by extending the current literature and increasing knowledge among stakeholders and practitioners in the field about the importance of developing a sustainable water supply strategy for Libyan agriculture in light of water scarcity conditions.

The distinct contributions of the research to literature and practice are summarised as follows:

Contribution to the literature

Water Management has three dimensions - technical/physical, organisational / managerial and socioeconomic/regulatory - that bring out issues of the quality of water, and the manipulation of its physical flow, human behaviour, and the legal-socioeconomic structures that contribute to constraints for Water Management (Bolding, Mollinga & Van Straaten 1995; Mollinga 2003). Thus it is imperative to align water policy with environmental, social and economic principles.

This study has evaluated the available options, given the current technology and information gained from real world practice, to develop a theoretical framework for water management policy in the JPR.

The results of the research support the need for an integrated theory that is able to grow and develop in the field of sustainable water security in agriculture in the Jefara region of Libya. Consistent with procedures recommended by Saunders, Lewis and Thornhill (2009), the draft model has been developed from information generated by a series of observations, interviews and data collection.

This study presents a theoretical and optimal model to achieve sustainable water policy in the light of the current circumstances in the country and the research area in particular. This model takes into account the interests of the major stakeholders, the farmers and policymakers, and encourages and facilitates cooperation and collaboration by providing information about their differing perspectives to each party.

An examination of the literature has revealed that the methodology and focus of this research has not been adopted in any previous specialised studies, confirming that the study is a significant addition to the literature. The results and the model presented in the research will serve as a base for conducting further qualitative and / or quantitative research in the study area and other associated fields. Investigative efforts in this study have opened up new horizons for further research on topics related to the problem of water resource management.

Contribution to practice

Water policy plays a major role in manipulating and perceiving water deficits. The objective of the main research question is to facilitate the development of an applicable sustainable water policy in the JPR of Libya. Further research into the effective utilisation of limited fresh water resources is a priority (Wheida & Verhoeven 2007b).

The study has examined the assumptions underpinning policies and the uncertainties affecting agricultural water supplies with the aim of improving the capacity for management of current and future risks in the Libyan context. The study provides insights on how water saving and a more efficient water policy framework could improve water sustainability in the JPR in the Libyan agricultural sector.

As this research has strong social dimensions, it has relied on qualitative data through direct interviews to examine the opinions, thoughts, attitudes and reactions of the major stakeholders in relation to the issue of water resource management as well as their justification for their position and perceived roles in relation to the problem. During the interviews, the diverse perspectives were shared with the participants, including excuses for themselves and criticisms of the others, thus generating further useful data about the interaction and relationship between the stakeholders in the research area. The responses of each party were then analysed and compared to each other to underpin the research findings. This has been the first study to investigate the level of engagement directly between farmers and policymakers to gain a better understanding of the key issues in formulating effective water management strategies.

This study has clearly demonstrated that at the present time there are very real dangers in the application of an abstract pricing mechanism to raise the WUE in agricultural sector in the JPR given the current conditions of the agricultural sector, markets and marketing. There are several options which pose far less risk that would be preferable to a pricing mechanism at this stage and potentially be able to bring about a substantial development in WUE. This research has contributed to a new understanding of the existing scope for improving WUE in agriculture in the research area.

This study has put policymakers directly in front of their responsibilities by offering them the practical knowledge about what is happening in the actual work environment. This study transparently highlights the challenges faced by policymakers and provides scenarios of dealing with them. Similarly, this study provides insights to farmers, who are the other side of the equation. It improves their understanding of their farming practice in relation to water scarcity, and has put them in front of their duties towards the strategies and policies set by policymakers. Importantly, the model developed in this research for use in the JPR context provides a model that could be applied to and / or adapted for use in other Libyan territories.

6.5 Limitations

There are no limits for research in general, but there are limitations for each piece of research and this research is no exception. A number of limitations to this study need to be acknowledged in relation to data collection and the research results. These should be taken into account when the benefits of the methodology and the findings are considered, whether theoretically in the literature or practically as applied to water policies.

The time factor was crucial to this piece of qualitative research, both in identifying the study area and determining the information gathering period. Qualitative researchers usually try to increase trustworthiness by prolonged contact with the interviewees and / or by long observation periods (Morse, J. M. & Field, P. A. 1995, p. 144). However, given the personal circumstances of the researcher, this was not possible. The period of data collection in this study was limited by the physical distance between researcher's place of study at USQ in Australia, the study field in the JPR in Libya and the timeframe allowed for the research. A further limitation in the study arises from the stratified random sampling not taking into account farmers using water from private wells. Consequently, the study could not benefit from their experience because they were outside the scope of the research.

An important limitation to the research is interviewee confidence building in relation to the research aims and methodology. Farmer respondents, in particular, questioned his neutrality and were suspicious of the motives for the research, believing that the study was in favour of AUJHJWSG and that the information collected would be to their detriment. The lack of mutual trust between the farmers and policymakers, as shown by the later research analysis, was clearly evident in the initial reactions of some farmers when requested for an interview. Although all participants were provided with a Participant Information Form stating the neutrality of the researcher and the confidentiality of information disclosed in the interviews, the researcher had to spend a long time talking to farmers about the research and his situation in an effort to convince them of the neutrality of the study. While details about the study and the reasons for undertaking the research, as well as general information about agriculture and water policies in Australia and the country's own experience with water scarcity interested the farmers and made them more comfortable with having an interview, some of them remained suspicious and were fearful and reluctant to provide information.

The study was further limited by the huge physical size of Libya which made it difficult for the researcher to examine conditions in regions other than the JPR. Comparisons between the JPR and other regions in Libya would have enriched the results. Despite this, given the severity of the water scarcity crisis in the country and the dependence of agriculture upon GMRP water, the findings of this research are transferable in a general way to other regions of Libya. However, despite the convergence of cultures between the NENAR countries, the research results are limited in that they cannot be easily generalised or applied beyond Libyan borders due to the differences in the circumstances of other countries. Political system of governance, policies and legislation, the severity of water scarcity problem, the degree of diversity in water resources, climatic conditions and average annual rainfall are all important variables and limiting the ability to generalise the results of this research to other countries.

6.6 Practical implications and recommendations

The research findings indicate that the ability of the AUJHJWSG administration to achieve its objectives in water investment and WUE improvement is hampered by factors associated with the different aims and interests of stakeholders, both inside and outside the AUJHJWSG. For water policies to be more effective and sustainable, they should be oriented towards developing proper responses to the issues and challenges arising from the differing concerns of the key water stakeholders.

A clear definition of the AUJHJWSG's ownership and dependency and its role and responsibilities is needed to begin the rehabilitation of its administrative structure and a system of incentives needs to be put in place to eliminate bureaucratic corruption. At the same time, the AUJHJWSG needs to be given the legal authority for sustainable and effective water governance and the power to implement and mandate water policy. Transparency is a key requirement for the development of integrated water resources management policies which take into account the social, environmental, economic and political dimensions and conditions.

Sustainable water policy cannot be developed in isolation from environmental, social, economic and political policies. An Integrated Water Resources Management approach is needed to consider all such issues simultaneously in order to secure the water sustainable management (WWAP 2006). All authorities concerned with water in Libya, the AUJHJWSG, the AIMG, the GWA, the General Environment Authority (GEA), the Ministry of Agriculture, Ministry of Economy, Social Affairs and the Government, need to work together to achieve sustainable development and there should be coordination, integration and linking between their policies. Integrated water resources management should also take into consideration environmental protection and address the problems of seawater overlapping, desertification and degradation of vegetation.

Sustainable development aims to take the middle ground by serving the interests of humans without jeopardising the environment (Richardson 2002). Education and the application of the law is needed to raise awareness about the negative effects some social practices have on water sustainability, in particular traditional water usage and cropping patterns and the continuous subdivision of land by inheritance. Problems arising from usufruct contracts, such as overlapping lands and properties, also need to be resolved.

The Libyan economy is limited and poor to a considerable extent, with its complete dependence on oil, a finite resource, thwarting development in other sectors. There is a serious need to invest oil revenues in developing agriculture, industry, especially those associated with agricultural production such as manufacturing, canning and preserving, human resources and sustainability in water and the environment.

As Libya’s main water resource is fossil groundwater lying within its borders, there has been little external political pressure on its management. Within the country itself, however, negative and ill-informed political interference in the AUJHJWSG’s works has disrupted policy development and implementation and wasted a lot of money and water to no avail. With a new regime and government in place, there is an opportunity for the terms of reference and responsibilities to be reorganised in the future. Political non-interference in water policy detail and application should become the norm for good governance. Political authority should only act to orientate and oversee policy and ensure the accountability of those responsible for the formulation and application of the policies.

A key goal of Libya’s previous government was the attainment of self-sufficiency and food security. However, prioritising strategic crops with high water needs, such as grain, ignored the interdependence of food and water and effectively meant that the achievement of food security would be at the expense of water security. The reality is that there can be no food security without water security. A more holistic and sustainable approach is to prioritise cropping combinations which take into account the concept of virtual water and thus create an optimal policy for achieving first water security and then food security.

Returns for the water value of JHJWSG should be strengthened and invested in research and study fields relevant to the development of water resources in Libya. There is an urgent need for increased attention to research and the development of innovative scientific methods in the search for alternative cost-effective and economic water resources. A continuous flow of water must be ensured for the country when the GMRP's non-renewable groundwater aquifers are exhausted or when GMRP operating costs become exorbitant in comparison with alternative water sources. At the present time, the most pressing areas of research are those concerned with desalination and water recycling. The research focus needs to be on using renewable energy sources, such as solar energy, to reduce the cost per cubic metre of water in clean and economical ways that are able to maintain the environment and are best suited to the climate, conditions and long stretch of coastline in Libya. Currently, undertaking such research is often not considered a priority in developed countries where the problem of water scarcity is not as severe as in Libya. However, research could be conducted in cooperation and partnership with NENAR countries sharing similar geographic and climatic conditions and similar problems of water scarcity.

The results of this study point to a number of important recommendations:

1- Loading farmers with the actual costs of GMRP water would make the production of all agricultural commodities economically unfeasible. Farming would become unviable and production would decrease dramatically despite the availability of water at a high cost. It is unavoidable that the actual costs of GMRP water, including its historical costs, will be taken into consideration, however, the water price should be determined as part of farming production costs after calculation of other costs and added value, with the prices of agricultural outputs adjusted at an acceptable level for the government, farmer market prices and the standard of living of the citizens. The impact of water prices should be influential to the degree that it is taken into account by farmers, but not so influential to the degree that farming becomes unviable.

2- Research should be conducted into the possibility of mandatory disclosure by farmers of the virtual water used in agricultural products in the social and economic sectors. This was also proposed in Spain to help develop plans for sustainable water management in the context of the European Water Framework Directive (Aldaya et al. 2010).

3- Private owner farmers often use their farms solely for housing and recreation. A fixed asset not subject to consumption, the property is considered as wealth as farmers do not pay any property or activity taxes for owning a farm or working in agricultural activity [(30)]. Libya, meanwhile, has incurred considerable cost in bringing water from deep aquifers in the desert in order to develop agricultural production. Part-time farming in agriculture, neglect of farms and the use of foreign workers are wasting money, water and hindering development. The imposition of a tax on agricultural land and crops, in particular on farm properties, should be reconsidered to encourage land use and production either by farmers themselves or by others through sale, partnership or lease.

4- There is a necessity to establish a culture of water value collection or payment for water use by raising awareness through education, the media and the force of law. Farmers do not take into account the water costs within production costs when examining the economic feasibility of producing a crop. As water is a public good belonging to the country, it is considered the weakest link in the chain of production costs for farmers, able to be reduced, evaded or obtained

[(30)] The agricultural activity tax in Libya was previously 5% of the income, but was exempted long ago to encourage farmers to engage in farming.

illegally. Farmers should be obliged to pay the cost of water as the central cost of agricultural products. Water value collection should take place periodically, and at frequent intervals, for example once a month, to make it easier for farmers to fulfil their obligations and prevent any accumulation of debt.

5- In addition to agricultural guidance, farmers should be provided with regular training courses, seminars and workshops on modern irrigation methods. Practical demonstrations, explanations and experience on the ground would help farmers understand how and by how much these methods can save water and thus farming costs. Farmers should be also provided with educational resources, handbooks and brochures to give information and guidance about more effective and sustainable practices, such as the amount of virtual water required for each type of plant in a day, a week or at any time of the day and the best irrigation technologies and facilities.

6- Restrictions should be placed on the use of private wells to control the problem of groundwater depletion and to limit further seawater overlapping and contamination of the environment. These restrictions would also support the AUJHJWSG's competition with these private wells. Groundwater is public ownership, so it should at least be priced. According to one of the study participants, a policymaker, one proposal under consideration is to charge farmers owning private wells a percentage of their well pump electricity bill as a price for groundwater.

7- Attention should be paid to the documentation and electronic archive online to establish and develop a comprehensive database. This would provide easy access to data and information for decision makers and all researchers in this field to conduct further research and studies in the future. The greater the dissemination of such information, the greater the benefits to both decision making and research.

8- Participation in international conferences and water organisations is of great importance for the AUJHJWSG. It would benefit from the expertise and experience of developed countries and be able to adapt the information and experiences to the environment and society in Libya.

6.7 Suggestions for future research

The exploration of the issues and themes associated with this research, taken in conjunction with the data and observations collected, strongly suggest that there are a number of important topics needing further research and investigation in the Libyan context, and some gaps in the literature needing to be filled. The following areas, in particular, have been identified as needing further research and study:

1- Research similar to this study is required into other GMRP's systems [(31)] both to establish the viability of the structural model of this research and to enable comparisons between the different regions in Libya. This would enrich this model and enhance the possibility of generalisation.

2- Comparative studies with the policies of other developing and developed countries are required to explore the impact of variables, such as culture, religion, governance, policies and legislation, on any generalisation of the findings of this study. Differing circumstances, environments and experiences

[(31)] The GMRP Authorities for the Utilisation of the Benghazi Plain Region and the Middle Region (See Chapter Two).

will play an important role in limiting or enabling the generalisation of the results to the different contexts in other countries and in Libya as well.

3- Real and transparent feasibility studies concerning the GMRP’s water investment in agriculture should be conducted. Comparisons need to made between the GMRP operating costs (without taking historical capital cost into account) and the cost of potential water sources alternatives, such as desalination, recycling and importing water from abroad. The findings and recommendations would provide additional evidence to the new government in Libya of the necessity of either supporting the GMRP’s water investment in agriculture or adopting the most effective water source alternatives to save time and the country’s wealth from waste, and push forward the wheel of sustainable development.

4- Libya needs an integrated feasibility study for different water uses which take into consideration the opportunity cost for the use of water in agriculture versus its use in other sectors such as industry and tourism. The concept of virtual water in agricultural production, studies of the domestic and international agricultural product markets, the Labour Force Employment, Gross Domestic Product (GDP) and Gross National Income (GNI) are all important factors that should be included in the feasibility study.

5- There is a need for more specialised research and both quantitative and qualitative applied studies into integrated water resources management in Libya. The research and studies could examine and conclude to what extent the structural model of this research, the policies and models of the environment, the economy, government, and social affairs are integrated and / or are inconsistent under an integrated management model for water sources.

6- Research participants from the AUJHJWSG, with some local and foreign investors and private farm owners claimed that the AUJHJWSG’s investment projects in partnership had achieved great success. However, the research found no confirmation of the contribution of water as the unit of investment in the income of these projects, with the implication that the realisation of profits or success in these projects does not necessarily translate into the optimal water use, ostensibly the main objective of the AUJHJWSG. The problem of water scarcity is fundamentally a social problem that has led, for example, to seawater overlapping and becoming a contamination problem with both environmental and economic dimensions in agricultural use. AUJHJWSG water users, local and foreign investors and farmers should take into account the environmental and social considerations as well as the economic considerations of their water use.

The current research suggests that there should be an open and transparent process of accountability for social and environmental responsibilities which would measure and disclose the pollution and damages caused by various projects and evaluate their returns, benefits and impacts. Research in Accounting of Social and Environmental Responsibility can assist in this area. Quantitative studies are therefore needed to measure and display the WUE element in financial statements as this current research points to the greater the increase in WUE achieved, the greater the increase in effectiveness of environmental and social performance of farms and projects. The net revenues and the negative effects of each cubic metre of water used or invested would be a fruitful basis for further research where they could be compared with virtual water accounts and conducting comparisons between the agricultural projects and as well as historical comparison between one year to another to provide a better understanding of potential effective and sustainable water management directions. Such studies would provide useful information to decision-makers in all sectors and to all interested parties of water, as well as to all sections of the community and the government.

6.8 Summary

Despite the severity of the water shortage problem and groundwater pollution and deteriorating quality in the JPR and along the Libyan coast (LG 1999), this study concludes that there is considerable hope of developing and framing a policy able to achieve sustainable water security using the available water resources of the GMRP. This chapter summarises and synthesises the results leading to this conclusion and to the related themes.

The study identified six main theoretical concepts which interact with each other to generate a seventh concept, sustainable water policy, the fruit of this engagement and interaction and the focus of this study. The engagement between farmers and policymakers in formulating water policy has been investigated through four associated sub-questions (RQs) of the research question. This investigation has yielded a theoretical contribution by providing a structural model, considered optimal, to reach sustainable water policy, in light of current circumstances in Libya and the research area in particular. The study has also contributed to practice by providing insights into how water saving and a more efficient water policy framework could improve water sustainability in the JPR in the Libyan agricultural sector.

Limitations affecting the study are highlighted, in particular, the timeframe for gathering information, the difficulties in choosing certain participants in the purposeful sample and the difficulties in accessing some potentially helpful information in the databases. The findings of this research indicate some practical implications for the AUJHJWSG administration in facing the challenges that limit its ability to achieve its objectives in water investment and WUE. A number of important recommendations arising from the study results are highlighted, as well as a number of important topics needing further research and exploration in Libya, and some gaps in the literature need to be filled.

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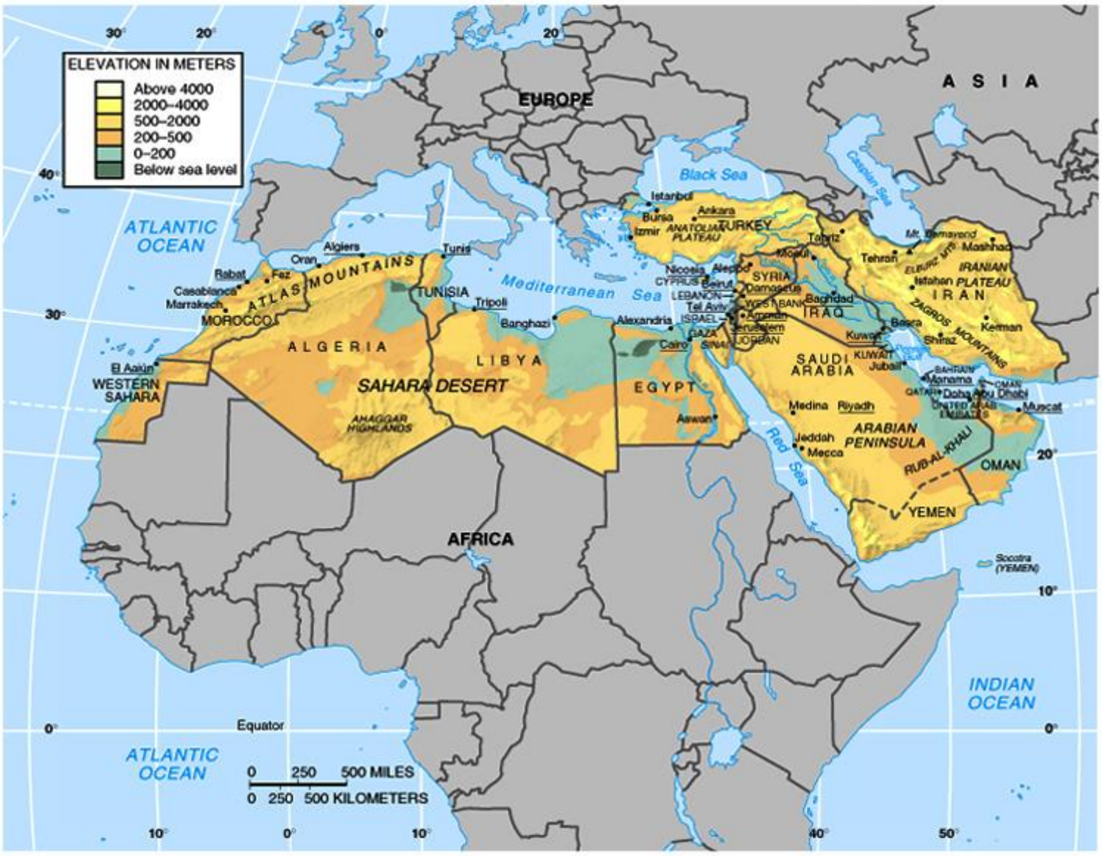
APPENDICES

Appendix A: *Near East / North Africa Region (NENAR)*

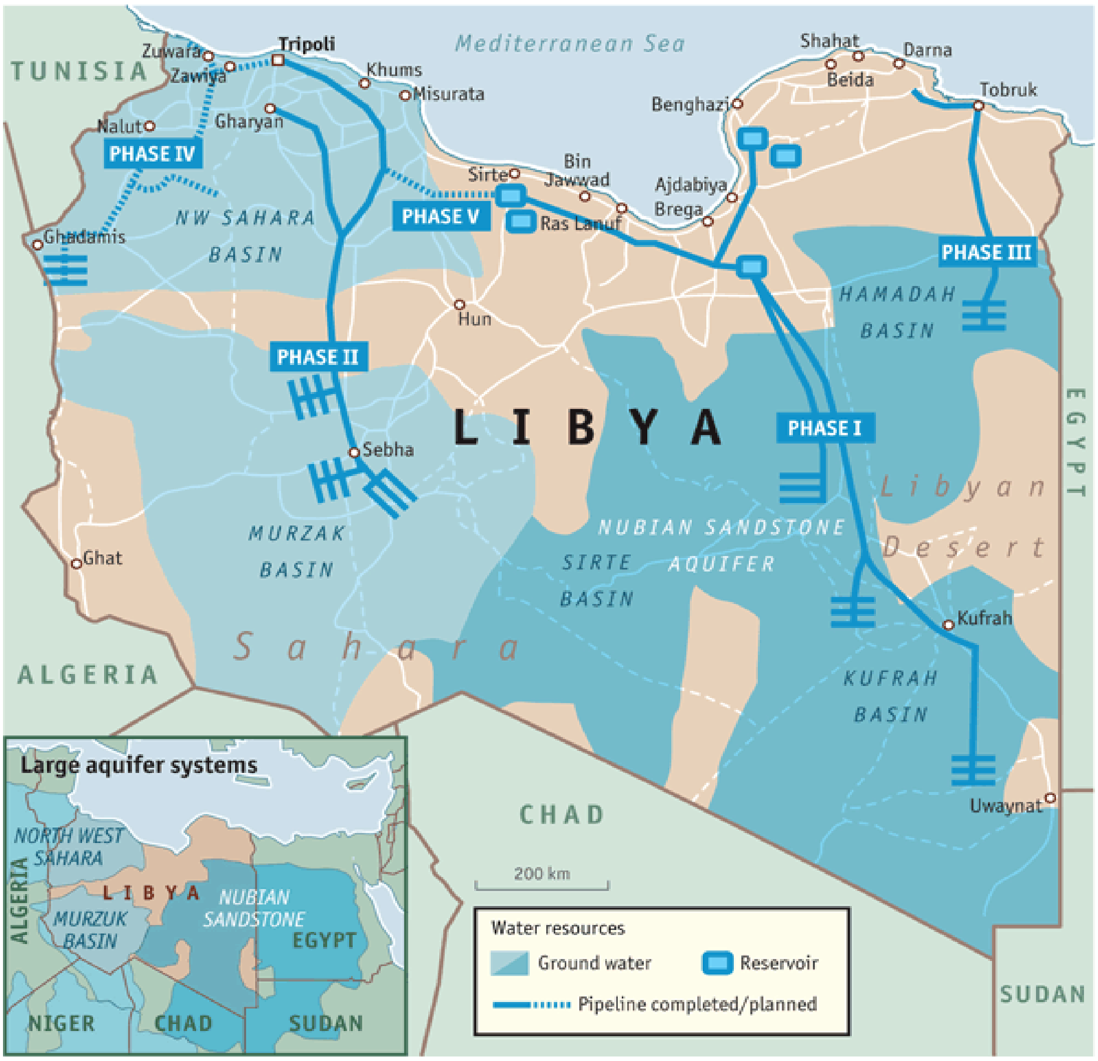


Source: wps.prenhall.com

Appendix B: *Jefara Plain Region location on the map*

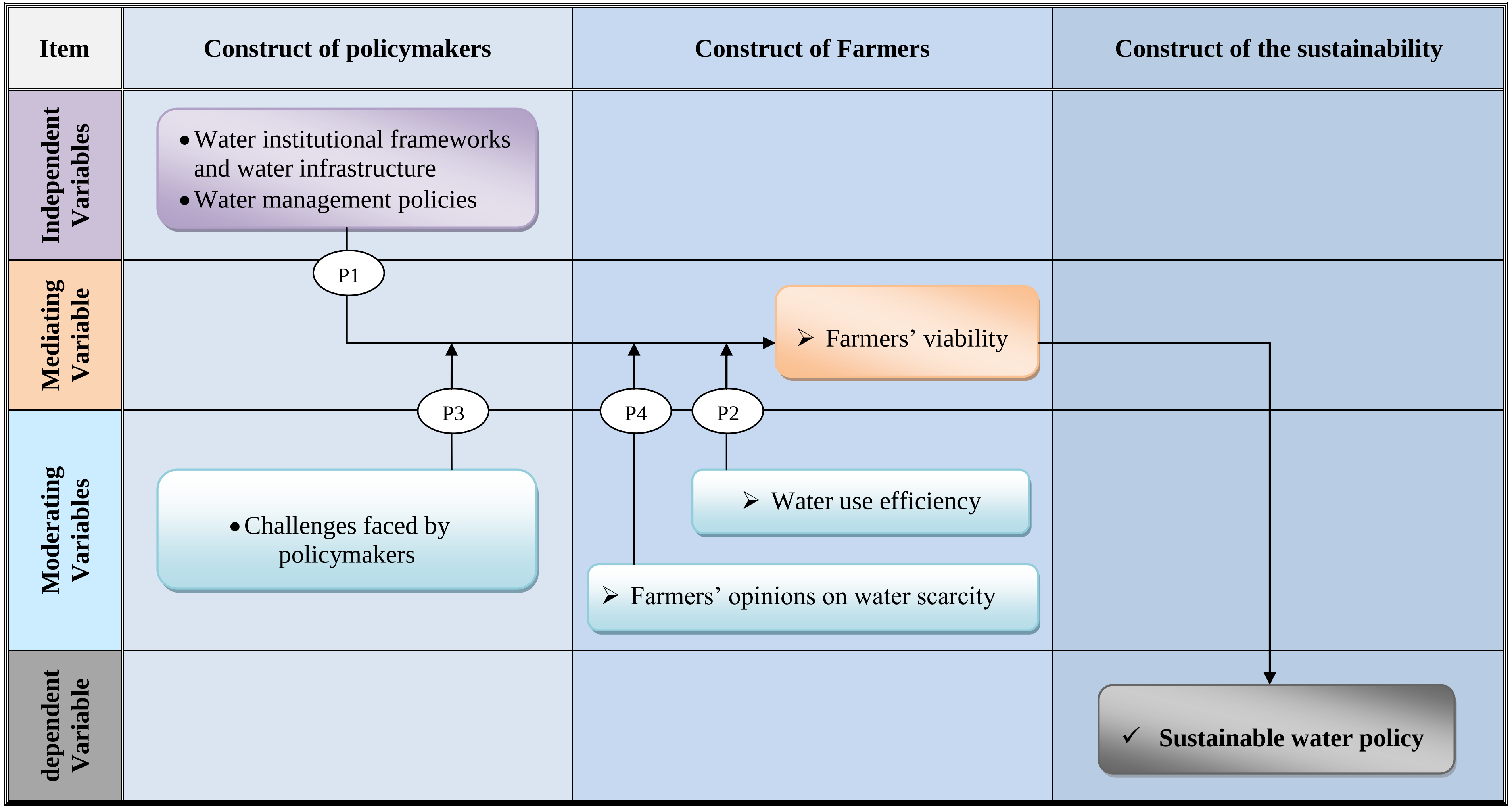
Source: adapted from Arid Ocean Maps website (http://www.aridocean.com/maps-by-country)

Appendix C: *Configuration of the GMRP on a map of Libya*

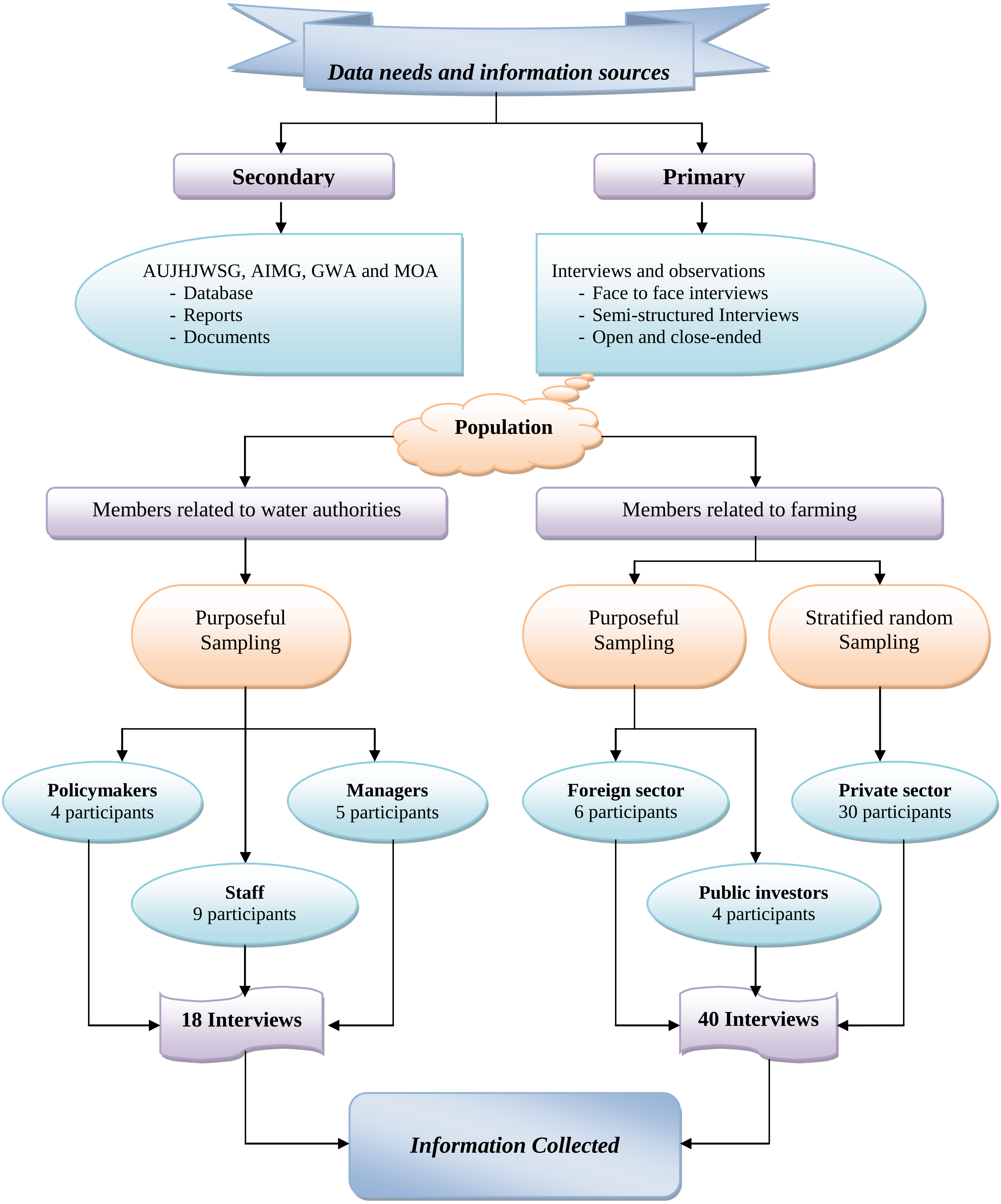


Source: www.gmmra.org

Appendix D: *Conceptual model of the study*



Appendix E: *Data needs and information sources*



Appendix F: Ethics approval

TOOWOOMBA QUEENSLAND 4350 CRICOS: QLD 00244B NSW 02225M
AUSTRALIA
TELEPHONE +61 7 4631 2300
www.usq.edu.au

OFFICE OF RESEARCH AND HIGHER DEGREES
William Farmer
Ethics Officer
PHONE (07) 4631 2690 | FAX (07) 4631 1995
EMAIL ethics@usq.edu.au

Friday 11 February 2011

Abdulmagid Abdudayem
Faculty of Business
USQ Toowoomba Campus

Dear Abdulmagid

The USQ Fast Track Human Research Ethics Committee (FTHREC) assessed your application and agreed that your proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research (2007)*. Your project has been endorsed and full ethics approval granted.

Project Title	Developing and framing water policy for sustainable water security in agriculture in the Jefara region of Libya
Approval no.	H11REA010
Expiry date	01/08/2012
FTHREC Decision	**Approved as submitted**

The standard conditions of this approval are:

(a) conduct the project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments made to the proposal required by the HREC
(b) advise (email: ethics@usq.edu.au) immediately of any complaints or other issues in relation to the project which may warrant review of the ethical approval of the project
(c) make submission for approval of amendments to the approved project before implementing such changes
(d) provide a 'progress report' for every year of approval
(e) provide a 'final report' when the project is complete
(f) advise in writing if the project has been discontinued.

For (c) to (e) proformas are available on the USQ ethics website:
http://www.usq.edu.au/research/ethicsbio/human

Please note that failure to comply with the conditions of approval and the *National Statement* may result in withdrawal of approval for the project.

You may now commence your project. I wish you all the best for the conduct of the project.

William Farmer
Ethics Officer
Office of Research and Higher Degrees

Appendix G: Participant Information

University of Southern Queensland

The University of Southern Queensland

Participant Information

TO: Participants

TITLE OF PROJECT: ***Developing and framing water policy for sustainable water security in agriculture in the Jefara region of Libya***

THE RESEARCHER: Abdulmagid Abdudayem, PhD Student, Faculty of Business University of Southern Queensland
Phone: +62 7 46311272, E-mail: Abdulmagid.Abdudayem@usq.edu.au

I would like to invite you to take part in this research project.

Description

This research will focus on examining the challenges faced by policymakers in terms of formulating effective water resource management strategies and the potential impact of these policies upon farmers' viability. Therefore, the research objectives are to examine the current Libyan water institutional frameworks and water management policies. This study will explore the ability of improving water use efficiency in agriculture in the Jefara region and will provide insights on how water saving and a more efficient water policy framework could improve water sustainability in the Libyan agricultural sector.

The researcher requests your assistance to be an interviewee in this project because you are a related to the project and eligible to be a participant of this project since you are a manager or staff member related to water authorities of Libya, or a farmer in the Jefara region of Libya.

This project is being undertaken as a part of a PhD project for Abdulmagid Abdudayem.

Voluntary Participation

Your participation in this project is voluntary. With your permission, we wish to audio-taping the interview to assist with transcription of your responses.
Should you not want the interview audio recorded from the start or during the interview please say so and the recording will be stopped.
You can withdraw from the project at any stage without comment or penalty. Your decision to participate or not, or to withdraw from the project will not affect your current or future relationship with the University of Southern Queensland.
This project involves the submission of anonymous (non-identifiable) material.
It is expected your participation will take approximately 30-45 minutes of your time.
Please note: the data obtained from this project may be used at a later time for any research purpose.

Risks

There are no risks beyond day-to-day living associated with your participation in this project.

Confidentiality

Any information obtained in connection with this project and that can identify you will remain confidential. It will only be disclosed with your permission, subject to legal requirements. If you give the researcher your permission by signing the Consent Form, the researcher plans to publish the results with his supervisor to the Academic Journal**.**
In any publication, information will be provided in such a way that you cannot be identified.
No questions of a personal nature will be asked, and the researcher will attempt to minimise any inconvenience.
All data received for this project will remain stored for a minimum of 5 years in secure facilities.

Consent to Participate

Please read this information sheet carefully so that you understand what the project involves.

The return of the completed anonymous survey is accepted as an indication of your consent to participant in this project.

Questions / further information about the project

Please do not hesitate to ask the researcher if you do not understand any part of the project, if you have any questions or if you require further information about the project.

Your cooperation and generosity in participating in this study is highly valued and appreciated.

Concerns / complaints regarding the conduct of the project

If you have any ethical concerns with how the research is being conducted or any queries about your rights as a participant please feel free to contact the University of Southern Queensland Ethics Officer on the following details.

Ethics and Research Integrity Officer
Office of Research and Higher Degrees
University of Southern Queensland
West Street, Toowoomba 4350
Ph: +61 7 4631 2690
Email: ethics@usq.edu.au

Appendix H: *Consent Form*

University of Southern Queensland

USQ AUSTRALIA

The University of Southern Queensland

Consent Form

TITLE OF PROJECT: ***Developing and framing water policy for sustainable water security in agriculture in the Jefara region of Libya***

THE RESEARCHER: Abdulmagid Abdudayem, PhD Student, Faculty of Business University of Southern Queensland
Phone: +62 7 46311272, E-mail: Abdulmagid.Abdudayem@usq.edu.au

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I confirm that I am over 18 years of age. *Omit if participants are under age of 18.*
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential. *If other arrangements have been agreed in relation to identification of research participants this point will require amendment to accurately reflect those arrangements.*
- I understand that the tape will be *(if tape is to be retained, insert details of how and where the tape will be stored, who will have access to it and what limits will be placed on that access)*
- I understand that I will be audio taped / videotaped / photographed during the study. *Omit this point if not.*
- I understand the statement in the information sheet concerning payment to me for taking part in the study. Omit this point if no payment will be made.

Participants under the age of 18 normally require parental or guardian consent to be involved in research. The consent form should allow for those under the age of 18 to agree to their involvement and for a parent to give consent. Copy and paste another signature field if necessary.

Name of participant……………………………………………………………………………

Signed………………………………………………………………**Date**……… / ……… / 2011

If you have any ethical concerns with how the research is being conducted or any queries about your rights as a participant please feel free to contact the University of Southern Queensland Ethics Officer on the following details.
Ethics and Research Integrity Officer
Office of Research and Higher Degrees
University of Southern Queensland
West Street, Toowoomba 4350
Ph: +61 7 4631 2690
E-mail: ***ethics@usq.edu.au***

***Appendix I:** Matrix form of reduced information*

Participant name	Age	qualification	specialisation	experience	Construct of poliymakers						Construct of farmers						Construct of sustainability		General information
					Concept 1		Concept 2		Concept 3		Concept 4		Concept 5		Concept 6		Concept 7		
					Water institutional frameworks		Water management policys		Challenges faced by policymakers		Farmers' viability		Water use efficiency		Farmers' opinions on water scarcity		Sustainable water securty		
1-					Information		Information		Information		Information		Information		Information		Information		
					Doc.12/G	Rec.3/9	Doc.4/A	Rec.3/3	Doc.15/C	Reg.2/6	Doc.2/G	Rec.2/3	Doc.1/A	Reg.1/5	Doc.5/G	Rec.2/8	Doc.4/A	Reg.2/3	
					Observation		Observation		Observation		Observation		Observation		Observation		Observation		
					Doc.11/A	Reg.2/5	Doc.1/B	Rec.1/7	Doc.8/A	Rec.1/2	Doc.5/A	Reg.2/9	Doc.17/G	Rec.3/1	Doc.2/G	Rec.1/4	Doc.6/G	Rec.3/4	
2-																			
3-																			
Descriptive statistics																			