The American University in Cairo
School of Global Affairs and Public Policy

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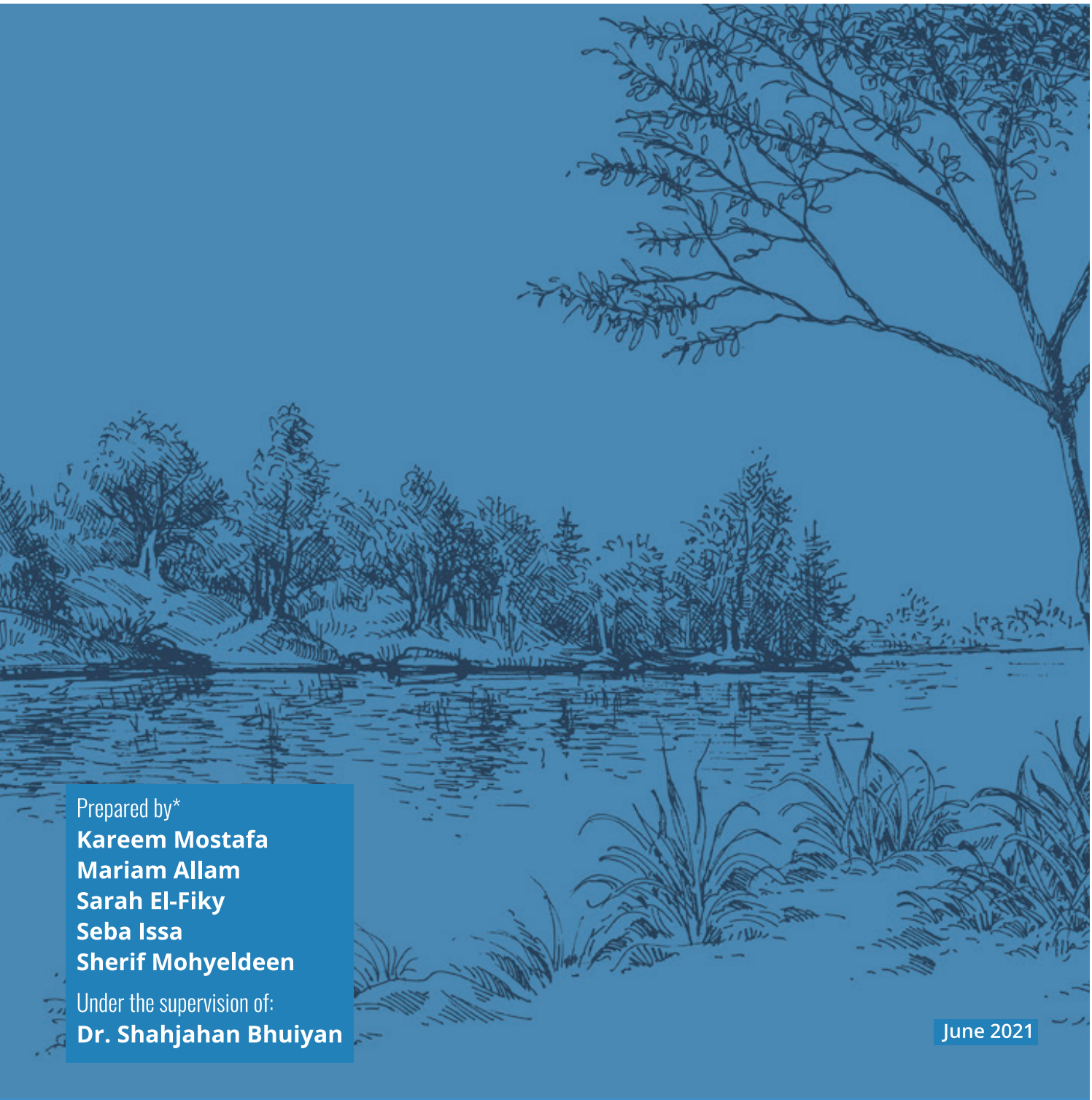
Water Security in Egypt: Issues and Perspectives

A Policy Paper



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List of Abbreviations

AHD	Aswan High Dam
AU	African Union
BCM	Billion Cubic Meters
CAPMAS	Central Agency for Public Mobilization and Statistics
EWRA	Egyptian Water and Wastewater Regulatory Agency
FAO	Food and Agriculture Organization
GERD	Grand Ethiopian Renaissance Dam
GoE	Government of Egypt
HCWW	Holding Company for Water and Wastewater
IBNET	International Benchmark Network
MALR	Ministry of Agriculture and Land Reclamation
MENA	Middle East and North Africa countries
MFA	Ministry of Foreign Affairs
MoHUUC	Ministry of Housing, Utilities and Urban Communities
MTI	Ministry of Trade and Industry
MWRI	Ministry of Water Resources and Irrigation
NOPWASD	National Organization for Potable Water & Sanitary Drainage
NPC	National Population Council
NWRP	National Water Resources Plan
UN	United Nations
SDGs	Sustainable Development Goals
SDS	Sustainable Development Strategy

Executive Summary

Under the looming threat of water scarcity, the government of Egypt (GoE) must impose effective policies that promote water conservation to ensure water security for the future of its population. This policy paper seeks to define, survey, evaluate, and recommend prospective policies that can address the problem of current water scarcity and achieve water security. This paper focuses on two research sub-questions: 1) How can the government implement policies that can help Egypt's water conservation? 2) How can Egypt create alternative water sources?

Using secondary sources and extensive desk research, this policy paper describes Egypt's current water crisis and its background. Besides, it illustrates the scope of the problem through identifying the main issues contributing to water scarcity in Egypt and their impact including, the population explosion and their projected growth rates exploring three different scenarios (pessimistic, neutral, and optimistic), the establishment of the Grand Ethiopian Renaissance Dam (GERD), and the climate change and its effects on different water resources in Egypt. By demonstrating the root causes of the problem, it was essential to examine the Egyptian efforts, initiatives, and policies to evaluate where serious policy interventions are needed to achieve water security.

The policy alternatives proposed aim to answer the main research sub-questions. They include three different options; 1) Adoption and implementation of innovative water governance practices in the agriculture sector; 2) Improvement of the institutionalization of water management; and 3) Effective implementation of legislations. These policy alternatives are later analyzed against criteria relevant to the Egyptian technical, political, administrative, and economic context. The best policy option is recommended based on the predefined decision rules, which are the most efficient in terms of cost and time concerning effectiveness in achieving the primary goal.

Finally, the policy implementation strategy and how it can be carried out efficiently is put in place. Additionally, the required mandates, stakeholders involved, and a rigorous plan for monitoring and evaluation are outlined to ensure commitment to achieving the objectives and overall buy-in from all the involved stakeholders. Moreover, to achieve the main aim of this policy paper and ensure the seamless implementation and success of the selected policy option, a set of short- and long-term strategies are also recommended. These strategies are non-regulatory policies that are put in place to complement and facilitate the attainment of the desired level of water security. Besides, such initiatives are vital to support the successful deployment of the recommended primary policy. Thus, having both working hand-in-hand will ensure the attainment of water security in Egypt in the near future.

Introduction

"Water is life", remains a meaningful phrase highlighting the critical importance of water for human survival. It reflects Kofi Annan's assertion, "Fierce competition for freshwater may well become a source of conflict and wars in the future" (Annan, 2001), explaining the extent to which the scarcity of water could threaten human lives.

Achieving water security is considered one of Egypt's critical determinants for achieving its Sustainable Development Strategy (SDS) 2030. This is because a sustainable and secure water supply is the foundation for other Sustainable Development Goals (SDGs). Thus, this paper aims to identify the current status of water security in Egypt and to identify the issues and challenges to achieve this goal. In doing so, the study attempts to answer this research question: "How can Egypt achieve future water security to its population?" This study will also try to answer the following two sub-questions:

1. *How can the government implement policies that can help water conservation in Egypt?*

2. *How can Egypt create alternative water sources?*

The primary research methodology employed in this policy paper is based on secondary sources. This was possible through reviewing a diverse body of literature. Besides, we had access to the most recent data reported by the Central Agency for Public Mobilization and Statistics (CAPMAS), the Ministry of Water Resources and Irrigation, the Food and Agriculture Organization (FAO) and other governmental entities and international organizations. This was facilitated by the help of the National Population Council (NPC), which was relentless in providing the most up-to-date data and reports.

Water security is a multi-faceted concept that involves both the protection of existing water supply and the creation of alternative water sources (Schultz & Uhlenbrook, 2007). Hence, in simple terms, water security is essentially the sustainable development of water resources and the safeguarded access to the various water facilities and services for humans and the environment for years to come. Thus, one of the ways to understand and define water security can be easily derived from the definition of "Sustainable Development", which is according to the United Nations (UN), "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 2020).

Accordingly, water security is defined by the UN as:

"[t]he capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability" (UN-Water, 2013).

This will be the primary working definition for this policy paper, as it explores water and its predicted scarcity from a multidisciplinary approach that tackles the different challenges and opportunities.

Introduction

The term "water scarcity" is not particularly new to Egypt, as this threat has been looming over Egypt's horizon for decades. What is new is the worsened water scarcity rate, as shown in Figure 1, which admittedly is impacted by different factors like the excessive population growth, climate change, the new Grand Ethiopian Renaissance Dam (GERD), and of course the ill-utilization of water resources. All of this requires a rigorous set of evidence-based policies to assure Egypt's water security and its population in the future.

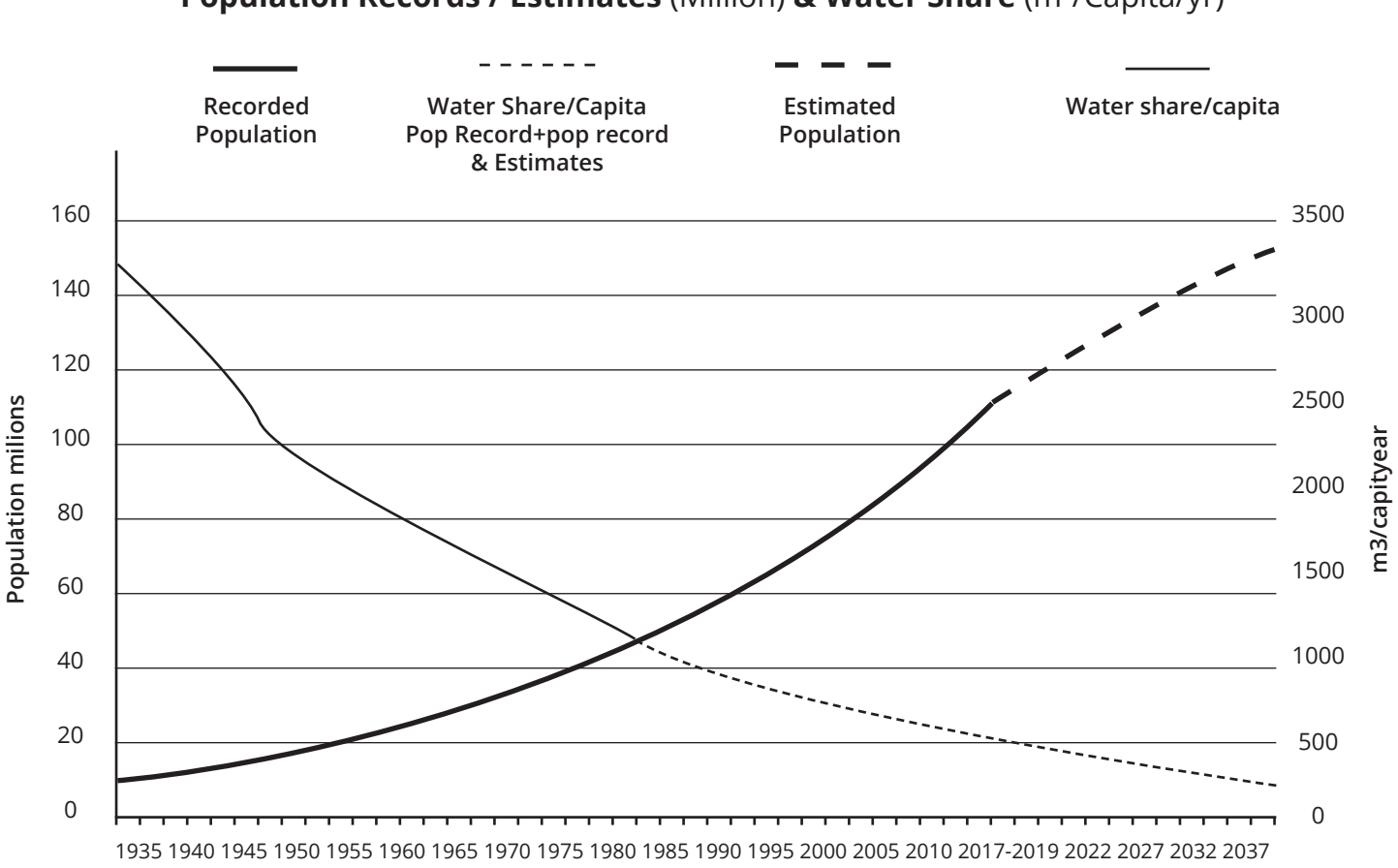

Figure 1: Population vs water records and estimates (1935-2037)
Source: Ministry of irrigation and water resources, 2020

This policy paper is divided into six sections; the first section provides a brief introduction about water security. The second section presents a review of literature about water, and it also identifies the gaps in the literature. Then the third section discusses the problem statement and its root causes. Afterwards, the fourth section introduces and develops a stakeholder's analysis of the main contributors and institutions involved in shaping water security policies and main actors affected by water security – or lack thereof. The fifth section recommends alternative policy options that are later analyzed based on the technical, administrative, political, and economic criteria.

Finally, the paper concludes with the sixth section emphasizing the best-fit policy recommendations regarding the selected decision rules based on the most efficient ones in terms of cost and time and their effectiveness in achieving water security.

Literature Review

Water and energy are the most vital and indicative resources to a country's development and prosperity. Egypt is one of the countries suffering from a semi-desert climate with a lack of fresh water sources. This scarcity is expected to worsen over the coming years due to climate change and global warming (Sanchez & Subiela, 2007). Now more than ever before, Egypt must develop multidimensional policies that match the size and cruciality of the problem and its consequences to reach an optimal level of using the available water resources. The National Water Policy in Egypt manadates water quality portection, optimal and effective usage of availabe water resources, and international cooperation to safegaurd and increase the Nile Basin supply (El-Saddek, 2010).

According to Zeitoun, Allan, & Mohieldeen (2010), Egypt's water security is contested by a set of external and internal factors. Two of the most imminent external threats are the transboundary conflict with riparian countries over Egypt's share of the Nile water (Mekonnen, 2010), in addition to climate change affecting the other – already limited – freshwater supplies (Barnes, 2014).

Most recent literature emphasized that the problem's scale calls for strict water governance and the promotion of using non-conventional water resources; governance refers to operational activities to effectively manage the existing water resources. As a means to an end, governance is "good" if it can solve water challenges; it is "bad" if it does not respond to place-based needs (Romano & Akhmouch, 2019). According to Romano and Akhmouch (2019), the best way to ensure adequate water governance is by creating the 3Ps framework. This framework thoroughly identifies the policies needed to curb water scarcity, the people affecting and impacted by the current situation, and the place, which adopts a place-based understanding of the mismatched needs and demands of different cities and territories.

According to research, the most efficient and sustainable means of creating non-conventional water resources would be desalination and recycling drainage water (El-Saddek, 2010; Barnes, 2014). Utilizing these two non-conventional methods are contended as two of the main enablers for Egypt to use a larger volume of water than that which comes in the forms of Nile water, rainfalls, or groundwater pumped from deep aquifers (Qadir et al., 2007). Besides, according to El-Saddek (2010) and El Baradei (2013), water treatment and desalination can be used as sustainable water resources for domestic use in many parts of Egypt since the shorelines of the Red Sea and the Mediterranean Sea cover about 2,400 km – combined.

Notably, Egypt does not suffer from water scarcity alone but as a part of the MENA region, which has five percent of the world's population but only one percent of its freshwater. Water institutions in MENA have shifted their attention incrementally from technical and engineering ways to cope with water shortages to good governance and political practices. Most MENA countries also share the same problem of having separate agencies for irrigation systems and water for drinking and domestic use without setting guidelines on how collaboration and coordination should occur. This means that part of the whole region's solution entails solving the lack of synergy problems (Rached & Brooks, 2010).

Some studies argue that the region is shifting its main agricultural goal from self-sufficiency to trade, which ensues significant issues, like food prices. Indeed, the debate about a policy of food self-sufficiency is highly considerable, and the decision to import is political in nature (Rached & Brooks, 2010). Thus, some MENA countries adopted smarter pricing. For example, Jordan and Tunisia prevent more affluent households from abusing the social tariff by requiring consumers who use more water than that allocated to them initially to pay at the higher rate for the full – not the marginal – volume.

Literature Review

Israel is one of the MENA region countries which found a solution in depending heavily on water desalination for covering more than 70% of its local needs. It also treats around 86% of its wastewater (Times of Israel, 2018). Additionally, despite the dominance of irrigation on water use, three-fourths of all farmland in Arab nations depend exclusively on rain to overcome the shortage of other resources. Yet, Egypt, Israel, Libya, and the Arabian Peninsula nations are the main exceptions. On the other hand, groundwater management is neglected in most MENA regions (World Bank, 2007).

It is possible to benefit from the Kingdom of Morocco's experience and develop a useful institutional and legal framework. The Tunisian experience was very useful in setting up a sound system for replacing costs and pricing water. In contrast, the Hashemite Kingdom of Jordan's expertise can be relied upon in improving the participation system (Fatta, et al., 2005).

Water legislation is crucial for implementing water strategies and policies. It provides the foundational legal framework for water governance. However, the legislation goes hand-in-hand with the institutional, organizational standards, management system, and enforcement of regulations. Most developing countries, especially the Arab countries, have adopted laws that improve water governance, manage and protect their scarce water resources. Despite their extensive efforts, most of them fail due to a lack of force to enforce such laws (De Stefano, et al., 2014).

From a broader perspective, it is noteworthy that water infrastructure is ageing, affecting water efficiency negatively and marginally increasing operative costs due to leakages. Cities like Liverpool, Lisbon, and Zaragoza, amongst others, have invested heavily to reduce leakages and to reconstruct the pipeline network. In Zaragoza, for example, water losses from the distribution network have been reduced by more than 40% over ten years (1997–2007) (Romano & Akhmouch, 2019).

Another international example is Singapore, which has built a robust, diversified, and sustainable water supply from four water sources known as the "Four National Taps". Water from local catchment, imported water, high-grade reclaimed water – also known as – NEWater, and desalinated water. Through the integration of the water system and increasing the efficiency of each of the four national taps, Singapore has overcome its lack of natural water resources to meet the needs of its growing nation (PUB, 2018).

In this regard, India also is considered as an inspiring model of best practices, as it deals with canals by covering them with solar power generating units. Thus, it could supply villages with electricity, prevent water loss by evaporation, and give poor villages electricity (Khalil, 2020).

This was a brief review of the past and most recent literature to understand the current water (in)security in Egypt and understand the regional and global context and the methods followed across the globe to mitigate the impact of such a problem. In doing so, the gap in literature was identified between the governmental plans and their feasibility to be turned into full-fledged evidence-based policies that can ensure water security for the future.

Problem Statement

The availability of freshwater resources in the country is limited to the River Nile, groundwater from both renewable and non-renewable aquifers, limited rainfall along the Northern Coast, and flashfloods in the Sinai Peninsula. Groundwater also exists in the non-renewable deep aquifers of the Western Desert and Sinai. Thus, Egypt currently receives approximately 98% of its freshwater from the River Nile outside its international borders. This situation is considered a significant challenge for the Egyptian water policy and decision-makers. Rainfall is very scarce and occurs only during the winter season. As a result, water resources management in modern Egypt has become a complex process that involves multiple stakeholders who use water for a myriad of reasons including, irrigation, municipal and industrial water supply, hydropower generation, and navigation. Furthermore, the Nile supports aquatic ecosystems that are threatened by pollution. The critical problem of water resources management in Egypt appears to be the imbalance between increasing water demand and the limited water supply.

According to the World Bank (2018), a water-scarce country falls beneath a level of 1000 cubic meters - a benchmark identified by the Internal Benchmark Network (IBNET). Thus, Egypt is considered one of the water-scarce countries despite its strategic location and ease of water accessibility. Egypt has also reached a very high and chronic water shortage level that might prevent it from achieving economic development.

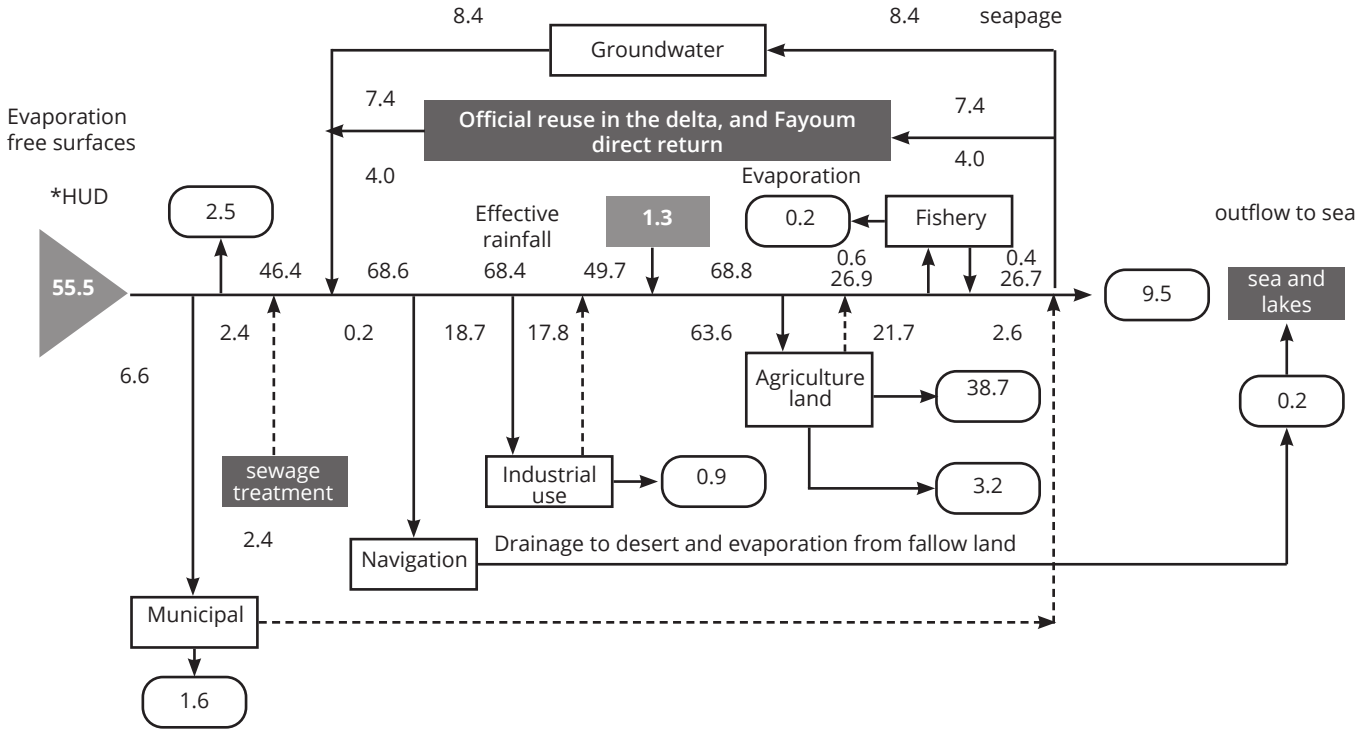

Figure 2: Overview of water sources and consumption in Egypt
Source: Ministry of Water and Irrigation, 2007

Besides, as illustrated in Figure 2, Egypt's total water resources are accounted for a total of 80.25 billion cubic meters (BCM)/year, where 55.5 BCM/year of which comes from the Nile water. This depicts Egypt's primary dependence on one water source, ignoring the potential capacity of other alternatives to bring about another source of sustainable freshwater, like rainfall, deep and shallow groundwater, and the desalination of seawater and wastewater.

Problem Statement

In general, conventional water resources in Egypt - represented by the Nile water, renewable groundwater, and some scant annual precipitation have been exhausted. That pushes the government to increase the efficiency of using it and explore new sources of non-conventional water resources to narrow the gap between water supply and demand, which is estimated at 20 BCM (Ashmawy, 2018).

The agricultural field uses around 85% of the total water usage. The actual consumption of agriculture is estimated at 40.4 BCM, while the amount of water allocated for agriculture is calculated at 68.5 BCM annually (Rady & Omar, 2018). It is essential to mention that about 80% of farmers use traditional agriculture methods, while about 15% of the areas depend on the drip irrigation system, which has been scientifically proven feasible. Therefore, most of the water wasted comes from the agricultural sector. Also, the water wastage coming from the drinking water sector is proven to be huge. During the fiscal year 2018-2019, losses in drinking water were estimated at a minimum of two and a half BCM, equivalent to about 29%, and according to other estimates, the value of wastage reached about 35% (Enterprise, 2020).

The total deep groundwater used in Egypt in 2016 was around 2.4 BCM and 6.5 BCM from shallow groundwater (Omar & Moussa, 2016). The Nubian Aquifer is the best example, as it is considered the largest aquifer in the world. It stretches down four countries in Northeast Africa, Egypt, Libya, Chad and Sudan, and covers about two million square kilometres. It extends down about 80% of the total area of Egypt, including the Eastern Desert. According to a relatively recent study published in 2019, it is expected that the available amount of water in the Nubian aquifer layer in Egypt alone to be sufficient to supply Egypt with water for 500 years. However, the main obstacle to this is that the Nubian reservoir is bottomless in the Western Desert, and its depth ranges between 1000 and 1500 meters, which makes it very costly to dig wells (Al-Saeed, 2019).

The following section explores Egypt's water supply and the impacts of the threatening factors on the future of water security in Egypt. Hence, we discuss the background of the problem from three main perspectives, namely: the population growth, the GERD establishment, and climate change. Then, we identify the current policy environment in Egypt and how it deals with the problem at hand and is proven useful in curbing and mitigating the threat of water scarcity.

What causes water (in)security in Egypt?

- **Population growth and its impact on water consumption**

According to CAPMAS 2020, the population of Egypt has reached 101 million in 2020. The problem has to do with a significant number of people and the increase of the people at a very high rate. Every week around 4,700 new births take place in Egypt. It is estimated that the population will reach 110 million in 2025. This is considered a massive threat to the already dwindling water resources because this increase will lead to more domestic consumption in the households and increased irrigation consumption for agric ulture to meet the people›s increasing needs for food (Dakkak, 2020).

As shown in Figure 3, the average share of individuals of fresh water in Egypt has been decreasing over the years. It is expected that it will reach 500-600 cubic meters in 2025. Although water production has increased in some of the years, as shown in Figure 4, population growth has led to increased consumption. According to these figures, Egypt has already fallen below the poverty line of water which is 1,000 cubic meters per person per year (Ahram Online, 2016).

Problem Statement

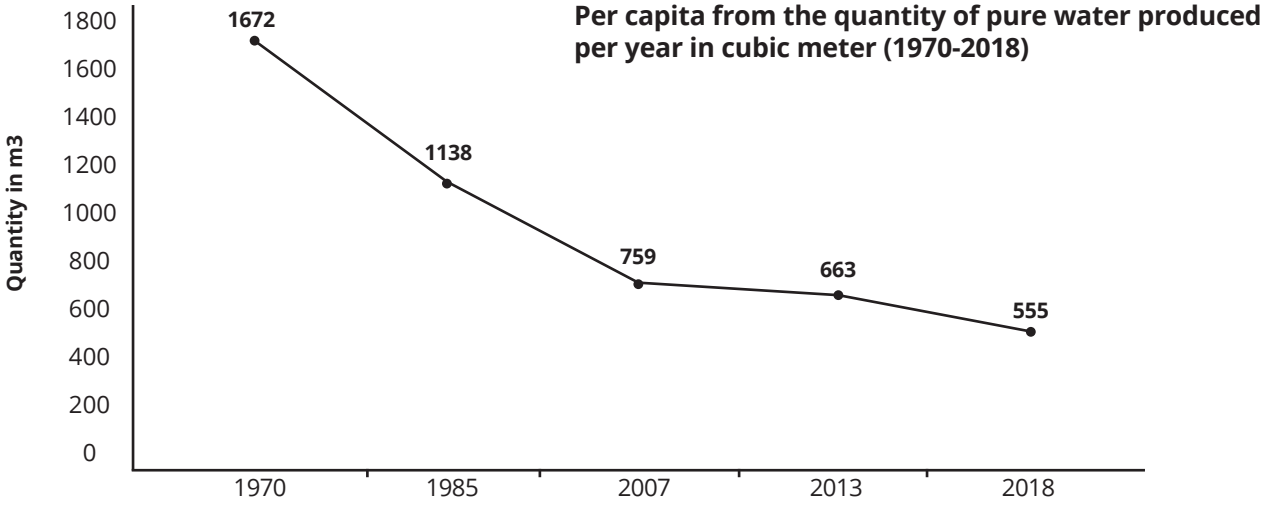

Figure 3: Average per capita from the quantity of pure water produced (CAPMAS, 2020)

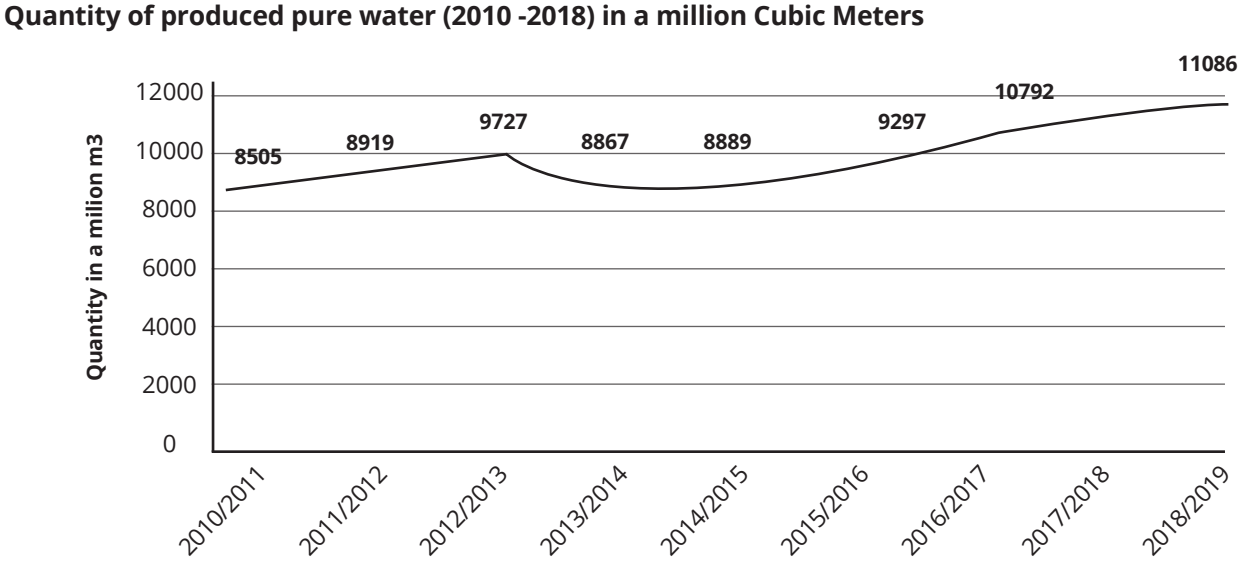

Figure 4: Quantity of produced pure water (2010-2018) in a million cubic meters (CAPMAS, 2020)

In mid-2020, the Egyptian Ministry of Health revealed three scenarios of population increase in Egypt according to a study of population forecasts "2020-2050". The first scenario predicts that there will be an uncontrolled population increase with a fertility rate of 3.5 children per woman. Following this scenario, Egypt's population will mount up to almost the double of our current population in 2050.

The second scenario is a more optimistic one, as it anticipates that the population increase will be more controlled, and the fertility rate will remain stable at its current level, which is 3.07 children per woman. In that case, the population will reach 160 million by 2060. The third is considered a utopian scenario as it expects the fertility rate to reach 2.4 children per woman (Gomaa, 2020). According to this scenario, Egypt's population will reach 152 million in 2050.

This population increase is reflected in the usage of freshwater. The average per capita share of freshwater is decreasing by about 11% due to the population increase. In 2050, the per capita share is expected to reach below 450 cubic meters for each individual. Thus, it is crucial to search for alternatives to meet the individual need of drinking water.

Problem Statement

The Grand Ethiopian Renaissance Dam (GERD) and its impacts

One of Egypt's main reasons for water scarcity stems from the fact that 97% of its water resources originate outside the Egyptian borders, causing significant stress and vulnerability to the water supply due to any uncoordinated upstream developments (AmCham, 2017). Therefore, the GERD is perceived as an existential risk, threatening the already insufficient water supplies in Egypt and power generation at its own Aswan High Dam (AHD). Also, given the current climate conditions, which are expected to get drier with the more frequent heatwaves. Unlike Sudan, Egypt has rare rain occasions, which is insufficient to create a natural water reserve for the Egyptian nation's demand and basic water needs (Negm & Abdel-Fattah, 2019). The main obstacle to benefiting from torrential water is that most of it falls inside the areas connected to the uninhabited desert, which wastes the water, as well as the high prices for establishing rain catchments, which leads to the waste of all that water (Hassan, 2016). Subsequently, Egypt is already suffering from water shortage that reaches up to 21 BCM per annum. Moreover, Egypt imports around 34 BCM of virtual water annually to balance the food gap (Abdelhaleem & Helal, 2015).
Although Ethiopia argues that the GERD will inevitably benefit downstream countries, including Egypt, and will not impact their water security by any means, the dam will give Ethiopia greater control over the Nile's flow. A significant concern is portrayed through the filling of the vast reservoir. Depending on the time it takes to fill the reservoir – which has already started during summer 2020 –3 to 7 years were estimated. The Nile flow into Egypt could be cut by 25 - 12% during the filling period.

The scope of the problem of the GERD establishment on Egypt has a multi-faceted impact on the water supply and Nile water as a primary source of water in Egypt, as illustrated below (Abdelhaleem & Helal, 2015):

1. The Nile water levels will decrease from 0.40 m to 0.75 m.

2. The Nile water velocities will decrease, so the sedimentation process may increase, affecting the water surface profile.

3. Agriculture lands in Egypt will decrease by 23.03% to 29.47%, leading to land dissertation›s imminent possibility[1]. in Egypt.

4. Reducing Egypt's water share by up to 5% will hurt safe navigation.

5. Hydropower losses from the AHD will vary between 20–30%.

6. Evaporation losses will increase by 5.9%, affecting the Nile water quantity and quality downstream of GERD by increasing the Nile water salinity.

However, with all the aforementioned implications, a conflict and dispute between the two parties will bring no benefit to any of them. De facto, by violating the Nile Basin agreements, Ethiopia has contested Egypt's hegemonic power in the horn of Africa, threatening Egypt's natural resources endowment represented by the Nile. This, in turn, is possessing a trigger for transboundary violence and conflict that still can be avoided through international tactical mediation across the riparian countries involved championed by the African Union (AU) and involving technical experts to reach a tripartite binding deal (Rahman, 2012).

[1] *Land dissertation is a phenomenon where desert lands increase through the excessive formation of dunes, due to the scarcity of water, causing disruptive effects on the quality of soil, vegetation, and cities (Tsoar & Zohar, 1985).*

Problem Statement

Climate change

Climate change is, de facto, one of the most severe environmental problems the world is facing today (Yehia et al., 2017). Climate change is not a new phenomenon; however, current climate changes are alarming; they are very rapid and far-reaching.
Apart from natural factors of climate change, such as volcanic eruptions, ocean currents; human activities
(for example, industry, transport, and agriculture) are mostly responsible for polluting our planet. Climate change is one of the consequences of this pollution. The effects of climate change are manifold since the results of such disturbances are at the same time, environmental, social, and economic (UNICEF, 2016).

In Egypt, the water domain will be one of the first to be impacted by climate change, as the country is already plagued by a water shortage and water resource management issues (World Bank, 2018). In other words, as mentioned earlier, Egypt is already dealing with population inflation, sprawl in urbanization, and different conflicting interests of its neighbouring countries (El Saeed, 2011). Mindful of the above, even if climate change would have no adverse effects, the average share of individuals of water in Egypt will be decreasing in the coming years.

Moreover, the Nile waters are susceptible to climate change, both in rainfall and variations in temperature. Data collected by the Egyptian Meteorological Authority – from 1901 to 2016 – indicate that a trend is forming in the overall warming of the air temperature and the possibility of reducing rainfall, as shown in the Figures below.

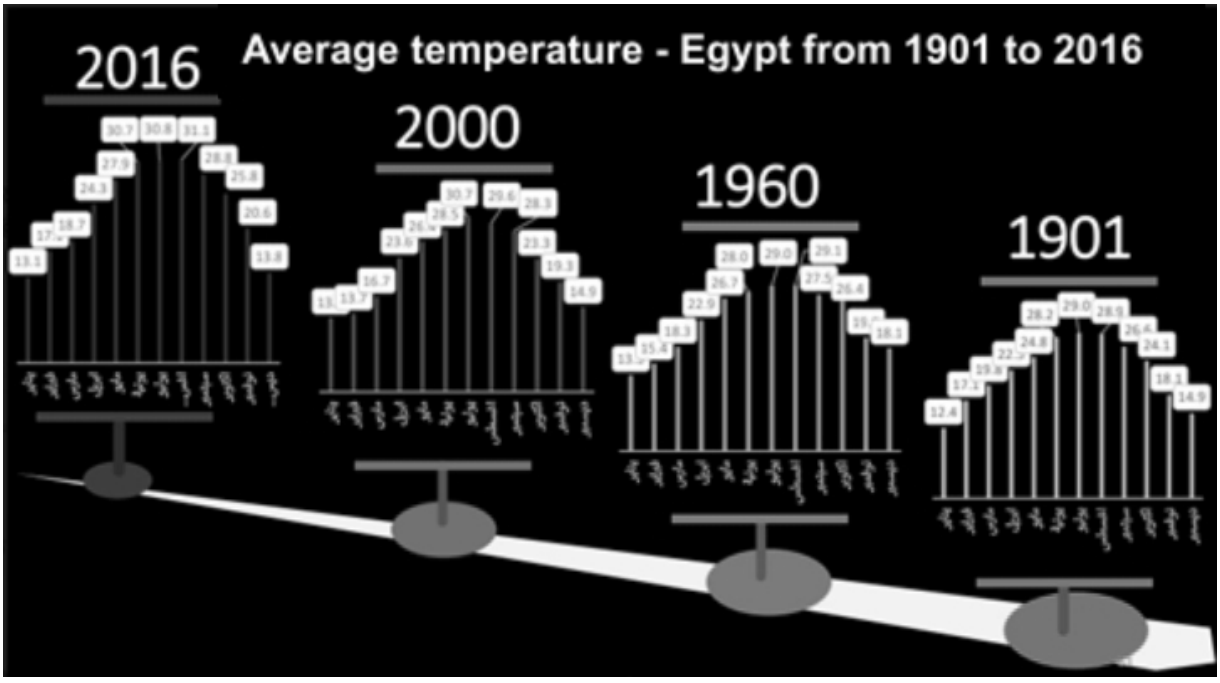

Figure 5: Average temperature - Egypt from 1901 to 2016 (CAPMAS, 2020)

Problem Statement

Average rainfall - Egypt from 1901 to 2016

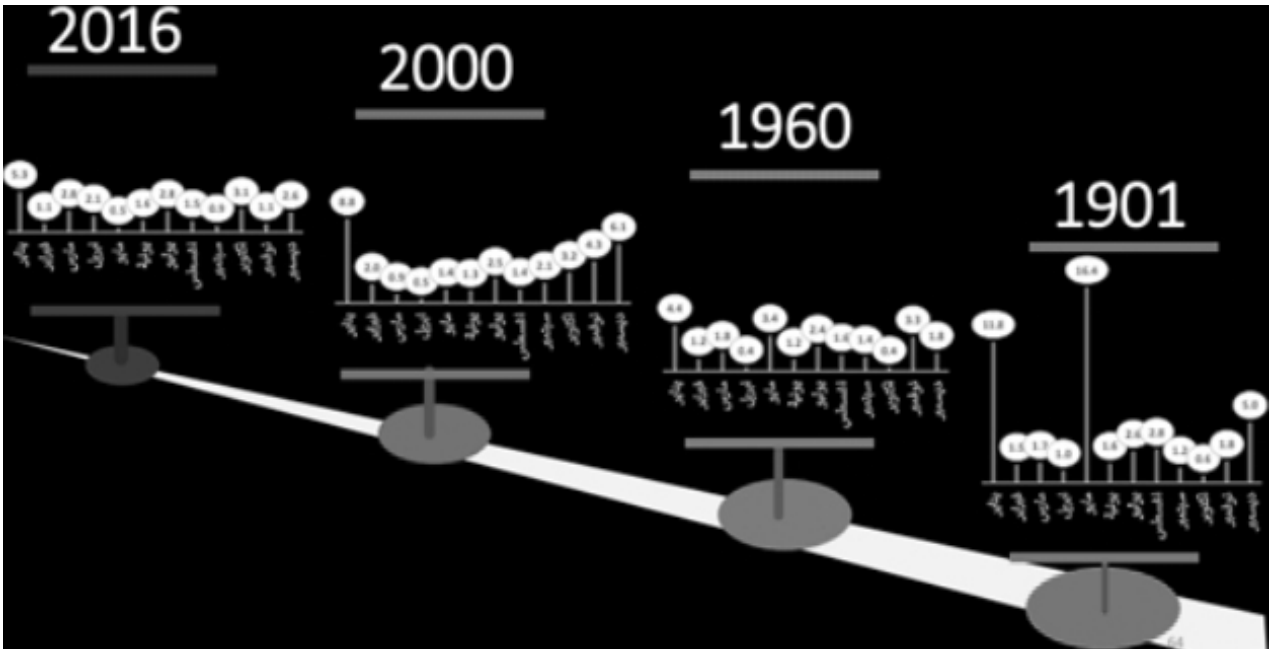

Figure 6: Average rainfall - Egypt from 1901 to 2016 (CAPMAS, 2020)

Egypt ranks 87th and 73rd places in the Climate Change Sensitivity Index and the degree of readiness to overcome the impact of climate change and is considered one of the most vulnerable countries to climate change, as shown in the Figure below.

Egypt's vulnerability to climate change

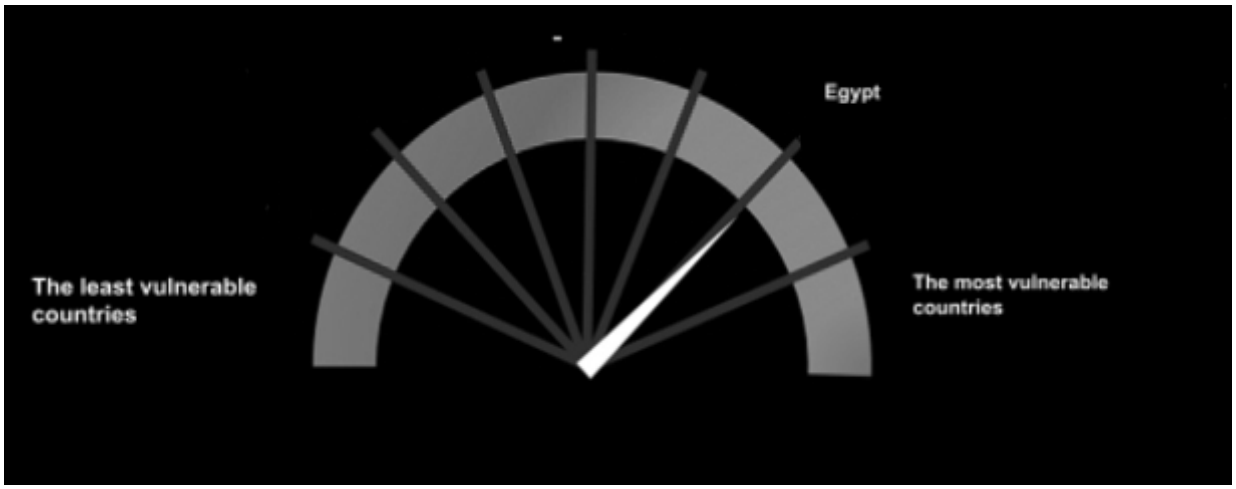

Figure 7: Egypt's vulnerability to climate change (CAPMAS, 2020)

Therefore, Egypt should plan for several different future scenarios and adaptation plans, given the expectations that climate change will increase temperatures and decrease precipitation levels.

Problem Statement

- **The Current policy environment and its limitations**

Egypt has been developing its 2030 Vision, which sheds light on the importance of reforms for effective water resources management in Egypt. There is no single overarching water resources law in Egypt. Therefore, Egypt has been managing its water resources system by developing various policies and legislation that would help avoid a water crisis in the future.
It is worth noting that most progressive policies and legislation did not achieve advancements for many reasons.

Legislative environment

A water-related law aiming at a more effective system for managing water resources in Egypt was provisionally approved by the Egyptian parliament on 2 March 2020 and is currently being discussed by the parliament.

The new draft law on water resources and irrigation is one of the most prominent legislation, primarily as it aims to maximize water resources utilization considering their limitations rationalizing consumption and developing the irrigation system at the national level (Hassan, 2020).

Institutional environment

The National Water Resources Plan (NWRP) 2017-2037, is a USD 50 billion, 20-year initiative in coordination with nine ministries including - but not limited to - agriculture, housing, health, environment, and planning (Ahram Online, 2017). The strategy is based on a four-pillar approach to mitigate Egypt's water scarcity issues, through 1- Improving water quality and reducing solid waste and pollution; 2- Water conservation rationalizing crop cultivation and promoting effective water management; 3- Water resources development by creating desalination plants and freshwater harvesting and storage; and 4- Raising awareness through establishing an open communication environment. Additionally, synergy and cooperation between all government entities are considered an integral part of realizing such a plan. The plan also includes reducing agricultural, industrial and domestic water consumption to 80% of current consumption (MWRI, 2005). However, actual results and impact on the ground from the NWRP are still to be witnessed.

Furthermore, Egypt's Vision 2030 is also an important reference when it comes to discussing the issue of water scarcity. The following policies are included within the policy:

1. Strengthening the institutional and legislative environment for the water resources management system.
2. Expanding the establishment and development of the infrastructure necessary to achieve the sustainability of the water system.
3. Implementing fiscal policy reforms and use economic tools to move towards more sustainable water resources patterns (MPED, 2020).

From a foreign policy perspective, The Egyptian Ministry of Foreign Affairs (MoFA) seeks a binding legal agreement that preserves its historical water rights before Ethiopia begins the second phase of filling the Renaissance Dam. The MoFA also cooperates with the Nile Basin countries to develop their water resources to reduce losses and increase river drainage for the basin countries› benefit (Helal, 2020).

Current projects

Egypt has currently embarked on several national projects to preserve its water resources. Among the most important is the canal covering and lining project, which avoids the infiltration of the water resources of 5 BCM of water per year. The initial plan was to work on lining 2000 km by the year 2019. However, the project period was shortened from 10 to 2 years, and the target was upgraded to 20,000 kilometres.

Problem Statement

The investments in this project are expected to round up to 60 million Egyptian pounds (Jad, 2020). Some researchers also claim that by the end of this project, Egypt could save up to 20 BCM annually to be used in agriculture and industry, or any other usages, and could have a tremendous economic return (Khalil, 2020).

Given that most of the wastewater comes from the agriculture sector, the MWRI announced in 2019 that modern irrigation systems would be used in irrigation instead of flooding irrigation. The three main modern methods suggested for Egypt are piped irrigation, and this system reduces the waste of water from about 60 to 70%. The second system is sprinkler irrigation, which is beneficial in crops such as wheat, reducing the waste of water by 70% to 80%, and the last system is the drip system. This system is suitable for all crops, which are grown on lines such as orchards, corn, vegetables and oil crops such as beans and sunflowers, and the percentage of waste in the system is reduced to approximately 90%, and for this reason, it is recommended in Egypt (Radwan, 2018). Development projects to change irrigation systems to drip irrigation have already been implemented in an area of 7476 feddans[2] (Egypt Today, 2020). The ministry is currently planning to expand these modern irrigation methods in 175,000 feddans (Daily News Egypt, 2020). The main obstacle toward reducing losses in this sector is the high cost and advanced technology and equipment needed for the implementation phase (Radwan, 2018).

The government is also implementing desalination projects on an enormous scale. It allocated 50 billion Egyptian pounds until the year 2052 for desalination of seawater. The total seawater desalination capacity by the end of 2020 is supposed to reach 1.7 million cubic meters per day, which is 6.6% of the entire drinking water (Hassan, 2020). This will be around two times of the estimated amount in 2018 – 2019 (CAPMAS, 2020) and expected to reach 2.8 million cubic meters per day at the end of this plan, which equals around 10.6% compared to our drinking water now (Hassan, 2020). The water desalination as a conventional water resource should be considered an imperative measure for water security in Egypt. The future use of such resources for different usages mainly depends on the desalination technologies› improvement rate and cost (El-Sadek, 2010). Despite the high-water desalination cost (ranges from $0.7 to $0.9 per cubic meter), it is still feasible to use this method in remote areas where constructing water transferring pipelines is relatively high (El-Sadek, 2010).

Due to the high production of wastewater in Egypt, which reached 4.6 BCM, the government has invested in establishing sewage plants. In 2015, the total number of wastewater treatment plants rose to about 395 with different wastewater treatment technologies. Al Jabal al-Asfar is considered a successful model for Egypt''s sewage plants (Zain, 2019). The treatment of wastewater has a positive economic return, as it increases national income, improves the balance of payments and reduces inflation. Despite the facts mentioned above, we should also mention some reservations in terms of health regarding the treated water from sewage, which makes its use limited to specific crops (Al-Sharq Al-Awsat, 2017). This as well as the cost of establishing triple treatment plants, that enable us to grow all crops, is four times the cost of setting a regular sewage plant and the quadruple treatment of wastewater used by Singapore is prohibitive and requires high technology (Hassan, 2017).

The government also works on water catchment projects, especially in Sinai and the Red Sea where rain and torrential waters are considered important freshwater sources for the tribes. This is because they use it

[2] Feddan is a unit of area. It is used in Egypt, Sudan, Syria and the Sultanate of Oman. In Egypt, the feddan is the only non-metric unit which remained in use following the switch to the metric system. A feddan is divided into 24 kirat, in which one kirat equals 175 square meters.

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for drinking and agriculture (Omar & Moussa, 2016). Despite this fact, only 1.6 BCM of rainwater is utilized although the amount of total rainwater that falls on Egypt, according to FAO, is estimated to be 51 BCM. In addition to that, the government managed to drill many wells in remote areas to collect rainwater. Since 2014, the government has already dug 6203 wells. These wells will be used for drinking, agriculture, and land reclamation (Egypt Today, 2020).

The government is also implementing projects to make use of underground water, especially in agriculture. An example of that is the one and a half million acres project, one of the mega agricultural development projects that Egypt started implementing in December 2015. The project depends 88.5% on groundwater and 11.5% on Nile water (Ashmawy, 2018).

Opportunities and limitations

One of the main legislative concerns regarding the existing legislation and new ones is the weakness of these laws and penalties for violating them (Bedawi, 2014). These laws have been imposed and approved by the parliament; however, they were not effective. According to legal experts, most of the laws are not applied on the ground, but rather are merely theoretical laws and the main reason for not using them is the weak government›s role in both monitoring and executing deterring punishment (Al-Bawaba News, 2018).

Moreover, the ineffective implementation of policies is partly due to the lack of a clear institutional framework and the lack of dissemination of information, training, and users and stakeholders (Rady., 2018). It is also due to the lack of public awareness and the need for more robust propagation of saving water in irrigation and domestic uses, thus advocating a new culture of water-saving among the whole society (Bedawy, 2014).

Furthermore, researchers think that water allocation in Egypt is based on demand without considering the economic value of water or applying the concept of cost recovery (Rady., 2018).

Nonetheless, The Ministry of Water Resources and Irrigation (MWRI) has issued a set of new policies at the national level to protect Egypt›s water security. According to the National Population Plan principles and its implementation plan 2020-2025, Egypt seeks to ensure that the rates of population increase do not exceed the state›s ability to provide essential services and do not affect the per capita share of natural resources, mostly water. The plan seeks to ensure that the population size in 2030 does not exceed (110.9) million citizens, compared to (101) million citizens in October 2020 (NPC, 2014).

Stakeholders Analysis

Water scarcity is considered a multidimensional problem; it is a social, political, and economic one. Therefore, managing water resources is composite and thus encompasses many stakeholders. In this section, the stakeholders will be identified then the power interest grid will be used to map the stakeholders concerning their interest and power.

1. **The Ministry of Water Resources and Irrigation (MWRI)** The MWRI is the leading governmental institution responsible for managing water resources. Besides, it oversees the management of projects related to irrigation and monitoring the water quality in Egypt.

2. **The Ministry of Agriculture and Land Reclamation (MALR)** The MALR is the governmental institution working to advance agricultural and land reform policies in line with national development plans. It is also involved in managing water resources on the non-farm level.

3. **The Ministry of Housing, Utilities and Urban Communities (MoHUUC)** The MoHUUC carries the responsibility for the provision of water supply and the sanitation services at the municipal and industrial levels. There are three entities operating dnder the MoHUUC: (i) the Holding Company for Water and Wastewater (HCWW), (ii) the National Organization for Potable Water and Sanitary Drainage (NOPWASD), and (iii) the Egyptian Water and Wastewater Regulatory Agency (EWRA), are in charge of the planning, the design, the construction supervision, the operation, and the maintenance of drinking water on the municipality level, treatment plants, distribution systems responsible for water supply, and wastewater treatment plants at the municipal level.

4. **The Holding Company for Water and Wastewater (HCWW)** HCWW oversees managing operational/administrative/financial/commercial performance of the water supply/wastewater service providers (i.e., its ACs), monitoring their level of achievements according to pre-set performance indicators and ensuring the execution of water supply/wastewater investment plans through updating of the AC master plans on an annual basis. It also manages and governs the water/wastewater facility assets in all governorates.

5. **The National Organization for Potable Water & Sanitary Drainage (NOPWASD)** The NOPWASD oversees drinking water treatment plants on the municipal level, distribution systems responsible for water supply, sewage collection systems, and treatment plants on the municipal level. It is divided into two main divisions: the first has to do with the potable water sector and the second has to do with sanitary drainage sector.

6. **The Egyptian Water and Wastewater Regulatory Agency (EWRA)** The EWRA was created under the MoHUUC. The EWRA is responsible for monitoring the compliance of affiliated companies with quality-of-service standards and determining the economic costs of service. Tariff adjustment decisions, however, remain under Cabinet authority. The EWRA began operations on July 1, 2007, albeit limited facilities and staffing.

7. **The Ministry of Trade and Industry (MTI)** The MTI oversees setting a policy for developing foreign trade and industry for the Arab Republic of Egypt and following up its implementation in a way that ensures the encouragement of exports and the regulation of import in addition to modernizing, developing and supporting the Egyptian industry in a way that increases its competitiveness and promotes attracting investments and expanding the existing industrial activities.

Stakeholders Analysis

Policies in the water sector will significantly affect the ministry's policies and strategy, especially when it comes to industrial development.

8. **The Ministry of Foreign Affairs (MFA)** The MoFA is responsible for formulating Egypt's foreign policy and protecting the Egyptian state's citizens and the representation of the Egyptian state in other countries and international organizations. The ministry's role is vital in negotiations and signing treaties concerning Egypt's water share, especially considering the GRED.

9. **The Ministry of Health and Population (MoHP)** The MoHP seeks to raise the level of health services and facilitate citizens' access to them. It is involved in the water sector concerning its effect on the health of the population.

10. **The Ministry of Environment (MSEA) & the Egyptian Environmental Affairs Agency (EEAA)** The MSEA, along with the EEAA, are responsible for tackling the environmental issues in Egypt. They are extensively involved in the water sector because they tackle water pollution.

11. **The Ministry of Local Development (MoLD)** The MoLD is responsible for coordinating between relevant national organizations and implementing policies on the local level. They are involved in the water sector as it is accountable for formulating projects to improve the delivery of services, including water and to raise the awareness of citizens.

12. **The National Population Council (NPC)** The NPC is responsible for investigating population trends and the relationship between population development and economic growth considering the available resources. It is also responsible for looking into the procedures and means that can be used in rationalizing population trends to achieve the interest of society and the family. Moreover, it is responsible for coming up with a general plan for family planning, proposing specific time programs for its implementation, and defining the concerned authorities' role in this field. It is involved in the water sector due to the relation between the shortage of water resources and the population increase. It has implemented various awareness campaigns on family planning and rationalizing the use of water.

13. **The Egyptian Population** The different segments of the Egyptian population are the main target groups and will be the primary beneficiaries of any policy, strategy, or project implemented. All the Egyptian people would be affected as water is used daily for drinking and sanitation purposes. Some people are more affected than others because, in addition to the purposes mentioned above, water also plays a role in their economic activity. This is the case for farmers, business owners, and people working in the industry.

14. **The private sector** The private sector should be included in the stakeholders profiling as they may act as a possible financing partner and the government for water projects. They are affected by water policies as well.

15. **International organizations and donors** They implement projects that affect and are affected by the water policy. Among the most active stakeholders in the water sector are The Islamic Development Bank (ISDB), The European Union (EU), The African Development Bank (AFDB), and Japan International Cooperation Agency (JICA).

16. **Civil society** The strong base of Egyptian civil society plays a significant role in raising citizens' awareness and increasing their participation and support.

Stakeholders Analysis

The power interest grid was used to categorize the relevant stakeholders concerning power and interest (Annex 2). The two stakeholders that have the highest interest and the highest authority are the MWRI and the MALR. Therefore, any policy recommended in this sector should be carried out in coordination with these two entities, and they should be the two leading entities. The other ministries mentioned above have less interest in the issue, however, they still have influence and thus should be consulted in any decision taken regarding the water sector. The Egyptian people, civil society, and NPC are the most interested in the issue; however, they have the least power. This should be addressed as they should participate in any water-related issues. The international organizations and the private sector are equally interested in the sector; however, they have a medium influence. Their influence should be increased by including them and giving them the space to function.

Alternative Policy Options

To achieve the paper's objective, the alternatives will not tackle the root causes of the problem and will focus on adaptation measures rather than mitigation. This does not mean that the mitigation measures should be ignored, but they should be long term plans. This is because working on addressing them will only achieve impacts on the long run and will not solve the current consequences of water scarcity on all aspects of life. Thus, we will focus on alternatives that will achieve an immediate impact on the short run. Of course, these alternatives should go hand in hand in solving the issues of population increase, the GRED, and climate change.

Alternative no. 1:
Adopting and implementing innovative solutions concerning water governance practices in the agriculture sector

Since around two-thirds of Egypt's share is used in the agriculture sector, it is imperative to investigate solutions that save water. Water governance has proven to be a handy tool to deal with water challenges and ensure that all have access to enough water for survival. This is because it involves rules and practices enough for making informed decisions regarding the management of water resources and where responsible institutions and officials are held accountable. Thus, water governance coordinates who does what? How? And on which level?

The economic tools of water governance can help change behaviour to use water more effectively, be rigorous and robust enough to encourage innovation, be politically acceptable, comply with legal and institutional frameworks, and apply under low monitoring and implementation costs. Among these economic tools are cost recovery, virtual water, water footprint, and water productivity.

Cost recovery has to do with the idea of active participation of water users in the process of collecting the cost recovery of supplying water for irrigation; this must take into consideration the financial capacity of water users, the acceptance and contribution of all relevant parties to this fee and of course for this to be legal. As for virtual water, it has to do with the amount of water consumed to produce agricultural commodities exported outside the country, and thus international food trade can be viewed as virtual trade-in water. This method can save vast quantities of water in several ways. For example, some crops with high virtual water quantities are dispensed with and imported from other countries while crops are cultivated with less virtual water. This process can also change irrigation methods and traditional agriculture and use the means modern and more efficiently. The water footprint is the sum of freshwater used in producing any product, whether directly or indirectly.

Alternative Policy Options

This concept helps in water conservation by improving water efficiency, whether in irrigation or production. Water productivity has to do with crop yield relative to the total water supplied per unit area. This could achieve water efficiency by obtaining the highest production per acre, using the least water.
By incorporating such concepts in dealing with water, Egypt will save lots of wasted water.

Alternative no. 2:
Improving the institutionalization of water management

This alternative›s main proposition is to establish a committee that includes representatives from different stakeholders who solve water scarcity in Egypt. As seen in the above sections, the government has already defined policies towards solving water scarcity and shortages. Moreover, it has implemented and is still planning to implement various projects to achieve water security. However, there seems to be no coordination between these different entities working on these projects and policies. In addition, there is no prioritization or a clear strategy to tackle the issue. Thus, it is of extreme importance that a committee meets regularly to coordinate the priorities, set a plan, and implement projects accordingly. Such a committee will be crucial to achieving any concrete steps towards solving the problem from its roots. By implementing this alternative, the goals of establishing this policy will be fulfilled because informed decisions will be taken in a participatory manner with all relevant stakeholders› presence.

Alternative no. 3: Effective implementation of legislations

Even though the new law is taking into consideration some of the deficiencies in the current law, including the flaw in the procedures followed to prevent the violations and infringements, this law can also become incapable of meeting the government's needs, the same as previous laws were, in case of the absence of monitoring and executing penalties and an enabling environment. Therefore, the government should tighten these penalties to deter violators, treat, and limit the harmful effects of some phenomena and variables in water resources and irrigation.

The effective implementation of such legislations and the managing of water resources, in general, require the development of the institutions engaged in the management of water resources and the improvement of coordination among relevant stakeholders (Bedawi, 2014).

It is of utmost importance to complement the effective implementation of laws and legislations with public awareness programs. This is because it is crucial to inform the public about water management projects and propagate water saving in irrigation and domestic uses.

Alternatives Analysis

In this section, various policy alternatives will be presented. Given the complexity of the problem at hand, different policy alternatives, answering the two research sub-questions will be explored. The other options will be presented with their advantages, disadvantages, and future scenarios for implementing this alternative in Egypt. An analysis will be carried out for each alternative (See Annex 1).

The below-mentioned criteria were selected to analyze and compare different alternatives. This would be done to attain the goal of water security for all Egyptians.

Criteria	Sub-Criteria
Technical Criteria	• Effectiveness: How the policy alternative will reach the goals set in the problem statement and the improvement brought through this alternative. • Technical Feasibility: The extent to which the alternative is feasible for the technology required for the implementation.
Administrative Criteria	Commitment: The extent to which the resources in terms of staff, skills, money & training available to implement the alternative.
Political Criteria	Acceptability: The extent to which the proposed policy would be accepted by relevant, influential stakeholders, including decision-makers, legislations, citizens, and unions.
Economic Criteria	Cost: The cost that the government will bear to implement these alternatives.

The first alternative will be very useful in attaining water conservation and creating water surpluses that could be used to fulfil the Egyptians' needs and achieve overall economic development in Egypt. The implementation of some water governance concepts and projects might require some technical expertise; however, Egypt has a huge asset of human capital of scientists and professors in the water field that could be consulted. Implementing the first alternative will entail staff, skills, training, and money to get implemented. It might also not be politically acceptable at all levels as some of the policy implementations might go against the interests of some groups like farmers and business owners. Implementing new methods and technology adopted under water governance might demand costs borne by the government and farmers.

The second alternative will also achieve the policy paper›s two objectives: finding water alternatives and achieving water conservation through the coordination of efforts and priorities. The government has enough administrative resources to implement this alternative, mainly that it would not entail any technical know-how or additional costs. It will, however, require political approval for its implementation. The primary constraint towards establishing such a committee could be the bureaucracy and the political will to set up this structure and operate it. Besides, there might be rivalry between the different stakeholders involved. This alternative, however, will not lead to high economic costs.

The third alternative will attain the objective of water conservation and does not require any technical needs. It will, however, require an administrative commitment to be implemented. The effective implementation of policies might go against some political groups› interest, and thus, might be some opposition and corruption that constraint this alternative

Alternatives Analysis

from being implemented. Minimal costs are envisioned for this alternative.

Decision Rules

The most efficient solutions in terms of cost and time and practicality should be selected. This decision rule was made due to the seriousness of the issue and the need for solutions that lead to radical change.

The preferred policy alternative

Based on this decision rule the second alternative was selected because it is the most effective as the establishment of such a committee will work on all related issues to water scarcity, poverty and shortage with the presence of all relevant stakeholders in all sectors and thus will yield comprehensive solutions with priorities set in place. It does not also entail costs to set up such a committee. If there is a political will to implement such an alternative, it would not require any time.

Implementation strategy for the policy alternative

The MWRI, in addition to the MALR, should take the lead in the formulation of such a committee. They should carry out extensive stakeholder analysis that captures all the governmental actors that should be involved. Besides, they should invite international organizations, civil society, and representatives of different population sectors. Experts in the field should also be invited. This participatory approach is vital to the achievement of any tangible results and the success of the committee.

Summary of the monitoring and evaluation plan

A rigorous monitoring and evaluation structure will be put in place to follow up on the implementation progress. A strategy and annual goals will be set in place with SMART (specific, measurable, achievable, realistic, and time-bound) indicators to measure the implementation to understand the progress towards achieving each goal. An operational plan that discusses each institution/ stakeholder's tasks should be drafted and monitored along the year. An annual report should be drawn that summarizes the achievements, best practices, lessons learnt, and recommendations of each year and the plan for the following year. The report should be accompanied by a dissemination plan to spread knowledge and ensure accountability.
The evaluation of the implemented policies and projects should be carried out to know what works, what does not work, and why. This would ensure a continuous learning process and the achievement of short and long-term objectives.

Limitations and unanticipated consequences

Limitations might come from some government agencies› reluctance to participate in this committee along with the unpleasant reputation of some other committees formed to solve fundamental problems facing Egypt and do not achieve the set results.

Alternatives Analysis

Risks and Risks Mitigation

Risk	Likelihood of Occurrence	Impact on the Implementation of the Policy	Mitigation Strategy
Rivalry between relevant stakeholders	Medium	The involvement of different stakeholders with different agendas might affect the productivity and quality of work produced by the committee and the overlapping of other institutions' mandates.	A strict set of regulations for the committee should be set to describe each institution's responsibilities and roles.
Difficulty in electing stakeholders from the community and involving the CSOs	Medium	The committee will not represent all relevant stakeholders.	Political mobilization to assure the importance of the attendance of relevant stakeholders to achieve tangible results.
Political sensitivity of the issue	High	The political sensitivity of the issue might act as a barrier to international organizations and donors' participation.	

Conclusion

During the work on this paper, the main goal was to find the best solutions and alternatives through which the Egyptian government could maintain "Egyptian water security". To achieve such a crucial goal, the paper examined the most significant problems that threaten Egypt's water security and found that the most notable of them is the rapid rates of population increase, as well as climate change and what it represents from challenges for the region in general and Egypt in particular, and the risks that are expected to result from the completion of the construction of the GRED.

The paper also found out that the government has tried to take a set of measures and policies that would reduce these risks, whether by issuing a set of legislations or preparing a new one, which is still under study until this paper›s date›s issuance. All these legislations are in the direction of regulating water resources and irrigation, conservation of water resources, or through the preparation of a set of ambitious plans, such as the MWRI's plan for the period from 2017-2037, and Egypt's 2030 vision, which aims in its essence to preserve water resources as well as develop them. To implement these plans, the study found that the government has embarked on the implementation of many projects,

Conclusion

whether related to water desalination or working on changing irrigation systems and developing new methods, trying to reduce losses from canals, and working to make the best use of rainwater and groundwater.

All the policies are facing a set of ooportunities and challenges, which limit its ability to achieve the desired objective. To overcome these obstacles, this study was carried out, inspired by international case studies and best practices, and by examining the most prominent opportunities and barriers related to the environment in which policies are implemented and carrying out a stakeholders' analysis.

The paper attempted to give answers to the main research questions, which are: "1) How can the government implement policies that can help water conservation in Egypt, 2) How can Egypt create alternative water sources?" by proposing a set of main suggested alternatives to overcome these problems and achieve the main objective of the study. After applying the suggested suitable analysis based on a set of technical, administrative, political and economic criteria and according to the selected decision rule for the study, which is cost and time as well as effectiveness, the study found that **"Improving the institutionalization of water management"** is the most efficient alternative. Through the government, it can achieve its objective and it can be the appropriate answer for the study questions if applied concerning its conditions and avoid its mentioned limitation, side by side with the paper suggested recommendations.

Actionable recommendations and aiding strategies

For the selected policy option to achieve optimum results, it is crucial to implement aiding strategies that are put in place to facilitate the realizationon of the main objective, which is «future water security». These strategies are designed to work hand-in-hand with the already chosen policy option. This ensures that the root causes of the problem are not neglected but attended to in the most timely and realistic way. The recommended aiding strategies are as follows:

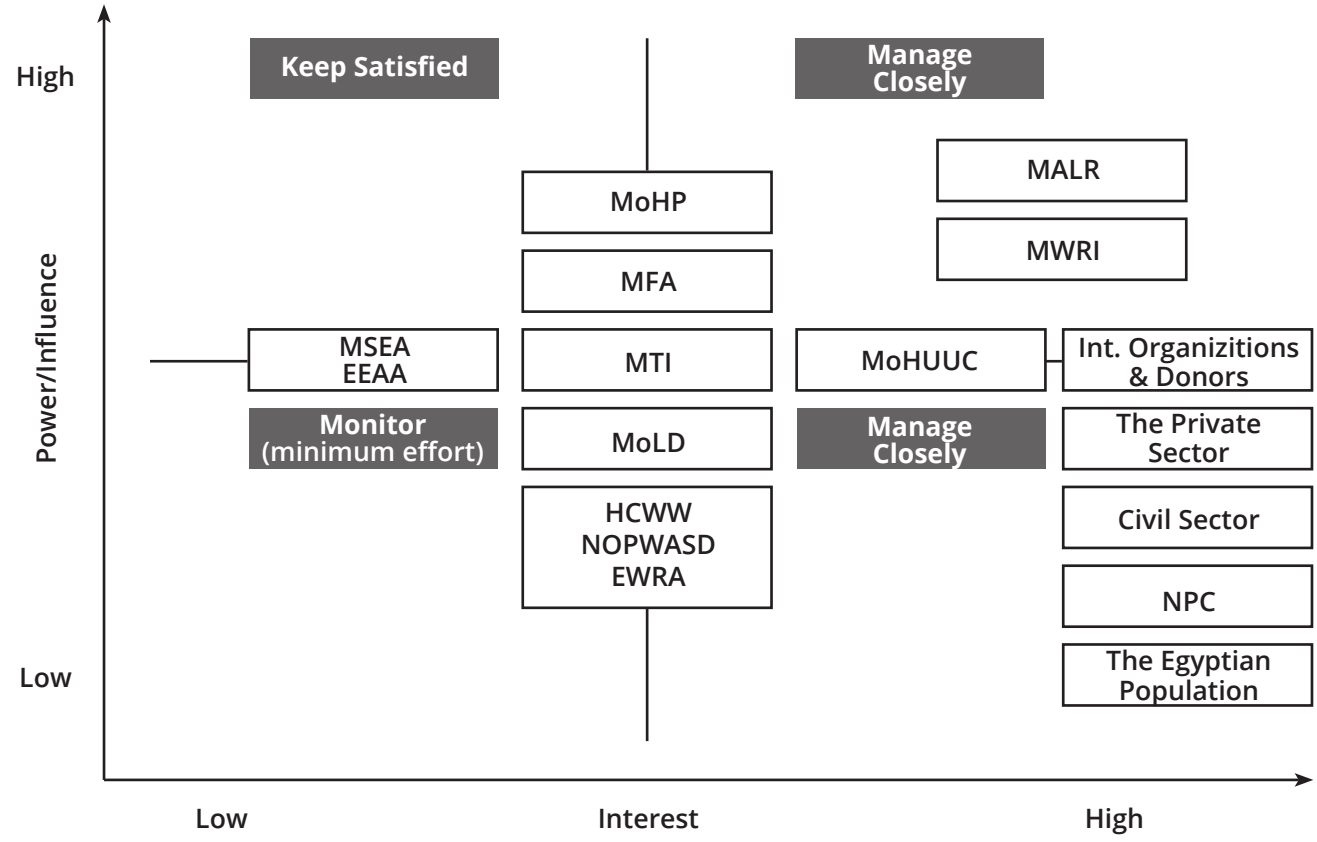
- Devloping a framework that aligns water security with larger socio-economic goals. The plan for distributing water among the various economic sectors must consider the cost, the new economic development requirements, and the other social aspects related to food security and poverty reduction.
- Depending more on crops of high economic value that consume less water and change the crop composition, considering the importance of water used in agriculture and production to maximize the value of water in the agriculture sector.
- Defining a policy through the competent government agencies in cooperation with the beneficiaries on all levels ensures that everyone is represented to improve agricultural production and maximize water productivity.
- Establishing and developing a comprehensive agricultural and climate information base for use in irrigation management.
- Policies must reduce the water footprint by using production technologies that require less water to produce a unit of product, and the government should use virtual water imports as a tool to reduce the pressure on the local resources of water.
- Encouraging the private sector's participation in financing, developing and operating irrigation systems, and preparing a long-term action plan for participation between the public and private sectors in implementing water projects. Improving the governance framework is essential to attract the private sector to participate in water projects.

Conclusion

- Preparing a strategic plan to improve water use efficiency by using economic tools for water governance, such as cost replacement. This is considered an essential tool for sustaining and securing water resources, and this can be applied to new lands as a first stage. Cost substitution is devoted to maintenance and operating costs, considering the need to reform the subsidy system to emphasize and guarantee support for the poor.
- Promoting dialogue between the government and civil society through workshops and seminars.
- Encouraging user participation in water resources management and decision-making processes and strengthening water user associations' role and function through capacity building programs and training courses.
- Increasing societal awareness of the water problem, the current and future challenges, and the need to change the current crop composition to improve water use efficiency by conducting a massive awareness campaign that includes all ministries and relevant institutions.
- Improving legal and regulatory tools, increasing institutional management efficiency, and forming bodies to implement water and environmental laws at all levels.
- Organizingng regional workshops or implementing regional projects in water governance to exchange experts and experiences and benefit from other countries' experiences.

Annexes

Annex #1 Stakeholders Analysis



Annexes

Annex #2 Criteria Analysis

Criteria	Sub Criteria	1st Policy Alternative	2nd Policy Alternative	3rd Policy Alternative
Technical Criteria	Effectiveness	High	High	Moderate
	Technical Feasibility	Moderate	High	High
Administrative Criteria	Commitment	High	Moderate	Moderate
Political Criteria	Acceptability	Moderate	Moderate	Moderate
Economic Criteria	Cost	High	Low	Low

References

Abdelhaleem, F. S., & Helal, E. Y. (2015). Impacts of Grand Ethiopian Renaissance Dam. British Journal of Applied Science & Technology, 8(5), 461-483.

Ahram Online. (2017, December 26). Egypt's water resources plan for 2037 to cost EGP 900 bln, irrigation minister tells parliament. https://english.ahram.org.eg/NewsContent/286036/64/1/Egypt/Politics-/Egypts-water-resources-plan-for--to-cost-EGP--bln,.aspx

Ahram Online. (2016, May 23). Egypt's freshwater share per individual decreases by %1.5: CAPMAS.. http://english.ahram.org.eg/NewsContent/217433/64/1/Egypt/Politics-/Egypts-fresh-water-share-per-individual-decreases-.aspx

Al-Bawaba News. (2019, August 6 .(25 million tons of rice is expected to be produced in 2019. https://www.albawabhnews.com/3705370

Al-Saeed, M. (2019). Large groundwater reserves in the eastern desert of Egypt. Scientific American Journal in Arabic. https://cutt.us/vSzIr

Al-Sharq Al-Awsat. (2017). Fears of wastewater treatment despite the benefits. https://cutt.ly/ajYPtoc

American Chamber of Commerce Egypt (AmCham). (2017, April 2). Egypt's Strategy for Managing Water Resources. http://www.amcham-egypt.org/Presentations/HighlightsfromWater20%MinistersAprl2Speech.pdf

Annan, K. (2001, March 12). Message of UN Secretary-General on World Water Day.

Ashmawy, K. (2018, November 14). Water Issues, Challenges and Solutions. State Information Service (SIS). https://cutt.ly/njYUf1z

Barnes, J. (2014). Mixing waters: The reuse of agricultural drainage water in Egypt. Geoforum, 191-181 ,57. https://doi.org/10.1016/j.geoforum.2012.11.019

Bedawy, R. (2014). Water Resources Management: Alarming Crisis for Egypt. Journal of Management and Sustainability, 124-108 ,(3)4. http://dx.doi.org/10.5539/jms.v4n3p108

Central Agency for Public Mobilization and Statistics (CAPMAS). (2020). Water Balance for Egypt. https://enterprise.press/wp-content/uploads/202089125033/09/2020_water-resources.pdf

Daily News Egypt. (2020, July 15). Egypt explores using modern irrigation methods in 175,000 feddan land. https://dailynewsegypt.com/15/07/2020/egypt-explores-using-modern-irrigation-methods-in-175000-feddan-land/

Dakkak, A. (2020, August 11). Egypt's Water Crisis – Recipe for Disaster. Echoing Sustainability in MENA (EcoMENA). https://www.ecomena.org/egypt-water/

References

De Stefano, L., Svendsen, M., Giordano, M., Steel, B. S., Brown, B., & Wolf, A. T. (2014). Water governance benchmarking: concepts and approach framework as applied to Middle East and North Africa countries. Water Policy 16(6), 1121–1139. https://doi.org/10.2166/wp.2014.305

Egypt Today. (2020, April 11). Egypt Upgrades irrigation system over more than 7k feddans. https://www.egypttoday.com/Article/1/84565/Egypt-upgrades-irrigation-system-over-more-than-7K-feddans

Egypt Today. (2020, August 28). Saving rain drops, Egypt dug more than 6K wells to collect water in four governorates. https://www.egypttoday.com/Article/1/91364/Saving-rain-drops-Egypt-dug-more-than-6K-wells-to

El Baradei, S. A. (2013). Saving on Energy of and Determining the Best Location of Water Treatment Plant along Rivers Depending on the Effect of Broad Crested Weir on Dissolved Oxygen Concentrations in Water. Journal of Clean Energy Technologies, 1(3), 202-205. https://cutt.ly/axgU50s

El-Saddek, A. (2010). Water desalination: An imperative measure for water security in Egypt. Desalination 250(3), 876-884. https://doi.org/10.1016/j.desal.2009.09.143

Enterprise. (2020, September 20). Every drop counts: Why is Egypt losing so much of its drinking water? https://enterprise.press/stories/2020/09/23/every-drop-counts-why-is-egypt-losing-so-much-of-its-drinking-water-22344/

Fatta, D., Alaton, I. A., Gokcay, C., Rusan, M. M., Assobhei, O., Mountadar, M., & Papadopoulos, A. (2005). Wastewater Reuse: Problems and Challenges in Cyprus, Turkey, Jordan and Morocco. European Water, 11(12). 63-69. https://cutt.ly/uxgSFLH

Gomaa, A. (2020, July 4). Deputy Minister of Health: 3 Scenarios expected for Egypt's population in Egypt 2050. Masrawy. https://cutt.ly/mjYF4a4

Hassan, A. (2020, June 9). Questions and Answers. Can seawater desalination plants succeed in achieving water security for Egypt? Al-Youm Al-Sabea. https://cutt.ly/XjYIvYR

Hassan, A. (2017, May 30). Housing enters the challenge of "triple treatment" to purify wastewater. Al-Youm Al-Sabea. https://cutt.us/nKfD7

Hassan, A. (2016, October 28). Experts: 51 billion cubic meters annually are the proceeds of rainwater in Egypt. Al-Youm Al-Sabea. https://cutt.us/O9sSu

Hassan, K. (2013). Impacts of Future Climate Change on Egyptian Population. Proceedings of XXVII IUSSP international population conference. https://cutt.ly/SxgJqea

Helal, M. (September 28, 2020). Ethiopia's Power Play on the Nile Has Left the Region in a Deadlock. Foreign Policy. https://foreignpolicy.com/2020/09/28/renaissance-dam-ethiopia-egypt-negotiations/

References

Jad, I. (2020, August 15). 5 billion cubic meters of water provided by the project of lining canals in the first phase. Rosal Al-Youssef. https://cutt.us/4MnnF

Khalil, A. (2020). The government restores the civilizeded form of canals and banks by lining them with the governorates. Sada Al Arab. http://www.sada-elarab.com/543146

Mekonnen, D. Z. (2010). The Nile Basin Cooperative Framework Agreement Negotiations and the Adoption of a 'Water Security' Paradigm: Flight into Obscurity or a Logical Cul-de-sac? The European Journal of International Law, 440-421 ,(2)21. https://doi.org/10.1093/ejil/chq027

Ministry of Planning and Economic Development (MPED). (2020). Egypt's Vision 2030. https://mped.gov.eg/EgyptVision?lang=en

Ministry of Water Resources and Irrigation (MWRI). (2005). National Water Resources Plan for Egypt 2017. http://extwprlegs1.fao.org/docs/pdf/egy147082.pdf

National Population Council (NPC). (2014). National Population and Development Strategy 2030 – 2015. Baseera. http://www.baseera.com.eg/Publications/PopulationStrategy.pdf

Negm, A. M., & Abdel-Fattah, S. (2019). A View from Egypt. In Grand Ethiopian Renaissance Dam Versus Aswan High Dam. Springer. https://link.springer.com/content/pdf/8-95600-319-3-978/10.1007.pdf

Omar, M. & Moussa, A. (2017). Water management in Egypt for facing the future challenges. Journal of Advanced Research, 412-403 ,(3)7. https://doi.org/10.1016/j.jare.2016.02.005

Qadir, M., Sharma, B. R., Bruggeman, A., Choukr-Allah, R., & Karajeh, F. (2007). Non-conventional water resources and opportunities for water augmentation to achieve food security in water-scarce countries. Agricultural Water Management, (22-2 ,1(87. https://doi.org/10.1016/j.agwat.2006.03.018

Rached, E. & Brooks, D. (2010). Water Governance in the Middle East and North Africa: An unfinished agenda. International Journal of Water Resources Development, 155-141 (2)26. https://doi.org/07900621003693321/10.1080

Radwan, I. (2018. December 2). Academics: Pointing and alternative crops save billions of meters of wasted water. Al-Ahram Gate. http://gate.ahram.org.eg/News/1825382.aspx

Rady, R and Omar, M. (2018, , July 3). Water resources management in Egypt: Assessment and recommendations. Alternative Policy Solutions. https://aps.aucegypt.edu/en/articles/470/water-resources-management-in-egypt-assessment-and-recommendations

Rahman, M. A. (2012). Water Security: Ethiopia–Egypt transboundary challenges over the Nile River basin. Journal of Asian and African Studies, 46-35 ,(1)48. https://doi.org/0021909612438517/10.1177

References

Romano, O & Akhmouch, A. (2019). Water Governance in Cities: Current Trends and Future Challenges. Multidisciplinary Digital Publishing Institut, 11(3), 500. https://doi.org/10.3390/w11030500

Sanchez, A., & Subiela, V. (2007). Analysis of the water, energy, environmental and socio-economic reality in selected Mediterranean countries (Cyprus, Turkey, Egypt, Jordan and Morocco). Desalination, 203 (1-3), 62-74. https://doi.org/10.1016/j.desal.2006.02.017

Singapore's national water agency (PUB). (2021, Feb 10). Singapore Water Story. https://www.pub.gov.sg/watersupply/singaporewaterstory

Times of Israel. (2018, August 26). Fears of water shortages in Israel after 6 consecutive years of drought. https://cutt.ly/Gjf2a9v

World Bank. (2007). Making the most of scarcity: Accountability for better water management results in the Middle East and North Africa. https://doi.org/10.1596/978-0-8213-6925-8

World Bank. (2018). Water scarce Cities: Thriving in a finite world. https://doi org/10.1596/29623

Tsoar, H., & Zohar, Y. (1985). Desert dune sand and its potential for modern agricultural development. In Gradus Y. (Eds), Desert Development (pp. 184-200). Springer, Dordrecht. https://doi.org/10.1007/978-94-009-5396-3_12

UNICEF. (2016). La lutte contre le changement climatique. https://www.unicef.fr/sites/default/files/fiche_thematique_changement_climatique_0.pdf

UN-Water. (2013). Water security and the global water agenda: A UN-Water analytical brief. file:///C:/Users/allam_mar/Downloads/analytical_brief_oct2013_web.pdf

United Nations. (2020). Sustainable Development. Retrieved from The Sustainable Development Agenda: https://www.un.org/sustainabledevelopment/development-agenda/

Washington, R.(2019, December 15). How Africa will be affected by Climate Change. BBC https://www.bbc.com/news/world-africa-50726701

Yehia, A., Fahmy, K., Mehany, M, & Mohamed, G. (2017). Impact of extreme climate events on water supply sustainability in Egypt: case studies in Alexandria region and Upper Egypt, Journal of Water and Climate Change, 8 (3): 484–494. https://doi.org/10.2166/wcc.2017.111

References

Zain, H. (2019, October 3). Egypt's sewage system turns from a curse into wealth with the largest projects in the Middle East. The Egyptian Observatory. https://marsad.ecsstudies.com/10149/

Zeitoun, M. A., Allan, J., & Mohieldeen, Y. (2010). Virtual water 'flows' of the Nile Basin, 1998–2004: A first approximation and implications for water security. Global Environmental Change, 20 (2), 229-242. https://doi.org/10.1016/j.gloenvcha.2009.11.003

THE PUBLIC POLICY HUB

Where Rigour Meets Creativity

The Public Policy HUB is an initiative that was developed at the School of Global Affairs and Public Policy (GAPP) in October 2017. It was designed to fill in the policy research gap in Egypt. It provides the mechanism by which the good ideas, plausible answers, and meaningful solutions to Egypt's chronic and acute policy dilemmas that are proposed by the country's best minds, the experienced and the creative from different age brackets, can be nurtured, discussed, debated, refined, tested and presented to policymakers in a format that is systematic, highly-visible and most likely to have a lasting impact.

It is designed to develop a cadre of well-informed and seasoned policy developers and advocates, while simultaneously fostering and promoting creative solutions to the challenges facing Egypt today. The project provides a processing unit or hub where policy teams are formed on a regular basis, combining experienced policy scholars/mentors with young creative policy analysts, provide them with the needed resources, training, exposure, space, tools, networks, knowledge and contacts to enable them to come up with sound, rigorous and yet creative policy solutions that have a greater potential to be effectively advocated and communicated to the relevant policymakers and to the general public.

Since its establishment, the Public Policy HUB has been supported by Carnegie Corporation of New York, UNICEF Egypt, and Oxfam. The Hub had partnerships with different ministries and governmental institutions like the Ministry of Social Solidarity, Ministry of Planning, Ministry of Health, Ministry of Trade and Industry, Ministry of Local Development, Ministry of Education, Ministry of Environment, National Council for Childhood and Motherhood, National Population Council, and General Authority For Transportation Projects Planning.

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