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Challenges to the Governance of Water Security in the UAE

Shaikha Saif Mohamed Alghafli

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جامعة الإمارات العربية المتحدة
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College of Humanities and Social Sciences

Department of Political Science

CHALLENGES TO THE GOVERNANCE OF WATER SECURITY IN
THE UAE

Shaikha Saif Mohamed Alghafli

This thesis is submitted in partial fulfillment of the requirements for the
Master of Governance and Public Policy

Under the Supervision of Dr. Clara Morgan

November 2016

Declaration of Original Work

I, Shaikha Saif Mohamed Alghafli, the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this thesis entitled “*Challenges to the Governance of Water Security in the UAE*”, hereby, solemnly declare that this thesis is my own original research work that has been done and prepared by me under the supervision of Dr. Clara Morgan in the College of Humanities and Social Sciences at UAEU. This work has not previously been presented or published, or formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my thesis have been properly cited and acknowledged in accordance with appropriate academic conventions. I further declare that there is no potential conflict of interest with respect to the research, data collection, authorship, presentation and/or publication of this thesis.

Student's Signature: Shaikha

Date: 09.01.2017

Approval of the Master Thesis

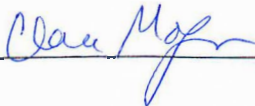
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Abstract

In the recent past, the United Arab Emirates (UAE) has seen tremendous economic growth, which has put pressure on its existing natural resources. Hence, the government of the UAE is working extensively on developing a strategic framework for sustainable water management. This study is aimed at analyzing the challenges to the governance of water security in the UAE. Evidence was collected from nine semi-structured interviews with senior officials and academics from different government agencies in the UAE. Quantitative data was collected on water consumption in the UAE in various sectors from a range of authorities (FCSA, DSC, MOENR, ADWEA, DEWA, SEWA and FEWA). The data and the results of this research show alarming water consumption rates by various sectors of the UAE. UAE's water consumption rate is four times above the average world consumption rate.

Key recommendations focus on improving the effectiveness, efficiency and trust and engagement in the governance of water security in the UAE. Recommendations include a Unified Water Strategy, centralizing data collection, reducing water leakage, researching new technologies for water desalination plants, establishing a common regulation and legislative framework, continuing with water subsidy reductions, and building awareness through information dissemination, educational programs for farmers and incentive programs.

Although the UAE is viewed as one single entity by interviewees, the data is dispersed and not managed under a single authority leading to mismanagement of scarce water resources. Good governance certainly needs effective data management. The situation of the UAE is similar to other GCC countries. This sheds light on the fact that the entire GCC region can unite together as one single unit in terms of water and electricity production and usage.

Keywords: Governance, water security, United Arab Emirates, GCC.

Title and Abstract (in Arabic)

التحديات التي تواجه حوكمة الامن المائي في دولة الامارات العربية المتحدة

الملخص

شهدت دولة الإمارات العربية المتحدة مؤخرًا نموًا اقتصاديًا هائلًا؛ مما أدى إلى إرهاق مواردها الطبيعية الراهنة، وبالتالي تعمل حكومة دولة الإمارات جاهدة على وضع إطار عمل إستراتيجي لإدارة المياه بطريقة مستدامة، وفي هذا الصدد، تهدف هذه الدراسة إلى تحليل التحديات التي تواجه حوكمة الأمن المائي في دولة الإمارات العربية المتحدة؛ إذ جُمعت الأدلة التي تستند إليها هذه الدراسة عن طريق إجراء مقابلات شبه منمّمة مع كبار الموظفين والأكاديميين العاملين في جهات حكومية مختلفة بدولة الإمارات، كما جُمعت البيانات الكميّة حول حجم استهلاك المياه بدولة الإمارات في قطاعات مختلفة من جهات عدّة، منها: "الهيئة الاتحادية للتنافسية والإحصاء"، "مركز دبي للإحصاء"، "وزارة الطاقة"، "هيئة مياه وكهرباء أبوظبي"، "هيئة مياه وكهرباء دبي"، "هيئة مياه وكهرباء الشارقة"، "الهيئة الاتحادية للكهرباء والماء"، وتشير بيانات هذه الدراسة البحثية ونتائجها إلى وجود ارتفاع مقلق في نسب استهلاك المياه في مختلف القطاعات بدولة الإمارات العربية المتحدة، وهو ما يعادل أربعة أضعاف متوسط الاستهلاك العالمي للمياه.

تركز التوصيات الرئيسية لهذه الدراسة على تحسين الكفاءة والفاعلية والثقة والاهتمام بحوكمة الأمن المائي بدولة الإمارات العربية المتحدة، وتتضمن التوصيات كلاً من: إستراتيجية موحّدة للمياه، مركزية جمع البيانات، تقليل حالات تسرّب المياه، البحث عن تقنيات جديدة لمحطات تحلية المياه، وضع أنظمة عامة وإطار عمل تشريعي، الاستمرار في تقليل الدعم الحكومي عن الماء، ونشر التوعية عن طريق بثّ المعلومات ووضع برامج تثقيفية للمزارعين وإطلاق برامج تحفيزية.

ومع أن الشريحة التي تمت مقابلتها تنظر إلى دولة الإمارات العربية المتحدة ككيان واحد، إلا أن البيانات المتوفرة تكاد تكون مشتتة، كما أنه لا يتمّ التعامل معها من قبل جهة وحيدة؛ الأمر الذي يؤدي إلى سوء إدارة الموارد المائية الشحيحة في الأصل، ومما لا شكّ فيه أن الحوكمة الرشيدة تحتاج إلى إدارة البيانات بطريقة فاعلة، لاسيّما أن الوضع في دولة الإمارات مشابه

لأوضاع دول "مجلس التعاون الخليجي" الأخرى، وهنا يجب تسليط الضوء على حقيقة أن منطقة الخليج ككل تملك القدرة على الاصطفاف معا لتشكيل كيان واحد في مجال إنتاج المياه والطاقة الكهربائية واستخدامهما.

مفاهيم البحث الرئيسية: الحوكمة، الأمن المائي، دولة الإمارات العربية المتحدة، مجلس التعاون الخليجي.

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And above all, I truly thank ALLAH who made it possible by every means and helped me graduate.

Dedication

To my beloved parents and family

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List of Abbreviations

ADWA	Abu Dhabi Water and Electricity Authority
BCM	Billion Cubic Meters
DEWA	Dubai Electricity and Water Authority
FEWA	Federal Electricity and Water Authority
GCC	Gulf Cooperation Council
HDC	Hot desert Climate
MIGPD	Million Imperial Gallons Per Day
OECD	Organization for Economic Co-operation and Development
PMO	Prime Minister Office
R&D	Research and Development
RSB	Regulation and Supervision Bureau of Abu Dhabi
SEWA	Sharjah Electricity and Water Authority
UAE	United Arab Emirates
UNESCO	Institute for Water Education

Chapter 1: Introduction

1.1 Overview

The World Economic Forum identified water security as one of the top 10 global risks in its 2016 *Global Risks Report* (WEF, 2016). Given the UAE's geography as a desert country with limited water resources, the problem has become a significant part of its public policy and governance concerns.

Water security is defined as the ability of a population to safeguard its access to adequate quantities of acceptable useable water for sustaining livelihoods, population well-being, and socio-economic development. An added dimension to security is also ensuring the protection against water-borne pollution and water-related disasters, sustaining the ecosystems within a climate of peace and political stability (U.N, 2013).

As part of policy planning, governments have to take into consideration their water security. Due to the arid climate in the UAE and the Arab region, potable water resources are a continuous cause of concern in the Arab region and among GCC countries (GCC, 2015, p. 1). Arab regions are expected to become even drier in the coming decades (World Bank, 2016). In addition; consumption has increased due to population growth (World Bank, 2016). Rapid development in the industrial sector has also contributed to this increase in consumption, especially with increase in industries which are non-oil based (U.N, 2013). In order to address this challenge, the UAE needs to have a focused plan for its future (GCC, 2015, p. 7).

This research study aims to understand the challenges of governance of water security in the UAE and various aspects of the security issues. It attempts to study

the current problems that the UAE faces in terms of industrial growth and the rise in water consumption levels, as well as the impact of domestic use and misuse leading to excessive water wastage. Some steps and solutions to curb this problem and sustain water security are also a part of study. The study aims to contribute to better policy planning in order to improve water security for the UAE.

1.2 Problem statement

It is important for government leaders and policy makers to acknowledge the sustainability and security of water resources. In order for the government to manage the country with minimum water security risks and issues, it must engage in creating awareness regarding the water limitations of availability and develop policies that secure the quantity and quality of water available to its population. In the context of the UAE, water consumption is increasing at alarming rates. It is therefore imperative to study the policies that governments have put in place to secure the availability of water and study the usage of water resources as well as the impact of the increase of water consumption on availability and its associated costs. It is also important to understand how environmental and climate factors influence water resources. The study aims to find policy solutions that help to maintain both the quantity and the quality of water available for the UAE population.

1.3 Purpose of the research

The purpose of this research study is to examine the water security situation in the UAE and to understand the challenges faced by the UAE in maintaining a secure, stable source of water for its population and its industries. The study also explores solutions for addressing situations in which the UAE will face water

insecurity due to high consumption levels, increasing population growth, climate change, and effects of pollution.

1.4 Research objectives

1. Study the system of water security governance in the UAE.
2. Identify current and future water security challenges risks.
3. Discuss existing government policies that address water security in the UAE.
4. Suggest governance improvements to water security in the UAE.

1.5 Literature review

In this literature review, the researcher will examine documents and scholarly publications that relate to the topic of the thesis: "Challenges to the Governance of Water Security in the UAE". The following areas are included in the literature review section: the concepts of water governance and water security, challenges to water security in the Gulf Cooperation Council (GCC) countries, and water security in the UAE.

1.5.1 Concepts of governance, water governance and water security

Governance:

Governance involves the exercise of economic, political and administrative authority to manage a state's affairs (Rogers and Hall, 2002). It includes a combination of different mechanisms, processes and institutions through which the task of governing takes place at different levels. Governance combines various instruments such as "statutes, including policy mandates; organizational, financial and programmatic structures; resource levels; administrative rules and guidelines;

and institutionalized rules and norms” (Lynn, 2000, p. 21). The concept of governance is not restricted to ‘government’ but is broader and more inclusive encompassing a range of actors, stakeholders, interests and institutions within a social system. By default, governance is “political” (Lynn, 2000) and deals with many transactions leading to compromise, victory or defeat. Any governance system allocates resources along with the obligation to carry out various tasks involving both public and private organizations.

Governance is important for ensuring economic, social and environmental outcomes. Good governance practices need to be in place in order to produce good outcomes. These can include inclusiveness, accountability, participation, transparency, predictability and responsiveness. However, if the governance system that is in place does not meet these conditions, then one can say that the system is characterized by poor governance (Rogers and Hall, 2002).

Water Governance

Water governance is a term that refers to “the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society” (Rogers and Hall, 2002, p. 16). Water governance includes developing and formulating a water policy that has as its objective sustainable development of water resources. The implementation of water governance policies need to involve key actors and stakeholders so that processes are effective (Rogers and Hall, 2002). The researcher will use the Organization for Economic Co-operation and Development (OECD) water governance principles to guide the analysis of the governance of water security in the UAE.

According to the United Nations report on water governance in the Arab region, there are several factors that restrict progress in water governance including, “unclear and overlapping responsibilities, inefficient institutions, insufficient funding, centralized decision-making, limited public awareness and ineffective regulations and enforcement” (UNDP, 2013, p. 1).

In conceptualizing good water governance approaches, Pahl-Wostl (2009) suggests that we need to put in place adaptive governance and social learning systems that are “essential for governing social-ecological systems during periods of abrupt change” (p.355). In particular, recent changes in the weather have highlighted the weaknesses of the existing resource management systems. The failure to govern these natural resources adds to the already existing scarcity issue. Therefore, it is vital to understand the importance of sustainable resource governance in times of global and climatic changes as well in terms of the scarcity of water in countries such as the UAE. In addition, Pahl-Wostl (2009) notes that in order to change a governance regime, governments need to incorporate social and societal learning. Social learning is essential for the general public, interested parties and government bodies to manage their resources efficiently. However, this social learning gets hampered if the environmental resources are handed over to private organizations and/or existing socio-economic situation.

Water Security

Water security is determined by three characteristics – 1. The availability of natural water resources. 2. The socio-economic scenario and 3. The global climatic change. All these factors combined together help in deciding the role to be played by each institution or authority in achieving water security (Greg & Sadoff, 2007, pp. 548-549).. Water security needs to be achieved by decreasing its negative impacts

and increasing its positive role in the socio-economic development of a region (ibid, p. 547).

Water security is related to the political scenario of a region as well as the availability of water to its population. In the Arab region, water security became a cause of concern around forty years ago among countries such as Syria, Iraq and Egypt. These countries experienced challenges to water security due to poor quantity and quality of water, which affected their capacity to meet their development plans and resulted in political unrest (Al Zubari, 2013).

When it comes to the GCC counties, there is a high dependency on water from outside the region or from neighboring regions, which sometimes becomes the reason for conflict (Al Zubari, 2013, p. 81). Yemen and Iraq are clear examples where such conflicts occur. Even Syria, Sudan and Egypt are affected by such challenges.

In addition to the political dimension to water security, there is also the availability and sustainability of water security. A country needs to ensure that it can secure a steady supply of water to its citizens. For the GCC and the UAE, their water supply comes from water desalination plants (GCC, 2015). Providing water security means that in the event of the desalinated water not being provided to the consumers in the GCC region, reserves which are put in place such as in Abu Dhabi are sufficient for the people to continue their routine activities for a considerable amount of time.

Water security has been defined as “multi-dimensional concept that recognizes that sufficient good quality water is needed for social, economic and cultural uses while, at the same time, adequate water is required to sustain and enhance important ecosystem functions.” (Al Zubari, 2013, pp. 82-83). Four

interrelated themes dominate the published research on water security. I draw on these four themes to determine how the term Water Security relates to the United Arab Emirates, now and in the future (Cook, 2012).

The first theme which water security focuses on is the quantity and availability of water and is often linked to water security assessment indices concerning water stress and water shortages. When considering water stress, evaluations are used to measure the ratio of water use and water availability and the estimated effects of the demand-driven scarcity by measuring how much water is withdrawn from rivers and aquifers, often referred to as blue water resources. The second of these indices, looks at water crowding or water shortage by measuring the number of people that have to share each unit of blue water resource. From this perspective, sufficiency of water supply for humans is the primary gauge of water security and for the individual, water security exists when they have access to safe and affordable water that meets their needs for washing, drinking and livelihood (Cook, 2012).

The second theme of water security is water related hazards and vulnerability. For example, UNESCO advocates an infrastructure and systems approach which involves, protection of vulnerable water systems, protection against water related hazards, such as flooding and drought, ensuring sustainable development of water resources and safeguarding access to water functions and services (Cook, 2012). A further definition of this theme is also the protection and prevention against contamination and terrorism, which is a relevant concern for the UAE as well as other areas in the Middle East in the current political climate. In order to implement this concept, water engineers have to develop an understanding of water security,

which involves using ordnances, gates and guards to ensure potable water and drinking water infrastructure security.

The third theme of water security can be broadly explained by the term "human needs" which covers a wide range of issues, including access, food security and human development related concerns. This can be summed up as the condition where there is a sufficient quantity of water at the required quality, at an affordable price, to meet both the short and long term needs that protect the health, safety, welfare and productive capacity of households, communities, neighborhoods as well as the nation. The United Nations has summarized these human needs as, all aspects of human security pertaining to the use and management of water. While this may appear to be a succinct explanation, it omits the importance of safeguarding the ecosystem as an integral component of both human and water security.

The fourth and final theme, which relates to water security, is that of sustainability. The Global Water Partnership stated that "water security at any level from the household to the global arena means that every person has access to enough safe water, at affordable cost, to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced" (Cook, 2012). In order to meet these criteria, we have to consider the following variables: meeting basic needs, securing the food supply, protecting ecosystems, sharing water resources, managing risks, valuing water and governing water wisely. This, the Global Water Partnership argues, suggests are the baseline requirements needed when considering what we want to address the term water security.

1.5.2 Challenges to water security in the GCC countries

The GCC countries face several challenges related to water security. The study of the Gulf Cooperation Council's Unified Water Strategy (GCC-UWS) includes evaluating the current situation of the water sectors in the GCC countries, analyzing their water strategies, formulating a Unified Water Strategy for all the GCC countries, positioning the GCC Member State Water Strategy with this Unified Water Strategy, designing a Strategy Management Office and developing a general framework for building future capacities. This strategy envisions establishing sustainable and secure water resource management systems to all the GCC countries by 2035. There are five main themes which represent this strategy –

- “1. Development and Sustainability of Water Resources.
2. Efficient and Equitable Water Resources Utilization.
3. Enhanced Municipal Water Supply Security.
4. Effective Water Governance and Awareness.
5. Economic Efficiency & Financial Sustainability” (GCC, 2015, p. 9).

The GCC-UWS aims to achieve a target of 60% usage of wastewater, reduce the per capita water consumption to 250 liters/day, and increase the irrigation efficiency to an average of 60% by all GCC countries until the year 2035. “(Average irrigation efficiencies in Bahrain=32%; Kuwait=25%; Oman = 55%; Qatar = 45%; Saudi Arabia = 50%; and UAE = 55% (Note: numbers are averages)” (GCC, 2015, p. 25). It also aims at cumulative savings in terms of volumes and associated costs for municipal water supply and wastewater, desalination production, energy requirements and emissions.

In terms of governance, the GCC-UWS notes that the water governance system in the GCC countries is “scattered between different authorities” (ibid, p. 7). The strategy proposes two strategic objectives for improving governance – the first objective aims to achieve an effective and integrated water resources management system and the second objective aims to achieve a water-oriented society in the GCC countries (ibid., pp. 19-21). For the first objective, several policy options are proposed for creating an integrated water resources management system. These include ensuring integrated planning and coordination among water sectors; ensuring water sector regulation; improving management capacity; improving the legal framework; providing data; customizing water standards; and regulating the use of aquifers (ibid., pp. 19-20). With regards to the second objective of achieving a water-oriented society, the strategy proposes policies related to awareness building on the importance of value of water and the importance of the conservation of water (ibid., p. 20).

Saif (2014) has proposed addressing GCC water security and scarcity issues through demand management and supply management.

Demand management:

Demand management employs strategies to decrease the demand on the water resource whereas supply management includes strategies to increase the water supply. Saif (2014) indicates that demand management should be given priority over supply management as it avoids unnecessary investment in new water and energy infrastructure (GCC, 2015, p. 2). For example, around 60-90% of the ground water in UAE, Saudi Arabia and Oman is used for agricultural purposes and out of this, more than 50% of the water is lost because of poor agricultural practices (Saif, 2014). Therefore, better irrigation systems will ensure food security without depleting the

already scarce natural resources. In order to better manage the demand of water, the GCC countries are working on the technical efficiencies related to the use of water by consumers. GCC countries are also promoting conservation and sustainability through open access to statistical information, online consumption calculators, awareness campaigns and other public participation techniques.

Supply Management:

All the GCC countries rely on water desalination processes for their water supply. In fact, 99% of potable water in the GCC comes from desalination plants (Saif 2012, p. 3). One of the main issues associated with water desalination plants are their high energy use (Busch, M., & Mickols, W,E, Saif 2012, pp. 165,299-312) Thus, GCC countries are trying to find alternative technologies for desalination processes that are less energy intensive and more sustainable.

Policy approaches to addressing challenges to water security

Al-Zubari (2008) draws attention to the various policy approaches that can be adapted by the GCC countries for efficient water resource management. He presents four scenarios in a narrative storyline to the year 2050 which include: Markets First, Policy First, Security First, and Sustainability First.

Under the “Market First” scenario, GCC countries lay emphasis on the economic growth at any cost. With the usage of advanced technology for economic development, natural and environmental resources depletion, environmental degradation, and health risks also increase. For this, privatization is seen as the solution, which will not only lower government economic burden but also attract investments having a positive impact on the vital sectors of water and energy. According to the “Policy First” scenario, it is envisaged that constitutional democratization, public representation and voting, auditing and transparency etc. will

be gradually introduced in the GCC countries, thereby, putting greater emphasis on human well-being and environmental protection.

Under the “Security First” scenario, large amounts of budget which are appropriated by the GCC governments towards the armaments/security on the expense of social, economic development and environmental protection lead to increase in corruption and unemployment. There is negligible investment in research and development (R&D) for non-conventional water resources and management of water resources and services is auctioned to multi-national companies. Non-adherence to the treatment standards in the reuse of waste water leads to major outbreaks of water-related diseases. Food self-sufficiency which is a major security issue in the GCC countries will also see a decline with the excessive usage of land and water resources.

In the “Sustainability First” scenario, proactive solutions to the challenges of sustainability are provided by adaptation of long-term integrated strategic planning and accomplished by heavy investment on educational, training and capacity development programs. Also, scientific

R& D is strongly encouraged along with the introduction of eco-taxes and polluter pay charges. Commitment towards the environment which is termed as “Environmental citizenship” will be practiced to eliminate the existing negative cultural habits and attitudes such as non-compliance, wastage etc. Under this scenario, GCC society will be a complete democratic society, balancing relationship and power between government, private sector and civil society which shall not only enable the government water/environmental authorities to take stronger decisions at the national and regional levels but also play an active role in the global environmental policies.

The most important policy lessons that these scenarios offer to the GCC countries is that investment in human resources development, governance improvement, Investment in R&D to solve societal problems and to meet its needs, GCC countries integration, and cooperation with the Arab countries are key issues in the long, intricate path to sustainability. In the latter, cooperation in the fields of food production and R& D in desalination and water treatment technology would help alleviate the problem of water scarcity in the region (Al-Zubari, 2008, p. 14).

According to Al-Zubari, integrating “Policy First” and “Sustainability First” approaches will contribute for quick progress without compromising on the economic development. Al-Zubari (2008) concludes that technological advancements along with greater efforts from the government bodies, private institutions and end-users all together will bring about the required change in the water and energy sector of UAE.

1.5.3 The current state of water security in the UAE

The UAE has an arid to hyper-arid climate with high temperatures and infrequent and low rainfall. In the summer season, the average maximum temperature reaches well in excess of 45 degrees Celsius, with relative high humidity in above 97 percent. The average daily evaporation is 8.2 millimeters, with average daily sunshine of 9.8 hours, one of the highest rates in the world and the average annual mean rainfall is around 120 millimeters (Al-Mulla, 2011).

The UAE has recognized the importance of conserving environment resources as an important foundation to its development policies for present and future generations, especially as it has been endowed with a variety of important

terrestrial, coastal and marine ecosystems. In addition to national legislation that targets environmental issues, the UAE is also involved with several regional and international protocols, including the high profile Kyoto Protocol since 2005.

Despite its highly arid condition, the UAE has been able to develop a thriving agricultural industry. Modern irrigation techniques and water resources from groundwater aquifers, wastewater treatment plants and from desalination plants have made it possible for large areas to be cultivated. There are more than 100, 000 hectares of cultivated land producing a wide range of crops, including, vegetables, fruit and fodder. (Al-Mulla, 2011)

While the total UAE demand for water is gradually increasing and is currently estimated to be 4.5 Billion Cubic Meters (BCM) per year the UAE total renewable freshwater resources are relatively low at less than 150 Million Cubic Meters per year. It is assumed that should current demand pattern and rates continue, the UAE's total annual water demand is expected to double by 2030 to reach between 9 and 10 BCM (Al-Mulla, 2011). The sectors that predicted greatest increase in urban demand such as household, industrial, commercial, institutions and public facilities, resulting from the population, industrial and commercial growth. Conversely, water demand for agricultural and forestry is expected to decrease relative to current values as a result of depleting groundwater resources, unless treated wastewater or desalinated water resources are used as alternative resources.

The need for desalination is closely linked with the discovery of oil. Oil revenues provided the UAE with the resources to invest in. Its economic growth and development has resulted in a huge influx of workers, which in turn increased the

consumption of water. Saif (2012) concludes that the future of the desalination related issues will be on the rise, however the massive investments directed towards this area by the government reflects the awareness and the forethought in planning the future of water security in UAE.

To help manage its approach to water governance, the UAE has in place a Water Conservation Strategy, which it developed in 2010 (Ministry of Environment and Water, 2010). The Strategy provides a framework for the sustainable management of UAE's water resources to 2021 (p. xv). The framework recommends eight key initiatives. These include developing an integrated water management approach, improving natural water resources management, developing a national agricultural policy to conserve water, managing efficiently desalinated water, rationalizing water consumption, developing water pricing and subsidy policies, better managing wastewater, and building

1.6 Summary

Capacity and knowledge in integrated water resources management (p. xv-xvi). The UAE government has not issued any reports that discuss progress towards achieving its Water Conservation Strategy.

In summary, this chapter acknowledges that water security in the UAE is a highly relevant and topical issue that needs to be addressed as a matter of priority particularly when it comes to policy planning and governance. This problem of water security is especially relevant to the UAE, given the increase in population and the subsequent increase in demand. The UAE government has begun to examine the issue through its Water Conservation Strategy, which can be considered as steps in the right direction. The question is whether the UAE can address effectively and

efficiently the challenges it faces in the governance of water security. The thesis identifies the key challenges facing the UAE in governing its water security and makes recommendations to improve the efficiency, effectiveness and trust and engagement of water security governance.

Chapter 2: Theoretical Framework and Methodology

The purpose of this research study is to examine the water security situation in the UAE and to understand the challenges facing the UAE in maintaining a secure, stable source of water for its population and its industries. The study also explores solutions for addressing situations in which the UAE will face water insecurity due to high consumption levels, increasing population growth, climate change, and effects of pollution.

2.1 Research objectives

My research objectives are to:

1. Study the system of water security governance in the UAE.
2. Identify current and future water security challenges risks.
3. Discuss existing government policies that address water security in the UAE.
4. Suggest governance improvements to water security in the UAE.

2.2 Theoretical framework

As mentioned earlier, governance involves a combination of different mechanisms, processes and institutions in order to exercise economic, political and administrative authority to manage a state's affairs (Rogers and Hall, 2002). The concept of governance includes a range of actors, stakeholders, interests and institutions within a social system. I use the term water governance to describe a "range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different

levels of society” (Rogers and Hall, 2002, p. 16). Theoretical framework draws on the concept of good water governance. After comparing two models of water governance, the USAID model and the OECD water governance model, the researcher selected the OECD’s water governance principles as a framework for analyzing my evidence (OECD, 2015). The analysis between these two models is presented below.

2.3 Model comparison

Table 1 illustrates the comparison between two frameworks: the OECD principles of water governance, which has been used for this study, and United States Agency International Development (USAID) framework on water governance, which is applied in the Middle East North Africa (MENA). The OECD model of water governance principles is more comprehensive and has involved several countries in its development than the USAID water governance framework.

Table 1: OECD and USAID Comparison

Area	OECD Principles on Water Governance	USAID Water Governance Framework
Description	The Organization for Economic Co-operation and Development (OECD) is an intergovernmental economic organization which provides a forum for the government of its member countries to share problems and	United States Agency for International Development (USAID) is the agency formed by the government of the United States which helps to end extreme global poverty and enable resilient, democratic societies to

Area	OECD Principles on Water Governance	USAID Water Governance Framework
	develop solutions to these problems.	realize their potential.
	The OECD formed in 1960 with an aim to stimulate economic progress and world trade. Most of the OECD member countries are developed countries which have high-income economies	USAID was formed in 1961 by the executive order of president John F.Kennedy from its predecessor agencies.
	It is headquartered in Paris, France and funded by contributions from member states.	USAID's programs are authorized by the Congress of the USA.
	Presently, the OECD has 35 member countries	USAID operates in Africa, Asia, Latin America, the Middle East and Eastern Europe.
	“This analytical framework was used to review water governance arrangements in 17 OECD countries (2011) and 13 Latin American countries (2012) as well as to carry out in-depth national multi-stakeholder policy	USAID applied in 6 countries of MENA.

Area	OECD Principles on Water Governance	USAID Water Governance Framework
	<p>dialogues in support of water reforms in Mexico (2013), Netherlands (2014), Jordan (2014), Tunisia (2014) and Brazil (2015)” (OECD,2015, p.2).</p>	
Application	<p>The OECD framework of water governance is based on three principles namely – 1. Effectiveness, 2. Efficiency and 3. Trust and engagement. For each principle there are four sub-principles.</p>	<p>USAID framework of water governance is based on the below five factors –</p> <ol style="list-style-type: none"> 1. Transparency 2. Participation 3. Accountability and Integrity 4. Rule of Law 5. Responsiveness
Analysis	<p>The OECD principles of water governance contribute to the “Water Governance Cycle” which has four stages – 1. Formulation of policies and strategies 2. Implementation 3. Monitoring and 4. Evaluation</p>	<p>The standard water governance functions of USAID are –</p> <ol style="list-style-type: none"> 1. Organizing and building capacity in the water sector. 2. Planning strategically 3. Allocating water 4. Developing and managing water resources 5. Regulating water

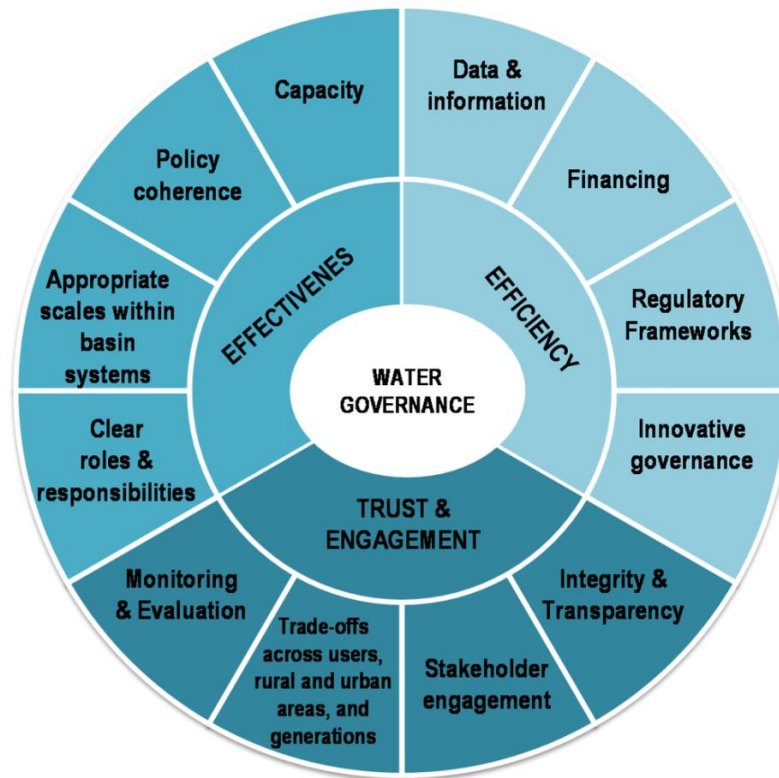
Area	OECD Principles on Water Governance	USAID Water Governance Framework
		resources and services

Sources: (Svendsen, 2010) and (OECD, 2015)

The OECD is an international organization consisting of 35 member countries that provides a forum for governments to share problems and develop solutions to these problems (OECD). The OECD launched the OECD Water Governance Initiative that brings together members from the public, private and non-for-profit sectors to share good practices in support of better governance in the water sector (OECD, 2016). As part of this initiative, the OECD developed the OECD Water Governance Principles. The OECD water governance principles are applied in 17 countries to review their water governance activities (OECD, 2015, p. 2). The OECD water governance framework is used to analyze governance and financial challenges to water security and has been applied in both developed and developing economies. In 2014 both Jordan and Tunisia applied the OECD water governance framework to analyze the challenges they face in governing their water security (OECD, 2015).

The researcher found selected the OECD water governance principles as a framework one because it has been developed in an international organization and tested in 17 countries, including countries in the Middle East. In contrast, the USAID framework for water governance was developed by an organization belonging to the United States. In addition, the OECD principles on water governance are comprehensive and reflect the consensus achieved among several countries involved in its development.

Figure 1: OECD Good Governance Principles



Source: OECD, 2015

The OECD's framework organizes good water governance principles into three broad areas: effectiveness, efficiency, and trust and engagement. The researcher will evaluate the challenges to the UAE water governance against these principles. In particular the analysis will compare research finding against these principles and identify the gaps. Based on the findings, analysis recommendation will be proposed.

A. Effectiveness: The effectiveness of water security governance involves processes and policies that define clear sustainable policy goals and that target all levels of governance. Effectiveness also entails implementation and meeting expected targets. There are four key sub-principles involved: (1) Setting clear roles and responsibilities; (2) managing water at appropriate scales within an integrated

system; (3) encouraging policy coherence across sectors; and, (4) adapting capacity to complex challenges and water sustainability (OECD, 2015, pp. 9-10).

B. Efficiency: focuses on the contribution of governance to maximize the benefits of sustainable water management and welfare with the least cost to the society. In discussing the efficiency of the governance of water security, it is important to consider how the UAE maximizes the benefits of sustainable water management and welfare with the least cost to society. The key sub-principles include (1) producing and sharing data and information; (2) mobilizing and allocating water finances efficiently; (3) effective implementation of regulatory frameworks; (4) promoting innovative practices (OECD, 2015, pp. 10-11).

C. Trust and Engagement:: addresses governance contribution to building public assurance and safeguarding the inclusiveness of stakeholders through legitimacy and fairness for society as a whole. In examining trust and engagement as a good principle of water security governance, it is important to consider the processes involved in building public assurance and safeguarding the inclusiveness of stakeholders through legitimacy and fairness for society as a whole. The key sub-principles include (1) mainstreaming integrity and transparency practices; (2) promoting stakeholder engagement; (3) encouraging water governance frameworks that help manage trade-offs across users, rural/urban, and generations; and (4) promoting monitoring and evaluation of water policy and governance (OECD, 2015, p. 12).

2.4 The UAE's water governance: institutions, laws, and stakeholders

In the UAE, water governance is decentralized because UAE is a federation. The UAE Constitution states that natural resources are the property of the individual

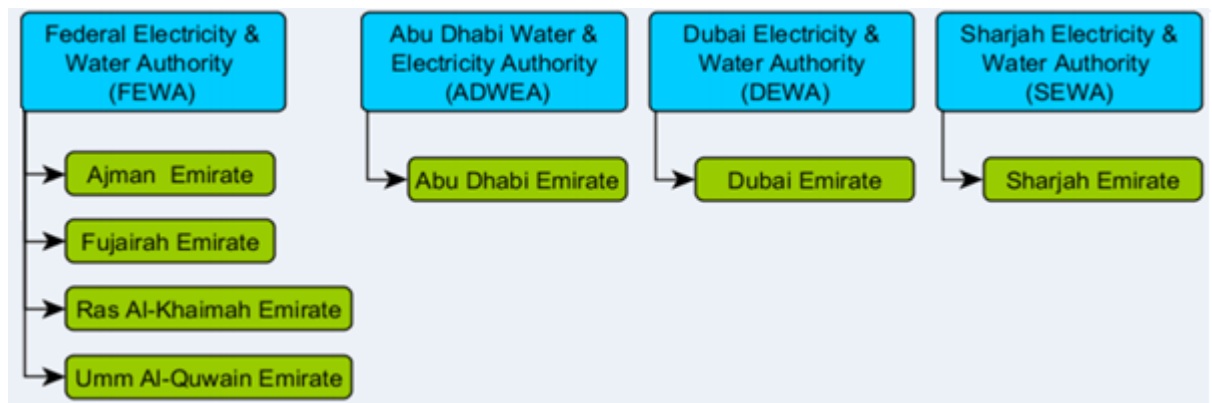
Emirates. Given the constitutional framework, each Emirate has in place the institutions, laws, regulations to manage its water resources (Water Conservation Strategy , 2010, p.xxi). At the same time, the Constitution does not give a clear indication with regards to the responsibilities for water conservation and water demand management. It mentions in Article 23 that “Community” is “shall preserve and utilize in a good way those resources and wealth for the interest of the national economy” (United Arab Emirates Constitution, 2013, p. 56). According to the UAE Water Conservation Strategy, the responsibility for water conservation and demand management was taken by the Federal legislature and executive through Federal Law (24) 1999, with responsibility being given to the Ministry of Environment and Water. In 2016, the UAE leadership expanded the role of the Ministry of Environment and Water, to manage all aspects related to international and domestic climate change affairs. The newly established Ministry of Climate Change and Environment addresses the issue of climate change, through the implementation of comprehensive policies and initiatives to mitigate and adapt to climate change and protect our unique environmental systems. (Ministry of Climate Change and Environment. <http://www.moccae.gov.ae/>)

The UAE’s water governance structure encompasses formal institutions, laws and stakeholders. Formal institutions follow definite procedures and have legal implication. At the same time, the researcher will also consider the role of informal institutions such as misuse of water and changing consumer behavior. In this case, the researchers will consider societal norms which do not have any legal implications. It is important for both formal and informal institutions to work together so the efficiency of water governance is increased.

2.5 Institutions

At the federal level, the Federal Electricity and Water Authority (FEWA) provides service to the four northern emirates (Part of Sharjah, Ajman, Ras Al Khaimah, Umm Al Quwain and Al Fujairah). At the sub-national level, the water and electricity authorities of Abu Dhabi, Dubai and Sharjah service their own emirates (Saif, 2012, p. 12) (See Figure 2). It is important to note that in the UAE, as well as in the rest of the GCC countries, water and electricity generation are interconnected. This is because seawater desalination technologies require heat to separate seawater into two streams – a freshwater stream and a brine (salt) stream¹(Saif, 2012). I will discuss in greater detail seawater desalination in the next chapter as it is the primary source of water for UAE.

Figure 2: Water and Electricity Authorities



Source: Saif, 2012, p. 12

¹ Desalination processes include Multi-stage Flash distillation, Multiple-Effect Distillation (MED), and Reverse Osmosis.

2.4.1 Federal Electricity & Water Authority (FEWA)

FEWA was established in 1999 under the Federal Law No. 31 to address the electricity and potable water needs of the Northern Emirates. According to the FEWA website, its main objectives that relate to water governance include to manage the demand for desalinated water efficiently to meet the needs for customers and to rationalize the use water and reduce wastage to ensure sustainable development. (Federal Electricity and Water Authority)

2.4.2 Abu Dhabi Water and Electricity Authority (ADWEA)

ADWEA is owned by the Abu Dhabi government. ADWEA is not only responsible for sustainability of water and electricity but also for the efficiency of production, distribution and consumption of water and electricity methods. ADWEA is participating within the government of Abu Dhabi in initiatives in managing the demand side and to optimizing the need in reducing the cost and diversifying the source of that water to improve the security (Abu Dhabi Water and Electricity Authority , 2016).

2.4.3 Regulation and Supervision Bureau of Abu Dhabi (RSB)

In addition, the Emirate of Abu Dhabi created the Regulation and Supervision Bureau of Abu Dhabi (RSB). The purpose of this bureau is to regulate water, waste water and electricity for the emirate of Abu Dhabi. The bureau's main function or responsibility is to ensure that sector licensees comply with the regulations, codes and standards set by them. The UAE Water Conservation Strategy views the RSB as a good governance model to follow because of its independence and transparency (Water Conservation Strategy, 2010, p. 62)

2.4.4 Dubai Electricity and Water Authority (DEWA)

DEWA was formed on January 1, 1992 by merging Dubai Water Department and Dubai Electricity Company. Since then, DEWA has made considerable achievements to be ranked as one of the best utilities in the world. As DEWA notes on its website, it is committed to a long-term sustainable future for delivery of electricity and water to the Emirate of Dubai. (Strategic Direction)

2.4.5 Sharjah Electricity and Water Authority (SEWA)

SEWA provides reliable services of water, electricity and natural gas to the entire emirate of Sharjah. One of SEWA's strategic objectives is to promote water and energy conservation awareness for its 2 million consumers. (SEWA Vision 2020, n.d.)

2.6 Laws

There are several legal frameworks that affect water governance in the UAE. At the international level, the UAE is signatory to several international conventions that have implications on its water conservation and water governance such as the UN Framework Convention on Climate Change, the UN Convention to Combat Desertification, and the Kyoto Protocol. The UAE is also signatory to regional agreements such as the Kuwait Regional Convention on the Protection of Marine Environment and Pollution and the Convention on the Conservation of Wildlife and its Natural Habitats in the GCC Countries (Water Conservation Strategy, 2010, p. 57)

At the federal level, there are a range of laws and decrees that have an impact on water conservation and water governance. The most important law is Federal Law

No (24) 1999 Protection and Development of the Environment. It covers various areas that affect water management. These include environmental assessments and protection; environmental monitoring; protection of the marine environment; polluted water discharges; protection of drinking water quality from storage tanks; handling of dangerous substances; and, natural reserves (Water Conservation Strategy, 2010, p.30)

2.7 Stakeholders

There is a range of stakeholders that are implicated in water governance. These stakeholders can be grouped into three broad categories: government, society, and business.

Government stakeholders include both federal and emirate level government entities.

Society includes the general public, the media, and environmental organizations.

Business includes industries and the financial sector as well as those institutional investors in water supply (e.g., desalination plants).

2.8 Research methodology

The thesis uses primary and secondary data as well as quantitative and qualitative data in order to analyze water governance in the UAE. The evidence collected includes:

1. Documentation from relevant sources
2. Published quantitative data

3. Semi-structured interviews with key officials involved in water security governance which were conducted from February to March, 2016 (see Appendix A for list of participants)

4. Collection of UAE water consumption data

For the qualitative data, audio recordings the interviews were transcribed, summarized and analyzed. Confidentiality and anonymity of all the interviewees were guaranteed to encourage accurate and full disclosure.

Secondary data – both quantitative (water consumption data of the UAE) and qualitative (interview) – will also be examined to validate the findings.

2.8.1 Research philosophy, approach and strategy

The research philosophy was to conduct semi-structured interviews of various officials in the water departments of the UAE and combine it with quantitative data collection.

This philosophy was chosen because it allowed for an emphasis on qualitative observations backed by published data on water consumption, which allowed for statistical analysis of the usage of water in the UAE.

2.8.2 The sample and its construct

The sample group included Heads and officials of Governmental Institutions and Policy Advisors (see Participant Codes). These Heads and officials of Institutions have experienced the role of change agents and have been responsible for leading change projects as part of their role. They are managers from the different government entities and have sound knowledge of the policies and procedures that are being implemented to tackle issues relating to water conservation and

consumption. Senior policy advisors were interviewed to know their insights on the same issues faced by their organizations.

All the sample individuals have worked in the same field and are well versed in the same context and have had the same level of interaction with senior managers as well as interaction with other Ministry departments cross functionally, however, with some variation with regards to the intensity of exposure at the local, state and federal levels.

Interviewing managers within the same context was important for data analysis, as this allowed the researcher to reach conclusions about the context that influenced them structuring their policies. The point of the same context, but within varied work environments meant listening for feelings (and frustrations) about their experiences in implementing policies with other member organizations and using that data in the analysis process. This context was particularly important for the analysis as stated from the introduction in the research objectives.

Along with the targeted interviews, the researcher collected all the published water consumption data that was available, as well as requested the individuals to submit any data that they were able to share.

2.8.3 Approaches to data analysis

The researcher first contacted the interviewees and explained to them the scope of the research study and attached a sample questionnaire. In doing so, first, the researcher described the activities and meanings of the participants and then derived the concepts that would form the basis of an understanding or an explanation of the research focus.

Hence, the opinions and policy practices of the participants constituted the subject matter of the research and these were then grasped and articulated by the researcher to provide a description of their impact within the context of the published water consumption data.

I would like to note that during and after the interviews, field notes taken down to capture the impressions helped me to focus and continuously evaluate what the interviewees said. The interviews were transcribed one by one, which helped in the thinking process before identifying the data to be selected from the interviews for analysis. This allowed the researcher to highlight points worthy of attention, such as emphasized statements or words repeated for emphasis. The researcher's attempt to take a 'holistic approach' – helped to 'grasp basic themes or issues in the data by absorbing them as a whole rather than analyzing them line by line.

2.8.4 Getting ready for conducting the interviews

First, the researcher compiled themes from the literature on water governance issues while going back and forth between the literature and the research questions. Then the researcher compiled the question and contacted nine officials to check their reactions to the interview, in terms of understanding the focus of the interview, on one hand, and understanding the questions, on the other hand. The researcher particularly meant to anticipate how to position the questions to derive themes from the respondents' answers that are relevant to the research questions.

The researcher learned from these initial meetings that showing the assurance of anonymity of the interviews up front was pivotal in clarifying to the interviewees the purpose of the interview. It was found that although the researcher explained the

purpose of the interview, the understanding was only secured after the researcher took them through the consent document that contained the purpose of the interview.

All interviews lasted about three hours each. The researcher learned, as well, that the respondents can drift away from the focus of the questions as they reflect on things that matter most to them. However, that was sometimes very important for the researcher's purpose because, for example, the way they discussed a point revealed what they value were the critical issues of water management and the ways to tackle them.

2.8.5 Conducting the interviews

The researcher conducted semi-structured interviews to capture the interviewees experience along the broad themes that came out from the literature review. Meanwhile, the researcher listened carefully to probe further in areas of their concern that could add new perspectives, however, within the boundaries of the research question.

Questions for Semi Structures Interviews:

1. In your view, what are the most important factors that affect water security in the UAE?
2. Which areas of the UAE are most at risk of water shortages?
3. Which is most likely to be affected human, domestic or industrial consumption? In your opinion why?
4. In your opinion, how is potential water security in the UAE linked to the increasing population?
5. In your opinion is there a correlation between potential water shortages and pollution and if so why?
6. Does climate change play a role in water security, if so, why?
7. Are you aware of similar forecasts of water shortages in other GCC countries? If so, how dos this compare to the situation in the UAE?

8. Which of these factors in your opinion need to be addressed in the short term and which require long term solutions?
9. How have you and your organization addressed these factors? How is your organization planning to address long term factors?
10. What are the key challenges and opportunities involved in addressing these factors? In your opinion, which policies have worked and which ones have not?
11. What specific policies need to be implemented?
12. What would you recommend as a government strategy to address water scarcity issues in the UAE? In the next 5 years? In the next 10 years?
13. In your view what role if any, will technology play in any short or long term solutions to the issue of water shortages?
14. Would you be able to share with me data or other documents related to this topic?
15. Who else would you recommend I speak to?

Thus, the probing questions were used to get more details on a particular issue or concern or empirical data that was important for the research question. In this study, the interviews were used to gather information that brought up particular insights about the respondents' experience in his particular Ministry or department. Moreover, the interviews were particularly helpful in that study because the aim was to look for the insiders' experience in tackling the issues that their particular department was responsible of supervising.

The semi-structured interviews were helpful in the study because of the potentially different experiences of the interviewees in the sample. This entailed

some flexibility in adding questions to seek further clarifications on a particular point of interest that would add meaning to the data collected.

The data collected from these interviews was used not only to understand and reveal the ‘how’ and ‘what’, but also to place more emphasis on exploring the ‘why’. Building on the study findings the empirical data available was analyzed.

2.8.6 Organizing a thinking process to run the interviews

First, the researcher thought of the interview in terms of specific topic areas and formulated the questions in a way that would help answer the research question. Then, the researcher created a certain amount of natural order on the topic areas, so there was a smooth flow of questions along those topic areas. Meanwhile, the researcher was prepared to alter the order of the questions, or skip certain ones, during the actual interview to match the flow of the answers.

More often, the respondents were elaborate enough and covered a question that the researcher planned to ask anyways. The researcher used open questions that could yield flow of ideas from the respondents without imposing a specific point that she would focus on. Not only did this technique allow the researcher to have an open mind to listen to themes that may not have been thought of while reviewing the imperial data but it, also, made the researcher go back and examine how the interview covered a particular pattern that came up in the data analysis.

However, at certain points in time there was a need for a closed question to clarify a vague reply and put responses into the right perspective. The researcher avoided leading questions to control bias for concepts or ideas that may be against the respondents’ themes.

It was, also, made clear to the respondents at the outset of the interview that the researcher was open to listen to any issues that they thought were important to them. This helped collect rich data that could be analyzed for meaning within their data context.

2.9 Quantitative analysis

The researcher collected data for the quantitative analysis from various government and water authorities. These authorities included the Federal Competitiveness & Statistics Authority, ADWEA, DEWA, SEWA, and FEWA.

The data included published water consumption statistics from the years 2005 – 2015 (10 years). The collected data is organized into:

1. Population growth data
2. Authority wide consumption data
3. Sector wide consumption data

The collected data helps support the analysis of water consumption in the UAE and the challenges the UAE faces in water governance. Population growth data is used to examine the effect of population growth on water consumption. The increasing population growth puts pressure on water security and on the provision of adequate water supply by government authorities

The authority and sector wide data was collected to analyze the increase in water consumption. Based on the data collected, there is a large increase in consumption especially in the residential and agricultural sectors. The data was divided to two sectors because it was difficult to disaggregate some of the data collected from other sectors.

2.10 Research limitations

The limitation of this research approach includes possible bias from the data collected from qualitative interviews as well as inaccurate water consumption data. A small number of interviewees were selected for the qualitative data collection. As a result, these senior officials and academics may share common views and approaches to the challenges to water security in the UAE.

With regards to the quantitative data, it was difficult to collect accurate data on water consumption in the UAE, particularly for the agricultural sector. Some of the data from one of the authorities was missing. It is therefore difficult to measure past and existing water consumption rates. In addition, the data gaps make it difficult for government authorities to plan for future water demand.

Chapter 3: Results and Solutions

This chapter is organized into two sections. The first section identifies key factors that have an impact on the UAE's water security and the second section evaluates the governance of water security in the UAE by drawing on the Organization for Economic Co-operation and Development's (OECD's) framework of principles on water governance. It discusses issues, solutions and initiatives in the context of OECD's broad principles of effectiveness, efficiency, and trust and engagement.

3.1 Factors that have an impact on water security

This section analyzes the results from the qualitative and quantitative data and explains how each factor impacts UAE's water security. Issues related to the governance of water security are identified with each factor.

Based on the evidence collected and the literature review, I have identified seven key factors that have an impact on UAE's water security and its sources for water consumption.

1. Geography
2. Climate change
3. Source of water in the UAE and their sustainability, including desalinated water
4. Water distribution network
5. Population growth and consumption
6. Sector-wide consumption and

7. Tariffs

3.1.1 Geography

The Arabian Peninsula, where the UAE is located, is extremely arid, dominated mostly by desert, and classified as a hot desert climate (BWh) under the Köppen climate classification (Saif et al., 2014). In the Arabian Gulf, rainfall is rare and irregular, averaging less than 100 mm/year for the region (Al-Mulla, 2011, p. 330). Considering UAE's geography and location, natural water resources are scarce (Interviewees 1, 2, 5, 6, 9, Al-Mulla, 2011). In addition Interviewees express that UAE does not have rivers, regular rainfall and sustainable water resources while at the same time, the UAE faces a high water evaporation rate of approx. 2000 mm/year and high evapotranspiration rate (Interviewees 1, 5 and 6).

One of the interviewees confirmed that the eastern and northern areas of the UAE have comparatively more rain than the interior parts indicating more infiltration which affects the water quantity in general (Interviewee 4).

3.1.2 Climate Change

Most of the Interviewees agreed that climate change has a negative impact on water security and noted its effect on the water cycle. Interviewees highlighted how climate change results in higher temperatures, less rainfall, higher evaporation rates, the rise of the seawater level, rise in sea temperatures, and extreme weather conditions. These interviewees confirmed how those natural conditions were difficult to deal with, manage their impact and respond to it effectively.

Rise in Temperatures

Interviewees indicated that the rise in temperature of 2 to 3 degrees Celsius will have an impact on water demand, particularly from the agricultural sector which requires irrigation water. Increase in temperature will increase the consumption, evaporation and evapotranspiration and thus more water is needed (Interviewees 3, 4 and 5). It will also have an impact on the general population's consumption patterns as well as on the livestock (Interviewees 2, 3, 5, 6, 8, 9). These conditions may result in water shortages if the supply of water cannot meet rising demand (Interviewee 6). Further, the rise in temperature will cause higher evaporation rates. According to Interviewee 3, this means that the salinity of the water in the UAE will gradually increase. The quality of the water that is desalinated will decline unless a new type of technology is integrated into the desalination process. Another interviewee noted that a rise in temperature could have a positive effect. With the increase in evaporation rates, this will lead to more rain in the hydrologic cycle (Interviewee 3).

Drop in Rainfall

Interviewees indicated that climate change will impact rainfall density and frequency, resulting in less annual rainfall. In the UAE, rainfall is already low but with climate change, UAE will receive even less rain, which will affect the availability of water resources in the long term. During the last twenty years, for example, from 1996 to the average rainfall in the country has dropped from about 110mm or 120mm per year to about 80mm per year. Less annual rainfall has an impact on the level and quality of natural water sources such as well-water and aquifers. According to one of the Interviewees the drop in rainfall causes a reduction in the recharge of groundwater. In addition, he note that without rainfall, the leaching process of pollutants, pesticides or other chemicals will not carried out and thus will cause contamination (Interviewee 5).

Rise in Sea Level

Interviewees also indicated that climate change has an impact on sea water levels. The rise in sea level could have an effect on the desalination plants since they are located on the coastline (Interviewees 2, 3). The efficiency in the production of water by these plants may be affected. A rise in sea water level may have an effect on coastal fresh water aquifers, which can affect the quality of water. The situation might worsen as the water table in the coastal aquifers declines, and is replaced by sea water (Interviewees 2, 5).

Rise in Sea Temperatures

Climate change also causes a rise in sea temperature. As a result, there have been several reports of large algal blooms. The phenomenon is called 'red tide' or 'brown tide'. The problem is that the algae releases toxins that are harmful to humans (Neuhaus, 2016). This large amount of algae reduces the oxygen levels in the water and hence, is unfit for both human and animal consumption. Red tides affect the performance of desalination by blocking the membranes of the desalination plant. Unless red tides affect the condition of the sea badly, the process of desalination does not get affected (Interviewee 1).

Extreme Weather Conditions

Climate change also causes an increase in the occurrence of extreme weather conditions. For example, with climate change, there will likely be more hurricanes, floods and other forms of sea water turbulence. These conditions will affect desalination activities and the water distribution infrastructure. In such cases, governments have to put in place emergency preparedness plans to address these types of emergencies (Interviewee 2).

3.1.3 UAE's sources of water and its water distribution infrastructure

Conventional sources are surface runoffs, falajes, springs, and groundwater from aquifers, while the non-conventional sources come from desalinated water from the seas and treated recycled wastewater.

Conventional Water Sources: Groundwater from Aquifers and Well-Water

Ground water is the main source of natural water resource in UAE. A continuous depletion in the ground water resource due to the over consumption of ground water resource (Interviewee 2) mainly by the agricultural sector is a one of the crucial factors affecting water security in UAE.

Although the entire UAE is at the risk of water shortage, the areas that are at most risk of water shortage are those areas that depend on natural water sources or that initially had wells (Interviewee 1, 3). One of the Interviewees indicated that Abu Dhabi faces the greatest risk of water shortage when compared to other areas of UAE because most of the groundwater is already salinized and all the reservoirs are exhausted (Interviewee 9). Today, UAE does not use groundwater for drinking purposes. This practice stopped more than 15 years ago (Interviewee 7).

Other areas in the UAE that are at risk are located near the shorelines where there are higher levels of saltwater intrusion (Interviewees 5, 9). When there is a decline in the ground water level, saline water intrudes and the ground water in all coastal areas may deteriorate (Interviewees 2, 5, 6). The eastern part of the country and northern part, generally have more rain indicating that there can be more infiltration and hence, feeding the water reservoirs. However, towards the internal part of the continent, amount of the rain is less, so the infiltration or the recharge is minimum which could affect the quantity in general (Interviewee 4).

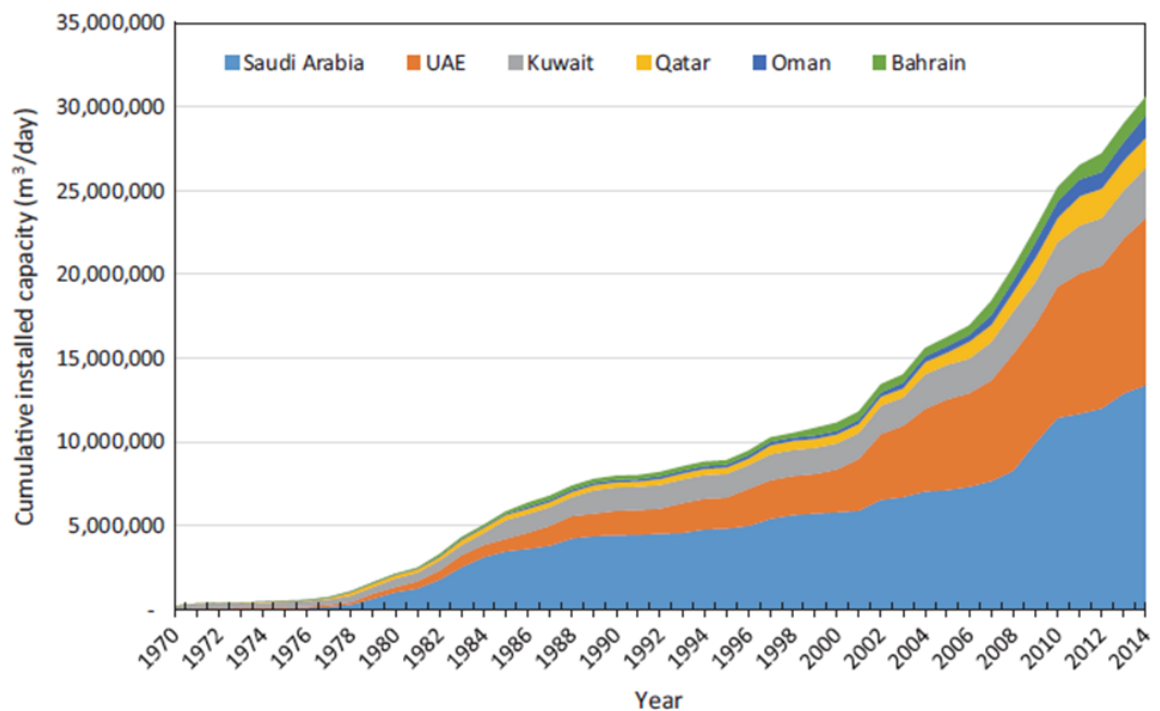
Interviewee 1 has worked in the water field for the last 25 years and was responsible for rigs and drilling. He indicated that in the 1980s, good groundwater was obtained from drilling 300 feet (91.44 meters) underground. However, today it would take about 1,000 feet (305 meters) of drilling to reach groundwater, and even then, the quality would be poor.

Ghoneim (2008) notes that groundwater can be an important source of water. However, new and innovative techniques need to be explored and implemented in order to improve the conservation of groundwater. Water basin water flow patterns need to be studied and the use of new techniques such as GIS and remote sensing should be applied to better study water content. For example, in Ar-Rafiah and Limbah water basins, technology can be used to locate and identify sources of water. This indicates that governments should be investing in researching conservation and water monitoring technologies. In effect, Ghoneim (2008) notes that these types of studies could help avert the possibility of water crises since groundwater patterns are being closely monitored.

Unconventional Water Resources: Desalination Plants

Due to the non-availability or scarcity of natural water resources in arid climates, governments have turned to sea water as a source for water. However, sea water needs to be first desalinated (removal of salt and other minerals) in order for it to be consumed by humans and animals. In fact, Middle East and North Africa account for 50% of the world's desalination capacity (Clean Energy Business Council, 2014, p. 3). Abundant sea water has there become a major source of alternate water supply for the GCC, as shown in Figure 3.

Figure 3: Cumulative installed desalination capacity in GCC countries since 1970



Source: Saif et al., 2014, p. 332.

UAE is highly dependent on the desalination of sea water as a major source for its water (Interviewee 1). Desalination has become the backbone for the water supply in all GCC countries with a daily desalination capacity having grown significantly across the GCC countries from 5 million cubic meters in 1970 to 30 million cubic meters in 2014 (Saif *et al.*, 2014). In fact, according to one of the Interviewees, 100% of the water that is used in the supply network in the UAE comes from desalinated water. GCC countries consume about 70% desalinated water of the worldwide capacity as shown in figure 3. USA, especially California and parts of Florida consume around 6.5% of the world wide capacity (www.desalinatedwater.info).

To ensure a secure water supply, the UAE government will spend US \$13.89 billion from 2012 to 2016 on desalination and distribution plants. The UAE has

several desalination plants that produce over 50,000 cubic metres on a daily basis as shown in Figure 4.

Figure 4: Desalination sites in UAE with a plant capacities over 50,000m³/day



Source: Saif, 2012, Appendix 2, UAE Country Profile.

Factors that Impact Desalination Processes

There are various factors which affect the process of desalination and in turn affect water security in UAE. As mentioned earlier, climate change has several effects on desalination processes such as changing the sea water level and its intrusion into coastal areas. As well, extreme weather conditions can impact desalination processes and distribution networks. In addition, the rise of algae due to increase in pollution in the water by discharging waste water in the sea can affect the performance of desalination by blocking the membranes of the plant (Interviewees 1, 2). In emergency cases, you need to ensure that there is a reserve water supply in place (Interviewee 7).

Pollution can also have an effect on the efficiency of desalination plants. For example, any type of chemical pollution, or natural pollution or oil pollution (Interviewee 2, 3). Water pollution in the Gulf region is the main factor which affects water security because most of desalination plants are located on the coastline.

Fuel shortages are another area that may impact desalination plants since they depend on energy for their production (Interviewee 8). Several Interviewees underlined the importance of good management of desalinated water (Interviewees 4, 5, 7) particularly in cases of emergencies.

Innovative Technologies to Improve Efficiency and Reduce Environmental Damage

There are several drawbacks associated with the use of desalination plants. These types of processes damage marine life. They also emit greenhouse pollutants and contribute to air pollution. They also are inefficient since they use excessive amount of energy for the desalination process. In addition, the disposal of the waste from the desalination process – or brine disposal – is causing environmental damage (Morillo *et al.*, 2014; Saif, 2012).

Given these negative effects of desalination plants, it is important to develop new technologies to improve their effectiveness and reduce environmental damage: e.g., new techniques for reducing the use of energy, which will, in turn, reduce the cost of desalination (Interviewees 2, 3, 6). In fact, GCC countries are using 10% of their primary energy for desalination (Clean Energy Business Council, 2014, p. 3). New technologies need to be developed to effectively dispose brine or to reuse it (Morillo *et al.*, 2014). More generally, technologies need to be developed to improve the so-called reverse osmosis (RO) process of desalination (Interviewee 8). The costs of desalination are high and these improvements will help reduce the costs while at the same time improving the efficiency of desalination plants.

3.1.4 Water distribution network

It is important to consider the effectiveness and efficiency of the water distribution network. The infrastructure for this network needs to be well developed to avoid water wastage (GCC, 2015, p. 4). UAE's Clean Energy Business Council (2014, p. 10) notes in its report, "the amount of non-revenue water i.e. water that is produced and lost in the region is 30 – 40% compared to international best practice of 10%. Infrastructure development is necessary in the region" (p. 10).

As one of the Interviewees indicated, sea water cannot deliver secure potable (drinking) water due to the content of high salt and unhealthy minerals. There needs to be a process in place to securely and safely transfer water to the customer. At the same time, the quality of the water has to be ensured and protected (Interviewee 3) (GCC, 2015, pp. 11-13).

Another Interviewee indicated that UAE's water transportation system has pipelines extending from Fujairah to Al Ain and from Fujairah to Abu Dhabi. In this distribution network, UAE is treated as one unit from a water security point of view. The infrastructure is considered to be very good and effectively meets the requirements of individuals (Interviewee 5).

3.1.5 Population growth and consumption

While the total UAE demand for water is gradually increasing and is currently estimated to be 4.5 BCM per year the UAE total renewable freshwater resources is relatively low at less than 150 MCM per year. It is assumed that should current demand pattern and rates continue, the UAE's total annual water demand is expected to double by 2030 to reach between 9 and 10 BCM (Al-Mulla, 2011). The sector of predicted greatest increase is in urban demand such as household,

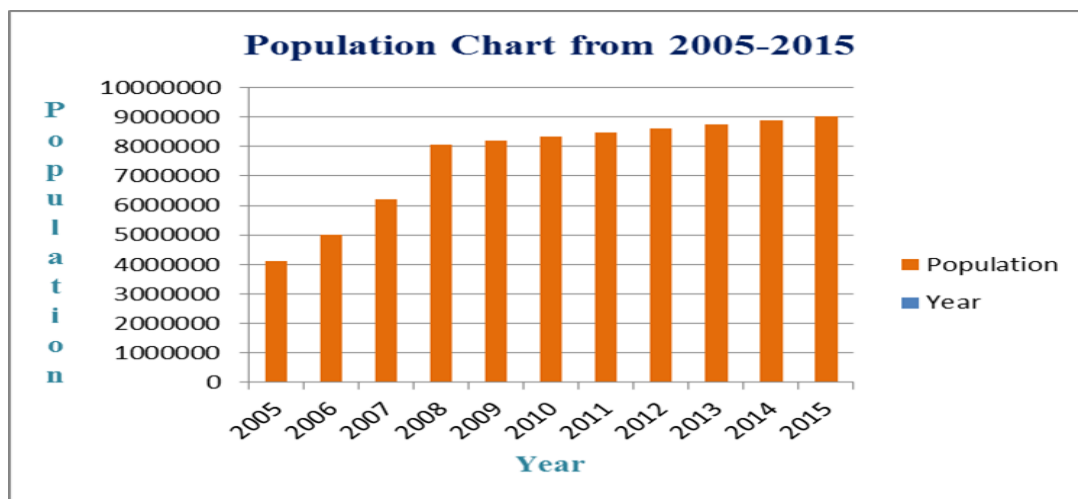
industrial, commercial, institutions and public facilities, resulting from population, industrial and commercial growth. Conversely, water demand for agricultural and forestry is expected to decrease relative to current values as a result of depleting groundwater resources, unless treated wastewater or desalinated water resources are used as alternative resources.

Interviewees indicated that the ability of the UAE to pursue its economic growth and meet the fundamental needs of the population will be threatened if water resources are not adequately managed (MoEW, 2014, Interviewees 1-5).

One of the major contributors is the population growth rate (page 4). Growth in populations increases pressure in the distribution mechanism for domestic, industrial and municipal uses (CEBC, 2013). Water is also required for agriculture and industrial usage. Population growth and the subsequent increase in the economic activities are the main reasons that affect the quality of conventional water resources along with increase in their demand (Interviewees 1, 3, 4, 6, 7 and 8) (GCC, 2015, pp. 3-4)

As illustrated in Figure 5, population of the UAE has increased at a steady pace over the last decade – from 4 million in 2005 to 9 million in 2015, as shown in Figure 5. Population growth rates have been relatively high, as shown in Figure 5. Rapid population growth exerts considerable pressure on the government to provide the necessary services in terms of water, electricity, health care, housing and other vital services.

Figure 5: Population growth in UAE from 2005-2015



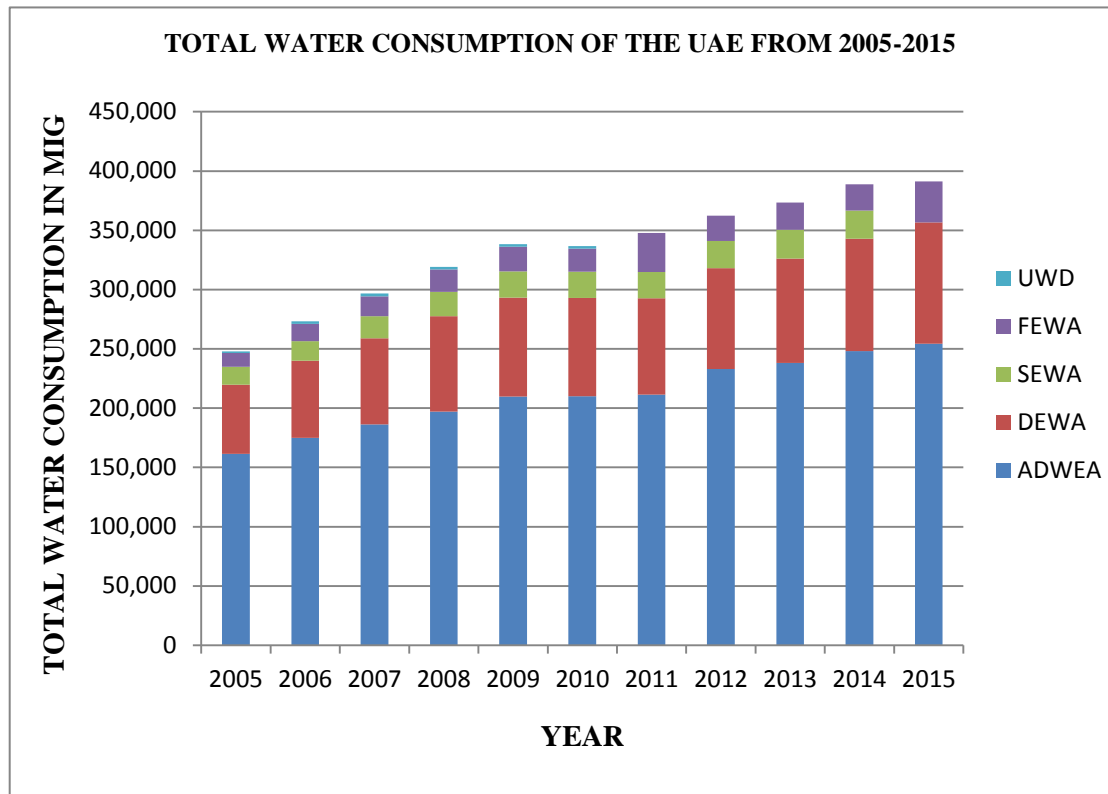
Source: Federal Competitiveness & Statistics Authority

Interviewees were concerned with the impact of population growth on water resources. They noted that population growth limits the amount of water that is available for usage per person. According to one of the Interviewees, projections show that per capita water availability is set to fall in the coming years (Interviewee 6). The future population growth will add to the stress and scarcity issues of water governance.

Water usage in Abu Dhabi and the emirates account for a large part of the total water usage. These two sources of consumption are growing rapidly, as evidenced in the rate of population growth in the UAE over the last ten years.

This rapid growth in population and water demands will expose situations that may lead to water shortages (Interviewee 6). This will lead to negative implications for health, quality of life and security (GCC, 2015, p. 4). Water consumption in Abu Dhabi is more than the other emirates and water consumption of all the emirates is increasing year by year as shown in Figure 6.

Figure 6: Total Water Consumption of the UAE from 2005-2015



Sources: ADWEA 2016, DEWA 2016, SEWA 2016, FEWA 2016.

Per capita consumption refers to the average consumption per person within a population. UAE has one of the highest per capita consumption of water which is 3-4 times more than the world's average (Interviewee 1, 2, 3, 5). This has been cited as the main concern by almost all the Interviewees regarding improper usage of water. According to Interviewee 6, the domestic sector of Abu Dhabi emirate alone consumes around 630 liters per capita which is 3 times the worldwide average use which is 180-200 liters per capita.

Bringing this enormous consumption to a normal level is not an easy task because human behavior is a real challenge here which will not change overnight and hence, it takes time for people to appreciate, recognize and the society to react in a positive way. It is happening but it is time consuming (Interviewees 1, 3, 4). The water consumption by human beings especially household and tourist places like

hotels where the foreigners – Europeans and Americans use more water than usual and also the agricultural activities, which do not take into consideration the scarcity of water which exists in UAE are the main issues related to high consumption of water in UAE.

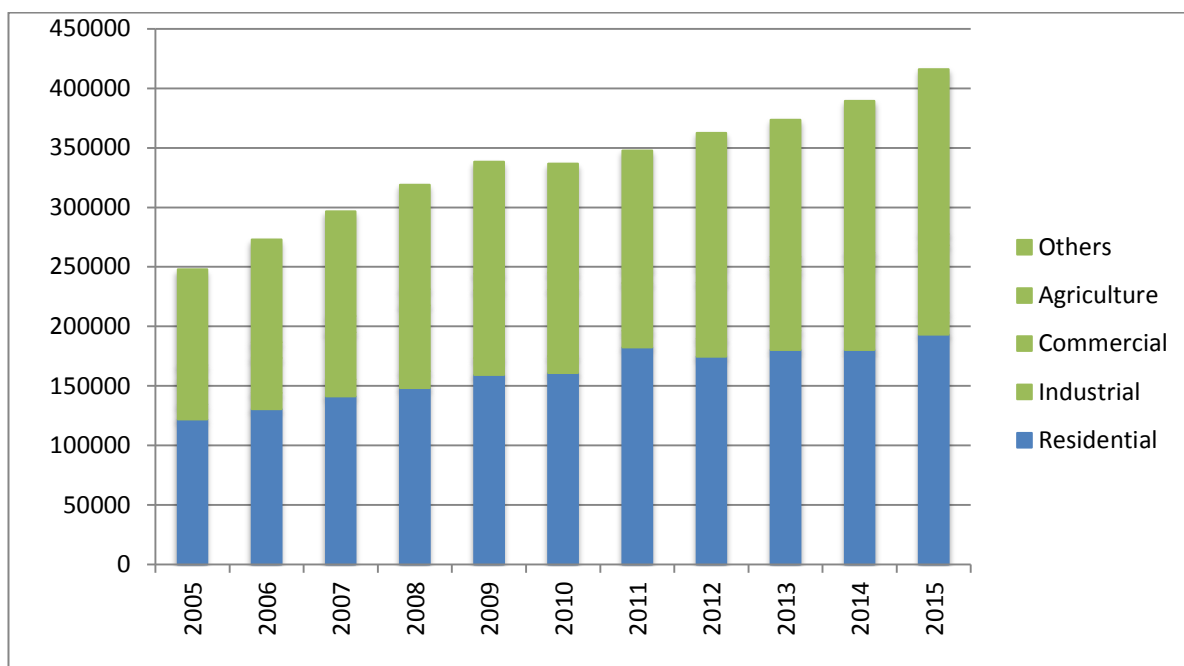
The key challenges are the awareness campaigns and the education campaigns for the society to optimize the water consumption (Interviewee 1). Educating the younger generation with regards to the consumption of water is of prime importance as it can make a huge difference in the future (Interviewees 1-9).

Another key challenge is that the responsibility of commitment to the environment is shifted to the government rather than on individual people. Although people support the campaign but they do not change their lifestyles to exercise commitment to the environment (Yaghi & Alibeli, 2016, p. 7).

3.1.6 Consumption by sector

The Interviewees agreed that the residential and other sectors that are the highest consumers of water, which includes for cleaning, gardening, washing etc. as shown in figure 7.

Figure 7: Sector Wide Water Consumption of the UAE: Residential and Non-Residential (2005-2015)



Source: Data was compiled from the following sources: FCSA, DSC, MOENR, ADWEA, DEWA, SEWA and FEWA 2005-2015

Agriculture and Green Lands Sectors

Despite its highly arid condition, the UAE has been able to develop a thriving agricultural industry. Modern irrigation techniques and water resources from groundwater aquifers, wastewater treatment plants and from desalination plants have made it possible for large areas to be cultivated. There are more than 100,000 hectares (Interviewee 9) of cultivated land producing a wide range of crops, including, vegetables, fruits and fodder.

However, agricultural development has come at a cost. Interviewees identified the agriculture and green land sectors as contributing to the large consumption of water in the UAE (Interviewees 2, 5, 6, 7, and 9). According to the interviewees, the sector consumes about 60%-80% of the total water supply.

Interviewees noted that agriculture development not only requires a large amount of usage, but it also is the most inefficient use of water. One of the key issues is water usage for agriculture is unregulated and not properly documented. This leads to unreliable data on consumption and usage (Interviewee 7, 9). At the same time, agriculture productivity is crucial to feeding a growing population. Another factor contributing to high water consumption is the expansion of green land. Green lands are developed as new cities or towns are built (Interviewee 5).

Interviewees indicated that there is scope for managing this growth in demand by improving water in the agricultural and green lands sectors. Governments need to focus on water consumption in these sectors given the hot environmental conditions and high evaporation rates. Interviewees recommended that technological investments need to be made to improve the conservation of water in these sectors. The use of treated wastewater in the agricultural sector can improve water sustainability in the UAE (Interviewees 2, 6, 8).

Industrial Development

Industrial production uses water for processing, cooling and disposal of waste materials (Interviewee 7). The industrial demand for water has been increasing steadily with the establishment of new industries.

Residential and Tourism Sectors

The residential and tourism sectors consume a large amount of water. Residential demand for water is influenced by various demographic factors: household size, consumption and lifestyle choices (www.moenr.gov.ae, 2014). A study undertaken by Abu Dhabi's Regulation and Supervision Bureau (RSB) indicated that the share of per capita water consumption in villas was about 3-9 times

the water consumption in apartments (Ministry of Environment and Water, 2010, p. xiii).

In general, the amount of water used by individuals in the residential sector will grow as incomes grow. For example, as workforce salaries increase, individuals have access to larger homes, with gardens and other water-intensive features. In addition, the presence of a large expatriate population may contribute to water wastage since there is less awareness of water security issues in the UAE.

There is a high consumption of water in the tourism sector. This is largely due the low cost of water that is supplied to this sector (Interviewee 1, 2). Furthermore, tourists are less likely to be aware of UAE's water scarcity challenges.

All interviewees agreed that there is an urgent need to improve water management in all of UAE's sectors (Interviewees 1-9). Under the current conditions, water is being wasted, and as long as people are not facing issues of water scarcity, they continue to believe that government should be providing access to water (CEBC, 2013). With increased economic development, population growth, urbanization and changes in lifestyle, water consumption continues to increase. Interviewees note that unless new policies are implemented, water shortages or limited access to water are likely to be experienced by the population (Interviewees 1-9).

3.1.7 Tariffs

As discussed above in this thesis, UAE will continue high consumption rate for residential, industrial and agriculture sectors. It is therefore important to use method to control water consumption. One such method is the rise of price (tariff) of water.

In most sectors, the cost of water is subsidized. This means that consumers of water are not paying the market price for the water they consume. According to the UAE Water Conservation Strategy, in 2010, water use costs the UAE economy AED 18.2 billion (USD 4.96 billion). The Emirate governments subsidize the difference of almost AED 13.1 billion (USD 3.57 billion) (Ministry of Environment and Water, 2010, p. 42). Since water is provided at a relatively inexpensive price, consumers tend to consume more water, which has an impact on water availability (Interviewee 1).

In the long term, the UAE's government entities are planning to reduce the gap that exists between production cost of water and the selling price. Tariffs have contributed to bridging the gap between subsidized cost and real cost. Interviewees agreed that the tariff policies improve water security in the UAE (Interviewees 1-9). At the same time, there are losses since the tariffs are still lower than the real cost of water production (Interviewee 8).

On a positive note, water consumption has declined when tariffs were put in place. In 2014, Emiratis consumed 44% of the overall water consumption in FEWA. When a tariff was adjusted from 1 fils to 1.5 fils, consumption declined to 40%. There was a saving of 4% of water within six months. As one of the interviewees noted, this decline in water consumption is a good indicator that water costs do have an impact on water demand (Interviewee1). However, it may be difficult to obtain accurate data given the multiple authorities involved in water governance in the UAE. . The researcher believes that in the long run, this rate needs to be increased given the rise in water consumption rates.

Interviewees recommended that more stringent measures be put in place to control water consumption because UAE has one of the highest per capita

consumption in the world. They also noted that the pricing mechanism should be revised from time to time in order to reflect to changing water supply conditions. They also recommended that organizations responsible for high water consumption levels should be fined. They recommended that water consumption monitoring technologies should be put in place (Interviewees 1-9).

3.2 UAE's governance of water security: applying the principles of water governance

As noted in Chapter 2, I base my analysis of UAE's governance of water security by drawing on the OECD's principles of water governance. These involve three broad principles of efficiency, effectiveness, and trust and engagement. When it comes to good water governance and water security, the Interviewees noted that unlike oil, there is no alternative for water. Water is a finite resource which sustains life and all its activities. It is therefore essential that government organizations prioritize issues of governance and uses that will ensure the future viability and sustainability of water resources (Interviewees 1-9). To this end, the water governance system should target the following goals; effectiveness, efficiency and trust and engagement.

3.2.1 Effectiveness

The effectiveness of water security governance involves processes and policies that define clear sustainable policy goals and that target all levels of governance. Effectiveness also entails implementation and meeting expected targets. There are four key sub-principles involved: (1) Setting clear roles and responsibilities; (2) managing water at appropriate scales within an integrated

system; (3) encouraging policy coherence across sectors; and, (4) adapting capacity to complex challenges and water sustainability.

(1) Setting clear roles and responsibilities

Interviewees pointed to several challenges that hinder the effectiveness of good governance of water security in the UAE. From a water security point of view, Interviewees indicated that the entire UAE is considered as one entity (Interviewees 1, 2, 5, 8). However, the governance of water security is not managed or implemented centrally or in a unified manner given UAE's federal structure and the decentralized nature of governance. Fragmentation among various water units leads to ineffective management of water resources, which adds to the strain of scarce water resources. In a similar vein, UAE's Water Conservation Strategy noted that "fragmentation exists that is likely to cause inefficiencies and ineffectiveness" (Ministry of Environment and Water, 2010, p. 64).

(2) Managing water at the appropriate scale or scales within an integrated basic governance system.

Interviewees noted that an integrated approach to water security balances the demand for water from various user sectors and the supply from all the available resources (Interviewees 2, 7). Because of the diversity in water resources, it becomes very important to properly manage them in an integrated manner (Interviewee 5). At the same time, mismanagement of water resources is an important factor that affects water security in the UAE (Interviewee 6). One aspect of integrated water management is to have a policy for treated wastewater and how its use can be maximized.

Interviewee 2 noted that an integrated approach to water security addresses issues of emergency conditions and sustainability of desalinated water as mentioned

earlier in emergencies such as natural disaster, UAE experience the water shortages. He emphasized that there is an urgent need to address this particular aspect to water security in order to mitigate any risks in an emergency. In addition, Interviewees raised the issue of developing strategic water reserves (Interviewee 5, 9).

The UAE government has recognized the importance of conserving environment resources as an important foundation to its development policies for present and future generations. Through national legislation that targets environmental issues, the UAE is also involved with several regional and international protocols, including the high profile Kyoto Protocol since 2005. The UAE government has implemented initiatives that encourage long-term sustainability of water resources through its Water Conservation Strategy and the Aquifer Storage and Recovery project (ASR). The aim of the ASR is to develop a sufficient capability for domestic water supply to serve Abu Dhabi and Dubai and the surrounding area for up to 90 days at a daily rate up to 40 MIGD (Million Imperial Gallons Per Day), the water would be reserved for use in case of an emergency (Al-Mulla, 2011).

One of the Interviewees established a National Water Center (<https://www.uaeu.ac.ae/en/nwc/>). The center conducts research and activities in integrated water management. It addresses a range of aspects related to the ecological quality, ground and surface waters, the development of suitable technologies for treating wastewater and water for human consumption and irrigation.

(3) Encouraging policy coherence across sectors

The effective governance of water security requires coordination across ministries, public agencies, and levels of government. Interviewees raised the issue of the lack of integration across different entities in the water sector, which leads to difficulties in achieving policy coherence (Interviewees 1-9). Interviewees indicated

there are several federal and local government authorities looking after water resources and hence, co-operation and support is needed from all the government entities, stakeholders, private authorities, stakeholders and end users (Interviewee 3, 9). Despite the fact that the country's economy is growing exponentially, Interviewees noted that there is a lack of communication between water entities. Interviewees indicated that this leads to poor handling of water resources. Interviewees noted that this remains a major concern (Interviewees 1-9).

Effectiveness involves putting in place mechanisms to encourage coordinated management of supply and demand of water. As noted earlier, the UAE is controlling water consumption through price mechanisms such as tariffs. Given that agriculture and green lands continue to be the highest water-consuming sectors, the UAE's Water Conservation Strategy recommends a national agriculture policy aimed at conserving water.

(4) Adapting capacity to complex challenges and water sustainability

Building capacity involves innovating and integrating new technologies to improve the effectiveness of water security. The Ministry of Energy has developed the UAE water innovation strategy. It is a new approach launched by the PMO (Prime Minister Office) in which the Ministry follows up the different initiatives and projects related to the innovation strategy in the water sector (Interviewee 2). The UAE has different entities which consume water and affect the water structure and this has led to reshaping the governance of water in general (Interviewee 4). The researcher recommendation continues renovation to address the future changes of water consumption. This strategy is in early stages and the researcher cannot evaluate whether it will improve the conditions.

To address future demand challenges, new technologies need to be incorporated into the development of reliable sources of water supply. Desalination technologies used in UAE are the most advanced technologies available (Interviewees 2, 6, 8). Due to technological advancements, the costs of producing desalinated water have declined (Interviewee 1). The UAE has integrated the use of low cost desalination plants. The researcher recommendation continues renovation to address the future changes of water consumption.

The UAE is working towards addressing future challenges. One of the new initiatives involves the UAE water strategy 2036 project. This project aims to develop full-scale integrated solution to enhance the water security in the UAE. It establishes an interconnected system and strategic storage capacity between four major water suppliers in the country (Interviewee 2). The Ministry of Energy indicated that it is working with water and electricity authorities in the UAE to develop the 2036 water security strategy, which is expected to be released in the fourth quarter of 2016 (www.moenr.gov.ae, 2014).

3.2.2 Efficiency

In discussing the efficiency of the governance of water security, it is important to consider how the UAE maximizes the benefits of sustainable water management and welfare with the least cost to society. The key sub-principles include (1) producing and sharing data and information; (2) mobilizing and allocating water finances efficiently; (3) effective implementation of regulatory frameworks; (4) promoting innovative practices.

(1) Producing and sharing data and information

One of the key challenges to good governance that the Interviewees identified is the lack of reliable data. Data gaps hinder the capacity to produce evidence and research on water security (Interviewee 4). Data management is an important issue which can be resolved if all the different water institutions in the country function on a single data platform. However, the water governance structure has to be first redesigned by implementing an integrated water resource management approach (Interviewee 2). Therefore, in order to enhance the efficiency of water security governance, the UAE also has to address the effectiveness of its institutions and reduce fragmentation among the entities.

The researcher agrees with interviewee 9's proposal to create "digital water atlas of the UAE". The atlas would function as a database of all water resources, factors that contribute to water insecurity, water supply activities and consumption. By having one database combining a complex set of variables, federal and local governments can more easily identify the problem and find a solution for it. Knowledge based resource management backed by intensive research and forecasting will help in reducing the water scarcity issues be it natural or artificial.

(2) Mobilizing and allocating water finances efficiently

The UAE is addressing the public cost to water supply production in various ways. One approach is through the price mechanism. As noted earlier, Emiratis have reduced their water consumption as a result to the increase in water prices. Other approaches include more efficient desalinated water production through investment in new technologies. As the Interviewees noted, the use of desalinated water is costly and its use has an impact on the environment. The use of different technology like Reverse Osmosis (RO) for producing potable water other than the

combined power and water technology that are used in desalinated water will reduce water cost and subsequently reduce impact on the environment.

(3) Effective implementation of regulatory frameworks

The Interviewees indicated that there is a need to improve the existing regulation and legislation framework (Interviewees 4, 5 and 6). More specifically, the legislation framework has to address the different sources of water such as desalinated water, ground water, and wastewater (Interviewee 4). The UAE Water Conservation Strategy recommends the development of common regulations, standards, and specifications for economic, technical and environmental controls in order to address the governance of water security (Ministry of Environment and Water, 2010). According to interviewee 6, six initiatives have been implemented and are currently on-going. Some of these initiatives will complete by end of year 2016 and some will be completed in the year 2017. Two initiatives are pending to implement due to budget constraint.

(4) Promoting innovative practices

According to one of the Interviewees, several studies and projects consider the inter-connection of the emirates in order to coordinate water management. These studies are not limited to the national level. A regional approach to water management is also being studied. For example, one of the options is to develop a common GCC water supply grid (Interviewee 7) by inter connecting water supply lines within the GCC.

Interviewees proposed several solutions to improve the supply of water. They noted that is important to diversify the sources of water. They recommended continuous research to find more eco-friendly and economic solutions to supply and desalinate water (Interviewees 3, 4, 5, and 8). According to one of the Interviewees,

Masdar is developing new technologies for water desalination and undertaking pilot studies. At the same time, there is also a need to invest in the use of innovative technology for demand management (Interviewee 2),

3.2.3 Trust and engagement

In examining trust and engagement as a good principle of water security governance, it is important to consider the processes involved in building public assurance and safeguarding the inclusiveness of stakeholders through legitimacy and fairness for society as a whole. The key sub-principles include (1) mainstreaming integrity and transparency practices; (2) promoting stakeholder engagement; (3) encouraging water governance frameworks that help manage trade-offs across users, rural/urban, and generations; and (4) promoting monitoring and evaluation of water policy and governance.

(1) Mainstreaming integrity and transparency practices

According to the UAE Water Conservation Strategy, the laws, regulations, standards and their enforcement should give direction, transparency and clarity in many areas such as in responsibilities, roles, and standards for a particular environment or sector (Water Conservation Strategy, 2010, p. 57). However, there is a lack of transparency in water governance standards. For example, standards for desalination plants are not clear. The problem stems from the lack of coordination in setting standards (p. 182). There is also a lack of transparency when it comes to reporting local capital expenditures on various water infrastructure projects (p. 153). This hinders the collection of relevant data on the cost of water development at the national level.

(2) Promoting stakeholder engagement

All the Interviewees indicated that water conservation and consumption should be integrated into the school curriculum. There are several initiatives that educate the public and create awareness about the value of water. For example, schools were part of an education campaign to decrease water consumption. The campaign involved prizes to those schools that were able to decrease their water consumption the most. Another educational campaign involves field visits to desalination plants. These visits help children gain a better understanding of the cost of water production. These types of awareness building program can help to change behavior and can bring positive societal change (Interviewee 1).

Educated people are more aware and more willing to pay extra money to protect the environment and also older people to be less willing to pay than young people (Yaghi & Alibeli, 2016, p. 5).

Another aspect to water conservation is to ensure that homes have efficient fixtures and appliances that are water efficient (Interviewees 1-9). This requires raising awareness among building developers and households to ensure that these types of fixtures are installed. A third area involves promoting the use of treated wastewater. The UAE Water Conservation Strategy emphasize that it is important to raise awareness on water reuse, particularly among farmers and the public (Water Conservation Strategy, 2010, p.30). Studies show that there is an increase in water consumption in residential villas. The reasons for the use of expensive desalinated water include watering gardens and washing cars. The consumption of water for such uses can be replaced with water of a lower quality, such as treated wastewater (Water Conservation Strategy, 2010, p. xiii). Consumers need to be made aware that there are different types of water and these can be used for different purposes.

(3) Encouraging water governance frameworks that help manage trade-offs across users, rural/urban, and generations

In order to improve the governance of water security, trade-offs have to be made across users. For examples, farmers should be encouraged to reduce their use of groundwater and desalinated water for irrigation by replacing it with treated wastewater. The public needs to be made aware that the use of desalinated water for washing cars is wasteful and encouraged to use treated wastewater for this type of use. Government should carry out awareness campaign on regular basis to educate the people on how to effectively use the water.

Other trade-offs include raising the price of water on consumers of water to encourage a decrease in consumption. At the same time, there needs to be water management policies for the industrial and agricultural sectors (Interviewees 4, 5, 9). Interviewees indicated that a reduction in the per capita consumption or demand management can solve most water issues (Interviewees 1, 3, 4, 5, 7).

(4) Promoting monitoring and evaluation of water policy and governance

UAE's Vision 2021 National Agenda focuses on improving the quality of air, preserving water resources, increasing the contribution of clean energy and implementing green growth plans. The UAE has incorporated a Water Scarcity Index as an indicator for preserving its water resources. This index monitors fresh water usage (including surface water, renewable water and fossil water) as a percentage of overall renewable water in the UAE. The result is weighted to take into account desalination and wastewater treatment. (Sustainable Environment and Infrastructure, 2016) The Water Scarcity Index indicator is an important step towards the monitoring of water security at the national level. However, the effective measures to

be taken to minimize the water security with the findings of Water Scarcity Index indicator is not implemented fully.

Tables 2, 3, and 4 summarize the study's evaluation of UAE's water security governance based on the OECD's principles of good governance. Table 2 sets out the key areas that need improvement in the area of effectiveness; Table 3 sets out the key areas that need improvement in the area of efficiency; and Table 4 sets out the key areas that need improvement in the area of Trust and Engagement.

Table 2: Effectiveness

Effectiveness Keys	UAE Status	Evaluation
Setting Clear roles and responsibilities	<ul style="list-style-type: none"> ▪ The governance of water security is not managed or implemented centrally or in a unified manner given UAE's federal structure and the decentralized nature of governance. 	Needs improvement
Managing water at the appropriate scales	<ul style="list-style-type: none"> ▪ The diversity in water resources, it becomes very important to properly manage them in an integrated manner. 	Needs improvement
	<ul style="list-style-type: none"> ▪ The UAE government has recognized the importance of conserving environment resources as an important foundation to its development policies for present and future generations. 	Good
Policy Coherence	<ul style="list-style-type: none"> ▪ Co-operation and support is needed from all the government entities, stakeholders, private authorities, stakeholders and end users. 	Needs improvement

Capacity	<ul style="list-style-type: none"> To address future demand challenges, new technologies need to be incorporated into the development of reliable sources of water supply. Continued renovation to address the future changes of water consumption needs to be encouraged. 	Need improvement
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Table 3: Efficiency

Efficiency Keys	UAE Status	Evaluation
Producing and sharing data and information	<ul style="list-style-type: none"> Data gaps hinder the capacity to produce evidence and research on water security. 	Needs improvement
Mobilizing and allocating water finances efficiently	<ul style="list-style-type: none"> The UAE is addressing the public cost to water supply production in various ways. One approach is through the price mechanism. 	Needs improvement
Effective implementation of regulatory frameworks	<ul style="list-style-type: none"> Need to improve the existing regulation and legislation framework. 	Needs improvement
Promoting innovative practices	<ul style="list-style-type: none"> To find more eco-friendly and economic solutions to supply and desalinate water. 	Needs improvement

Table 4: Trust and Engagement

Effectiveness Keys	UAE Status	Evaluation
Mainstreaming integrity and transparency practices	<ul style="list-style-type: none"> ▪ Lack of transparency in water governance standards. 	Needs improvement
Promoting stakeholder engagement	<ul style="list-style-type: none"> ▪ Water conservation and consumption should be integrated into the school curriculum. 	Needs improvement
Encouraging water governance frameworks that help manage trade-offs across users, rural/urban, and generations	<ul style="list-style-type: none"> ▪ In order to improve the governance of water security, trade-offs have to be made across users. For example, increasing tariffs on water consumed by the residents of UAE. At the same time, there needs to be water management policies for the industrial and agricultural sectors. 	Needs improvement
Promoting monitoring and evaluation of water policy and governance	<ul style="list-style-type: none"> ▪ The Water Scarcity Index indicator is an important step towards the monitoring of water security at the national level. 	Needs improvement

Chapter 4: Recommendations and Conclusion

4.1 Recommendations

Improving effectiveness and efficiency

1. Unified water strategy

In order to improve the effectiveness of the governance of water security in the UAE, I recommend continuing the implementation of a Unified UAE Water Strategy. This strategy would be similar to the ongoing project of GCC Unified Water Security Strategy. In this way, the UAE can address the problem of fragmentation across the various institutions responsible for water governance. A Unified UAE Water Strategy will ensure better co-ordination among the authorities of all the emirates.

2. Integrating Policies across Authorities to Achieve Policy Coherence

In order to improve effectiveness of the governance of water security in the UAE, my second recommendation is to have policy coherence by integrating across different authorities in the water sector of the UAE so that the issue of lack of co-ordination among UAE entities can be addressed in a proper manner. This recommendation is in line with the GCC-Unified Water Strategy which emphasizes improving the governance in the water related sectors in each GCC country.

3. Centralized Water Data Center

My third recommendation improves the efficiency of the governance of water security. I recommend establishing a common center that deals with all the water related data for the entire region of the UAE. Instead of data being scattered and divided among the different authorities such as ADWEA, DEWA, FEWA and

SEWA, there needs to be one joint authority that is responsible for water data collection. The data collection also involves proper mapping of both water supply and water demand. The UAE must have a reliable measure of the consumption of water at any given moment; otherwise, it may risk water shortages. This is particularly worrisome in cases where there is an emergency.

According to the FEWA data that researcher analyzed, there is a consistent shortage of about 4,000 MIG per year from 2004 to 2010. This means that during those years, FEWA may not have counted the consumption of a certain sector or Emirate (e.g. Sharjah). Because of the missing data, the exact picture of the usage of water could not be concluded. The issue of Ministries not having complete data definitely leads to a strong recommendation that more efforts can be put in ensuring that the consumption of all the emirates is mapped correctly.

4. Reducing water leakage

In order to improve the efficiency of governance of water security in the UAE, the fourth recommendation addresses the urgent need to reduce or stop the leakage of water and water wasted unduly in the daily tasks. The concerned water authorities of the UAE should also record and report the amount of wastewater consumed by them and the amount of water leakage or wastage in their respective region so that when accountability increases, stringent measures are put in place. This recommendation is in line with the challenges mentioned in the GCC-Unified Water Strategy.

5. Researching new technologies for water desalination plants

The fifth recommendation involves researching and investing in new technologies in order to improve the effectiveness and efficiency of water desalination plants.

6. Common regulation and legislative framework

To improve the efficiency in governance of water security, my sixth recommendation is to establish a common regulation and legislative framework for the various authorities dealing with different sources of water in the UAE. The various water ministries, government authorities, semi-government authorities and private institutions related to the water departments should coordinate to develop the common regulation and legislation standards and specifications. This recommendation is also in line with the GCC Unified Water Strategy which proposes to improve the legal framework.

7. Continuing with Water Subsidy Reductions

My seventh recommendation is to continue with the present policy of reducing water subsidies in order that consumers are aware of the market price of water. This means that the government should continue with its policy of increasing water prices as this will result in a decrease in water consumption and a more effective approach to the governance of water.

Improving Trust and Engagement through Awareness Building

8. Information dissemination

My eighth recommendation addresses the issue of building trust and engagement across the various UAE populations and sectors. In order to improve trust and engagement in the water governance of water security, efforts need to be made to widely disseminate information about water usage and consumption. The UAE government and private organizations have adopted many educational consumer initiatives and programs. However, there is a need to include multi-lingual educational campaigns directed at awareness building among workers as well as the tourists in the UAE. This is also in line with the GCC Unified Water Strategy which

proposes to build awareness on the value of water and the importance of water conservation.

9. Educating farmers and public on the use of recycle water

To improve the governance of water security, my ninth recommendation is to educate and encourage farmers and the general public to use recycled water rather than using desalinated water. This will not only bring down the cost of water to the end user but also decrease the burden of production of new water. This is also in line with the GCC Unified Water Strategy which proposes to build awareness by targeting certain levels in society.

10. Incentives for water conservation and reduction of water consumption

In order to build the trust and engagement related to the governance of water security, the tenth recommendation proposes the implementation of incentives, awards and recognition. These incentives aimed at encouraging institutions and individuals to conserve water and reduce their consumption of water in order contribute to UAE's water security.

4.2 Conclusion

The main objective of this research study was to understand the challenges to the governance of water security in the UAE. The UAE consists of seven emirates, all of which are located in arid and hyper arid areas where natural water resources are scarce and in which there are very hot environmental conditions and high evaporation rates.

As explained in the study, there is a high dependence on desalinated water in the UAE. This study discussed the impact and extensive usage of desalinated water in the UAE. Securing the sustainability, quality, access, and efficiency of desalinated

water as a source of water remains one of the most important challenges for all water authorities in the UAE.

The research study discussed the effect of population growth and climate change on UAE's water security and the challenges these two domains pose to UAE's water security. In particular, the rapid increase in population has led to an increase in economic development – industrial and commercial activities certainly put pressure on the governance aspect of water security in the UAE.

The evidence gathered from documents and from interviews confirms that the UAE government is addressing the issue of water security through initiatives such as its Water Conservation Strategy. The interview data indicate that the UAE government has taken various initiatives to educate the different consumer segments mainly targeting the younger generation. However, as the research study points out and as the interviewees indicated, more needs to be done to ensure efficiency, effectiveness and trust and engagement in the governance of water security in the UAE. The study proposed ten recommendations for improving the governance of water security in the UAE. These recommendations were organized in terms of improving the efficiency, the effectiveness and trust and engagement in water security governance.

The study noted that it is important to continue with the implementation of a unified water strategy and the reduction of water subsidies by raising tariffs. The study also highlighted areas of improvement such as developing policy coherence across the various water authorities and creating a centralized data center, and the integration of technology to improve efficiency demand and supply management of water.

Both primary and secondary resources emphasized the notion that there is a strong relationship between the water and electricity sectors of the UAE and hence, they cannot be seen as two different sectors. At the same time, all the participants were of the opinion that the entire region of the UAE should be considered as one unit when it comes to matter of water security in the region. The data and the results of this research strongly suggest that there needs to be a cap on the average consumption of the UAE because the UAE has a water consumption rate that is four times higher than the average world consumption rate.

The similarities that exist in addressing the challenges of water security in the UAE and in other GCC countries sheds light on the fact that the entire GCC region can unite together as one single unit in terms of water production and usage. This is being addressed by the GCC as they have agreed to develop a Unified Water Strategy. This will not only help in better enforcement of legislation and regulation but also address the mismanagement aspect of water governance in the UAE and other GCC countries.

In conclusion, the ultimate goal of sustainability of water security and water resources can be achieved by implementing an integrated water resource management approach., as recommended by the GCC Unified Water Strategy This kind of approach basically attempts to balance between the demand for water from user sectors and the supply from the available resources and implements the technical, socio-economic and institutional tools to manage the water resources. The UAE's 2036 water security strategy and the implementation of new technologies will definitely work towards better governance and improvement of water security in the UAE.

4.3 Limitations of the study

Although this study has achieved its research objectives, it does have some unavoidable limitations. These include the potential bias from the small sample of senior officials and academics selected for the qualitative data collection. As well, there were some limitations with collecting accurate sector consumption data. In addition, some of the data provided by the government authorities was incomplete. Despite these limitations, the study makes an important contribution to analyzing the challenges the UAE faces in the governance of its water security and to proposing recommendations to address these governance challenges.

4.4 Future research

Future research could address specific domains related to water governance. For example, studies could address the governance of wastewater or the governance of desalination plants. As well, other studies could compare water governance across types of states – for example the governance of water security in federal states and in unitary states. Another area of research could examine water governance at the regional level -- for example, the Arab regional level and the GCC level. It will be important to also closely monitor the developments taking place with the GCC Unified Water Strategy.

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Appendix

Analysis of Interviews

KEY THEMES	SOURCES CONSULTED FOR IDEA	INTERVIEW DATA
1. Water sources / Geography of UAE	Interviewee 1	For 99% of the water in the UAE, the source is desalination. Either it is an RO plant or MSF or MED plant.
	Interviewee 2	UAE is located in desert area where natural water resources are scarce by its nature.
	Interviewee 3	UAE is in a better position when compared to other GCC countries. Areas where we initially had wells are at most risk of water shortage.
	Interviewee 4	When compared to other GCC countries, UAE is more advanced in terms of implementation and strategy. Eastern and northern part of UAE has comparatively more rain than the interior parts indicating more infiltration which affects the quantity in general.
	Interviewee 5	Lack of fresh water resources and less rainfall. UAE is more advanced when compared

		<p>to other GCC countries and desalination water is sufficient to meet all domestic needs of the country.</p> <p>Coastal areas might be subjected to more ground water deterioration than other areas because of saline water intrusion.</p>
	Interviewee 6	<p>High evaporation rate which is 2000 mm/year along with already scarce natural resources is the main cause.</p> <p>We are little bit ahead especially in terms of research and development for using new technology in desalination and renewable energy in desalination.</p>
	Interviewee 7	<p>There are three sources of water - the drinking water produced from desalination plants, the ground water which is from aquifers and the recycled water which is recycled waste water from the treatment plants.</p> <p>100% of the water that is used in the supply network is product from desalination. So, we have no water that is used for drinking purposes which is coming from the ground water. This</p>

		<p>practice of ground water use in drinking water has actually been stopped more than 15 years.</p> <p>We rely on sea water for production of drinking water.</p>
	Interviewee 8	<p>UAE may be we are a bit more advanced in securing the water system because we plan to utilize strategic reservoir of water for the coming years. So, we are already investigating and developing a big reservoir in the western region to reserve the existing natural ground water for the years to come by integrating it in our system and at the same time, keeping the reservoir working as a natural resource available in case of any security or shortage and this is one of the major difference between us and the other GCC countries.</p>
	Interviewee 9	<p>Cannot compare UAE to other GCC countries because of the difference in land area, availability of other resources and difference in the amount of rainfall.</p> <p>Abu Dhabi is at most risk when</p>

		<p>compared to other areas of UAE because most of the ground water is already salinized and all the reservoirs are exhausted. Next come the areas near the shorelines where salt intrusion is more</p>
<p>2. Problems – improper usage of water / key issues that need to be addressed</p>	<p>Interviewee 1</p>	<p>Improper usage of water that is highest per capita consumption which is 3-4 times more than the world's average.</p> <p>Entire UAE is at risk of water shortage.</p> <p>Residential sector affects water consumption mainly because of the lower price at which water is supplied.</p> <p>Population directly affects the potential water security in UAE.</p> <p>There is some correlation between potential water shortage and pollution.</p>
	<p>Interviewee 2</p>	<p>Continuous increase in the water demand which is directly related to the increase in population and increase in the economic activities.</p> <p>The per capita consumption is above the international average figure.</p> <p>Integration between the different entities in the water sector is an issue here.</p>

		<p>Issues such as emergency conditions, sustainability of desalinated water and</p> <p>Integration between the different water geographies in the country need to be addressed immediately.</p> <p>The water sector in GCC countries is very much similar. There is an ongoing project to develop a GCC Unified Water Security Strategy.</p>
	Interviewee 3	<p>The entire process of water right from production, transmission and distribution needs to be addressed.</p> <p>Per capita consumption needs to be controlled.</p> <p>Residents consume highest water.</p> <p>Increasing population requires more water.</p> <p>The climate change for the gulf means that you get even less rain per annum.</p> <p>The rain is already low so the climate change means that we are getting even less than historically what we used to get and that immediately has a negative impact on the level of water in wells in</p>

		<p>quantity and quality and the same time, if the gulf water is evaporating at a higher rate let's say, it means that the salinity of the water in the gulf becomes gradually higher and the quality of water that we can distribute through perhaps some type of technology will suffer.</p>
	Interviewee 4	<p>Population growth and certain human activities affect the quality of conventional water resources and subsequently increase their demand.</p> <p>In UAE, we have different entities that consume water and affect the water structure and this led us to reshape the governance of water in general.</p> <p>Lack of sufficient data which hinders the outcome of the data and research. So, need to organize the design of water sector first and then handle the data later.</p> <p>Exact studies not available to clearly evaluate the effect of pollution on the water system.</p> <p>We have dry areas that some of the</p>

		<p>studies show that in the coming years the temperature will be increased by one or two degrees and this is consistent with the studies which were conducted in the Arabian Peninsula and if the temperature is high, the consumption will be high. In the meantime, high temperature causes high evaporation which at the end, will lead to more rain through the hydrologic cycle.</p>
	Interviewee 5	<p>There are manmade conventions and natural conventions because the country as a whole is located in an arid region and the lack of fresh water resources, lack of rainfall, perhaps are the most important factors that limit the availability of water resources in the country.</p> <p>Highest per capita consumption and high usage by the agriculture sector.</p> <p>Lack of sufficient funds to support research and develop new practices.</p> <p>Because of high evaporation and evapotranspiration, more water is needed</p>

		<p>for irrigation. So, need to conserve water in this sector.</p> <p>Other conditions that are manmade including, for example, the excess use of water without real need in different practices like for irrigation, at home, in car washing and others where water is not used in a proper way most of the time and there is excess use of water specifically in irrigation and in the development of green areas specifically houses in the city.</p> <p>Pollution is directly related to water shortage because when the water table in the aquifer declines, salt water intrudes.</p> <p>Climate change affects water security. For example, from 1996 to the average rainfall in the country has dropped from about 110mm or 120mm per year to about 80mm per year.</p> <p>Agriculture sector mostly affects water consumption because this sector consumes more than 50% of water in the country</p>
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	Interviewee 6	<p>In a hyper arid region like UAE, we have scarcity of natural water resources and the rainfall density is less than 100 mm/year and evaporation rate is very high – 2000 mm/year.</p> <p>Mismanagement of water resources.</p> <p>Firstly, we are suffering from water shortage, depletion of ground water and because the ground water is still the main resource for supplying irrigation water to these two sectors – agriculture sector and forestry sector and unfortunately, we have now some dry areas or depleted areas which are suffering from shortage, depletion and deterioration of ground water in terms of both quantity and quality.</p> <p>Using desalinated water is very costly apart from having an environmental impact.</p> <p>The highest water consumption sector in the country now in the UAE or Abu Dhabi is agriculture. It consumes about 60% and second comes the domestic and</p>
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		<p>then the industrial and commercial. Even in the domestic sector, we are one of the highest per capita water use in the domestic sector which is now for Abu Dhabi emirate is around 630 liters per capita which is 3 times the worldwide average use which is 180-200 liters per capita.</p> <p>Whenever population increases, the demand increases.</p> <p>Water pollution is not a big issue in Abu Dhabi except the ground water deterioration which is natural pollution. There are many man made pollutions because of the pesticides, chemical fertilizers but it is not as big as natural up coning. In terms of desalination, we don't have a problem of contamination of the desalinated water in the network as it's very negligible or does not exist by any means. In terms of the other risky issues is the discharge of treated waste water to the marine water which has some environmental impact and</p>
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		<p>pollution impact but now, there is direction from the government to solve it and to reach zero discharge by 2018 and utilize all the tertiary treated waste water in different sector – agricultural sector or forestry sector and stop discharging any water into the marine bodies.</p> <p>The climate change impacts water security from different angles. First one is shortage of supply because of the impact of climate change and rainfall density and rainfall frequency, it is expected that there will be some impact on the renewable resources supply in UAE. On the other hand because of the temperature increase and the impact of the climate change there will be increase in the demand. So you need more water and you will suffer from less renewable water in the future. So, there will be some gap. The other third future impact is the impact on the sea water rise and the most of our desalination plants exists on coast. So, if there is any increase in</p>
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		<p>the sea water level there will be some impact on the intake of water in the desalination plants and of course if there is any impact on the quality there will be impact on the efficiency of the desalination process. So these are the three main categories of impact.</p>
	Interviewee 7	<p>UAE in particular has more challenges because it has witnessed the highest growth in terms of economy, population, industrial practices which most of these industries are actually consumers of high water consumption.</p> <p>The highest water demand consumption is actually water used for irrigation.</p> <p>Availability of sufficient fuel to maintain the production of water is the main challenging factor.</p> <p>All the production is actually dependent on an energy source. So, the challenge is to ensure that we have a sustainable supply from the energy source that can be used to help in the production of water.</p>

		<p>Pollution affects the water quality.</p> <p>If the climate change affects the sea water level, then it might impact the infrastructure.</p>
	Interviewee 8	<p>Water pollution in the gulf region is the main factor which affects water security because most of our desalination plants are located in the gulf sea.</p> <p>In addition to this, shortage of fuel is another important factor because sometimes we need to produce power and water at the same time and as we depend mainly on desalination units which produce power and water.</p> <p>Residential and industrial sectors are the highest consumers.</p> <p>With more population, we have more demand and high demand of water will add to the potential risk of water security.</p> <p>The challenge is that we are mainly dependent on other organizations such as ADNOC for fuel and gas which needs to be controlled.</p>

		<p>The other challenge is that because of the large area from Al Ain to Abu Dhabi utilization of water became a challenge due to the fact that we have to build a lot of transit lines for power and water distribution system to cover all the areas.</p> <p>Lack of better utilization of water for irrigation system and human acts related to the utilization of water.</p>
	Interviewee 9	<p>Water consumption by the residential sector and tourist places like hotels especially where Europeans and Americans stay, the consumption of water is high.</p> <p>Agricultural and industrial sectors take up activities which do not take water scarcity into consideration.</p> <p>Aflash system is best Arabic method for irrigation and transportation of water in GCC countries and it is well maintained in Oman but does not exist in UAE.</p> <p>Polluted water like sewage water is thrown into wedges which reaches the ground water and pollutes it.</p>

		The other emirates especially the areas which are nearer to the shorelines where the salt intrusion in ground water is a big problem.
3. Governance – initiatives – how are problems being addressed	Interviewee 1	<p>Long term plan – Balance the cost of water and selling price.</p> <p>Example – In 2014, the UAE locals consumed 44% of the overall water consumption in FEWA. We adjusted the tariff a bit from 1fils to 1.5 fils. That contribution came down from 44% to 40%. There was a savings of 4% of water within six months. That gives a good indication that value for water is one of the key factors in controlling the consumption.</p>
	Interviewee 2	<p>Recently, MoENR launched UAE water strategy 2036 project. This is a project to develop full-scale integrated solution to enhance our water security. It is looking in deep to develop interconnection system and strategic storage capacity between four major water suppliers in the country.</p>

		<p>Apart from this, the Ministry of Energy developed the UAE water innovation strategy. It's a new approach launched by the PMO (Prime Minister Office) in which the Ministry is in-charge to follow up the different initiatives and projects related to the innovation strategy in the water sector.</p> <p>The ministry is in-charge of following up and reporting the status of water security indicator which is a National Indicator as part of UAE National Agenda. Now, we have several projects and initiatives that directly relate to the issues above and address different challenges, of course from different angles and different levels.</p> <p>Entire UAE is one entity from water security point of view.</p>
	Interviewee 3	<p>Co-operation and support is needed from all the other government entities and stake holders.</p> <p>Policy of increase in tariff has worked but regarding other policies, it's too early</p>

		to conclude.
	Interviewee 4	<p>As a UAE university, we have addressed all these issues in our research. In addition to this, we have addressed these issues in our curriculum for college and science and college of engineering.</p> <p>Water education in different colleges like college of science and college of engineering is the most important and this is a long term plan.</p>
	Interviewee 5	<p>Implemented modern irrigation techniques like drip irrigation.</p> <p>Water conservation strategies need to be developed.</p> <p>Development of strategic reserves of water perhaps from desalination water, excess of desalination water can also be under the long term plans.</p> <p>On the long term, university has developed what is called the national water center and this center is entrusted to conduct research and activities to identify the long term activities at the country level not only at the university</p>

		<p>level like contribute to the development of new technology in the areas of artificial recharge of ground water, water desalination, water recycling, conservation of water in irrigation.</p>
	<p>Interviewee 6</p>	<p>Need to improve the regulation and legislation framework.</p> <p>Environmental agency of Abu Dhabi is a competent authority for managing and regulating the ground water resources only. The other two resources which are desalinated water or treated waste water is managed by other two resources which is ADWEA for desalinated water and ADSSC (Abu Dhabi Sewerage Services Company) for treated waste water.</p> <p>We are working on new technologies for saving water in domestic sector with ADWEA. We are also working with Masdar for long term project to use renewable energy and innovative technology for desalination with our agencies, stakeholders and other institutions.</p>

		<p>We are developing ground water monitoring policy, we are developing Environment 2030 which includes a lot of initiatives and activities related to water and water use.</p> <p>We are working on developing long term water resources strategy for GCC.</p> <p>We are working with the ministry of climate change and environment to develop federal water policy.</p> <p>There is some fragmentation, some duplication in the responsibility and this has been tackled and raised in the high water strategy for the emirate which was launched in January 2015.</p> <p>Ground water aquifer recovery project in Lewa is one of the primary project in the region, not only in GCC but also in the middle east.</p>
	Interviewee 7	<p>Initiatives for demand side management have been taken up. For long term planning, we have to consider alternative supply sources through GCC or inter connections with the GCC or</p>

		<p>interconnection between the emirates itself which will add more security.</p> <p>We are participating in number of studies as a stake holder, for example, for the ministry of energy which is now doing specific project on the water security strategy, we are a member of that project team, supporting ministry of energy, we have been a member of the project team for GCC water studies. We have also been a member in the study for developing total water strategy for GCC which is a project that was funded by GCC, Mr. Ahmed Al Khaliji for full strategy for all GCC countries including UAE. GCC or interconnection between the emirates itself, with Dubai, Abu Dhabi and Sharjah and also will add more security.</p> <p>For the regulation and supervision bureau, our role and responsibility is ensuring the continuous supply of water for all the people including the needed and hospitals, facilities that are in any</p>
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		<p>special needs for those.</p> <p>GCC water strategy study that was conducted and completed this year has actually addressed all the factors related to water.</p> <p>We do have demand forecasting for up to 2030 and even up to 2035. So, the planning in this case is looking up to the perspective of population and the perspective of increasing the production capacity to meet the population needs.</p> <p>The latest major undertaking was introducing the aquifer recharge which is at LEWA and this project provides additional security to the water supply system and can maintain the supply of water for up to 3 months.</p> <p>The bureau has been working with various stake holders like Mubadla, ADNOC to ensure that we have long term plan to understand basically fuel balance in the system and accordingly we can plan our systems to take that into consideration.</p>
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		<p>Future policies to be implemented are mainly to do with, in terms of ensuring that the three water resources we have whether it is sea water, desalinated water or ground water should be used in the most efficient manner without depending solely on one source of water because this is only good for consumption.</p> <p>Currently there are new technologies for water desalination which are being considered, studied and there are pilot studies that are being conducted by Masdar in which they are piloting four different new innovations that they have considered for future water technology and looking at from the performance of the energy plants as well as efficiency of energy.</p>
	Interviewee 8	<p>We are planning and reviewing the fuel availability and communicating with the authorities such as ADNOC group and others in the country to make sure that the fuel is available to us in the coming years.</p>

		<p>Long term plan – blocking water to make sure that the water is also produced from different sources and the existing technology by adopting the RO system.</p> <p>Reusing the treated sewage water to manage and utilize it again in the agriculture and industrial zones.</p> <p>Increase of tariffs has seen a reduction in the overall consumption.</p> <p>Ministry of energy is now developing UAE natural water security lands and they are investigating all the elements of risks in the whole UAE system covering all the emirates. This will include the areas of study where the study will find out that needs more attention, then they will study the network, and then after they finish this review, they will come up with ideas on how each emirate will be connected with the other one and how this will help each other in case there is a shortage or even risk of non-availability of water in the seven emirates.</p>
	Interviewee 9	

		<p>Need co-operation from all the authorities in UAE.</p> <p>Need better policies for industrial and agricultural sectors.</p> <p>There is a big project for water harvesting which has been made in the western side of the country. And this situation is comparable to UAE in many ways. Especially, Al Hasa area is similar to UAE because they are depending mainly on Aflash system which has to be reissued again. This Aflash system is best Arabic method for irrigation and transportation of water in GCC countries. It is well maintained in Oman but here in UAE it is not.</p> <p>In Short term, the plan is to knock the doors of industrial and agricultural people, convey the problem to them and to initiate their interest to solve it by themselves. And to suggest to them that when they don't face this problem correctly, it endangers their activities and also endangers the water security of this</p>
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		country.
4. Factors that have an important effect	Interviewee 1	<p>Technology plays a major role now in lowering the production price or cost per gallon or per liter produced.</p> <p>In most sectors, the water is subsidized and that is one of the reasons that affect the stability of the water and usage of water.</p> <p>As we are totally dependent on desalination, climate change does not really affect our water security unless the condition of the sea changes i.e for example, if red tides occur, they affect the desalination process by blocking the membranes.</p>
	Interviewee 2	<p>Whenever the population increases, the water consumption increases. It is projected that the demand for water resources in the country will double between 2010 and 2030 and this is of course, led by the population increase and to some extent increase in the different economic development— industrial and commercial activities.</p>

		<p>Sea water intrusion and in-land sabkha water intrusion happens in UAE which is responsible for polluting the water.</p> <p>Climate changes affect the water cycle, the natural hydrological cycle. If the climate changes causes higher temperatures, this will directly affect water demand. If the climate change causes sea water increment, then the operation of desalination plants located on coastline will be highly affected. In addition, it may increase the seawater intrusion to coastal fresh water aquifers.</p>
	Interviewee 3	<p>Climate change has a major impact on water security because it means less rain in an area which already receives scanty rain and also causes high evaporation.</p>
	Interviewee 4	<p>Climate change affects in a major way because when the temperature increases, not only the consumption increases but also the evaporation rate increases.</p>
	Interviewee 5	<p>The climate change plays a role in water security. During the last twenty years, for example, from 1996 to the average</p>

		<p>rainfall in the country has dropped from about 110mm or 120mm per year to about 80mm per year. So this drop in the rainfall has affected the availability of water in the aquifers and therefore, this is perhaps, because of the climate change and if this continues then we will have decline in the recharge of the ground water in the country.</p>
	Interviewee 6	<p>The climate change impacts water security from different angles. First one is shortage of supply because of the impact of climate change and rainfall density and rainfall frequency, it is expected that there will be some impact on the renewable resources supply in UAE. On the other hand because of the temperature increase and the impact of the climate change there will be increase in the demand. So you need more water and you will suffer from less renewable water in the future. So, there will be some gap. The other third future impact is the impact on the sea water rise and</p>

		<p>the most of our desalination plants exists on coast. So, if there is any increase in the sea water level there will be some impact on the intake of water in the desalination plants and of course if there is any impact on the quality there will be impact on the efficiency of the desalination process. So these are the three main categories of impact.</p>
	Interviewee 7	<p>Factors that affect water security can only be related to extreme water events where you have a major crisis in the context that you lose production.</p> <p>Because our production water plants are all running along the coast whether it is running towards the Saudi borders or Fujairah, any climate change may impact the infrastructure. So, it is only from that perspective that if it happens like hurricanes or sea water turbulence so there will be definitely an impact on the infrastructure whether it is floods infrastructure or network infrastructure.</p>
	Interviewee 8	<p>The climate change will definitely play a</p>

		<p>major role in water security. For example, when it is hot in summer time, the temperature will be high and this will add a huge increase in water. We also have drained wells and even the condition of the wells is not suitable for water utilization and this will add major risk to water security.</p>
	Interviewee 9	<p>Climate change plays a negative role in water security which nobody knows but what we have seen in the last rain in Alghurair area which most of the people are saying that they didn't see it before, could be related to such changes but also could be related to periodical changes that take long time and since none of us have seen it before, so it's a problem.</p>
5. Solutions	Interviewee 1	<p>Short term plan - creating consumer awareness.</p> <p>Long term plan - Concentrating on the younger generation and showing them how to conserve water.</p> <p>Need to balance the cost of water and selling price.</p>

		<p>Educating the consumers is a challenge because our community is a mix of multinational countries in which some countries have plenty of rivers and water. So, they don't know the value of water.</p> <p>Reduction in the per capita consumption is the only solution.</p>
	Interviewee 2	<p>As an overall goal, the sustainability of our water security / water resources is the target. This can be achieved by implementing the integrated water resource management approach.</p> <p>Integrated water resource management approach is an approach to make balance between the demand for water from user sectors and the supply from the available resources. The approach implements the technical, socio - economical and institutional tools to manage the water resources.</p> <p>The technology can be used for demand management like water saver devices, green building practices, using of smart devices to operate the supply network, all</p>

		this technology will lead to better water management.
	Interviewee 3	<p>Innovative ways of producing local quality water needs to be developed.</p> <p>Demand management and diversifying the source of production needs to be done.</p> <p>New technology can be used to treat waste water and introduce better methods to desalinate water.</p> <p>Educating the society.</p> <p>Securing the sources of water and usage of treated water should be more.</p>
	Interviewee 4	<p>Immediate action needs to be taken in terms of population growth.</p> <p>People behavior needs to be managed.</p> <p>Including water education in college curriculum.</p> <p>There are chances to improve the situation of water sources through research and consistent strategy.</p> <p>Strategies towards the agricultural sector need to be revised as 80% of the water is consumed by this sector.</p>

		<p>Educating the younger generation is utmost important.</p> <p>Pricing mechanism needs to be revised regularly and have strict laws for people or entities affecting the natural resources.</p> <p>Also, the consumption by any entity that leads to deterioration of water needs to be punished. We need to have strict regulations for such people or entities that harm the environment including water.</p> <p>Some rules need to be complied and regulated in a way which addresses all the different resources of water – desalinated water, ground water and treated waste water.</p> <p>Use of treated waste water needs to be maximized.</p> <p>Technology is crucial but need continuous research to find more eco-friendly and economic solutions to supply water.</p> <p>Population growth needs to be controlled.</p>
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	Interviewee 5	<p>Educating the general public and conserving the water by agricultural sector.</p> <p>Using latest technologies in desalination.</p> <p>Increasing the use of treated waste water.</p> <p>Development of strategic water reserves, perhaps by using the excessive desalinated water.</p> <p>Have to reduce the water consumption in agricultural practices – what kind of plants and vegetables need to be cultivated.</p> <p>Expansion of agricultural activities and constructional activities need to be monitored and controlled.</p> <p>Recycling of water and conducting research is important.</p> <p>Technology is crucial in water conservation and water availability like through water harvesting from rainfall events through recharge of treated waste water.</p>
	Interviewee 6	We need to put in a lot of efforts in terms

		<p>of governance, utilization and high water demand management.</p> <p>Demand side management needs to be immediately addressed.</p> <p>Increasing the supply, demand side management and strengthening the institutional and regional legal framework in the country.</p> <p>In domestic sector, you have to use new water saving faucets. You can use faucets with less flow up to 1.5 liter/minute instead of 7-8 liter per minute.</p> <p>In terms of water supply, there are a lot of new technologies now to improve the assessment and exploration of ground water.</p>
	Interviewee 7	<p>Instead of being dependent only on desalinated water, sea water and ground water should also be put in use.</p> <p>Demand side management.</p> <p>Proper planning with adequate information database for accurate demand forecast along with increased</p>

		<p>use of treated waste water.</p> <p>Technology moving from thermal technology to membrane technology is the future and apparently even hybrid arrangement which is combining thermal and membrane is more likely to be considered including the possible use of future nuclear in the desalination industry. Also, adopting advanced technology when it comes to consumption has a great scope for becoming more efficient.</p> <p>We need to have a pragmatic approach about the various needs of the customers and should actually try to make the most appropriate and feasible supply made available to the customers.</p> <p>Maximizing the use of recycled water to all the demand centers instead of only on irrigation.</p>
	Interviewee 8	<p>Long term plan, maybe for availability of fuel in the sector in order to make sustainable fuel available to generate the required power and water at the same</p>

		<p>time.</p> <p>Other factor is water contamination in the gulf region which needs a plan from authorities like the security of the country as well as Abu Dhabi environment agency.</p> <p>We need to think about alternative source for production of water and instead of just producing power and water from the existing desalination plant, we need to think about standalone water treatment plant such as the RO (Reverse Osmosis) where we can produce only water and don't have to mix this with power.</p> <p>Need to increase the usage of treated waste water and increase water tax as the tariff up to this point is not reflective of its cost, there is a lot of loss in the system due to utilization of water.</p> <p>For future generation, we need to have different technology for producing water other than the combined power and water today.</p>
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		<p>For water security, the most important thing in the next 5 years is look at the demand wise level and to act fast in developing new plans for power and water or to develop scenarios for water.</p> <p>In the next ten years, certain study which is now carried out by the ministry of energy for the entire UAE will indicate the area of security that needs to be controlled and from that point of view, an action needs to be taken for better inter connection between the emirates, building new plants, utilization of underground water and building strategic reservoirs.</p> <p>The technology plays a major role because we are adopting new RO technology and this can produce water to the customers provided they have enough electricity available. In addition to this, there is a new technology for utilization of sewage. Another one is utilization of natural reservoirs of water by having electronic monitoring devices to monitor</p>
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		<p>the water in the ground and to keep monitoring this water and utilize it in future in case we need it. And then we can adopt new technology at customer level to use less water than it is today like sensor devices on the pipes which supply water to the customers.</p> <p>Tariffs need to be introduced because when the tariffs were increased to a certain level, the utilization of water came down.</p> <p>Educate all humans on utilization of water and not allow them to use for irrigation system or uncontrollable use because this will add to shortage of water.</p>
	Interviewee 9	<p>Water reservoirs need to be developed and maintained.</p> <p>Digital water atlas of UAE needs to be developed which will enable us to see the problem, find a solution and monitor the results of this solution.</p> <p>Educating the younger generation and creating awareness in both public and</p>

		<p>officials.</p> <p>We have to put rules for factories that use lot of water, to treat it enough to be reused again whereas for the agricultural activity, we have to change the habit of using normal water for flooding the farms and use another method that saves more water. And it needs monitoring of both activities and when I say monitoring, I mean monitoring of the seas by the government –what is right and what is wrong and advice accordingly.</p>
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List of Interviewees table

CODE	DATE	ORGANIZATION	POSITION
Interviewee 1	10.02.2016	Federal Electricity & Water Authority	Senior Official
Interviewee 2	10.02.2016	Ministry Of Energy	Expert
Interviewee 3	11.02.2016	Abu Dhabi Transmission & Despatch Company	Expert
Interviewee4	15.02.2016	UAE University	Academic
Interviewee 5	15.02.2016	UAE University	Academic
Interviewee 6	16.02.2016	Environment Agency-AD	Advisor Water Resources
Interviewee 7	16.02.2016	Regulation & Supervision Bureau	Expert

Interviewee 8	18.02.2016	Abu Dhabi Water & Electricity Authority	Expert
Interviewee 9	21.02.2016	National Center of Meteorology & Seismology	Researcher

Data collection

The Governance of Water Security in the UAE

The data collection will consist of semi-structured Interviews with officials in government agencies in the UAE.

1. In your view, what are the most important factors that affect water security in the UAE?
2. Which areas of the UAE are most at risk of water shortages?
3. Which is most likely to be affected human, domestic or industrial consumption? In your opinion why?
4. In your opinion, how is potential water security in the UAE linked to the increasing population?
5. In your opinion is there a correlation between potential water shortages and pollution and if so why?
6. Does climate change play a role in water security, if so, why?
7. Are you aware of similar forecasts of water shortages in other GCC countries? If so, how does this compare to the situation in the UAE?
8. Which of these factors in your opinion need to be addressed in the short term and which require long term solutions?
9. How have you and your organization addressed these factors? How is your organization planning to address long term factors?

10. What are the key challenges and opportunities involved in addressing these factors? In your opinion, which policies have worked and which ones have not?
11. What specific policies need to be implemented?
12. What would you recommend as a government strategy to address water scarcity issues in the UAE? In the next 5 years? In the next 10 years?
13. in your view what role if any, will technology play in any short or long term solutions to the issue of water shortages?
14. Would you be able to share with me data or other documents related to this topic?
15. Who else would you recommend I speak to?