

BEYOND SCARCITY: AN ASSESSMENT OF WATER MANAGEMENT IN EGYPT FROM A POLITICAL ECOLOGY PERSPECTIVE*

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Abstract

Water management constitutes a challenge for contemporary Egypt, as the country faces a water shortage that, in certain areas, might endanger the basic needs of people in the dry season. This article seeks to understand the origin of water problems, and argues that beyond existing scarcity due to environmental challenges, current sociopolitical conditions play a significant role. Egypt is socially, economically, and environmentally in a difficult position to be sustainable. The paper utilizes the political ecology approach to shed light on the nexus between the fields mentioned above and tries to create an integrated and comprehensive strategy to analyze the water problems and possible solutions for contemporary Egypt. SWOT analysis helps evaluate the existing conditions (strengths and weaknesses) and potentialities (opportunities and threats) for the Egyptian agriculture and water management sector. Three different angles are utilized during the analysis: the infrastructural background (the economic aspect), the institutional basis (the political aspect), and the international impacts (the environmental aspect) that affect water policy. Regarding the mounting challenges, a slow change of the system is expected, but negative changes in the natural environment could accelerate pressure on Egyptian society and government to adjust. However, the support of international partners to maintain a politically and socially stable Egypt contributes to maintaining archaic political-economic structures that are unsustainable.

Keywords

Egypt, ecology, Nile, water scarcity, military, SWOT

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Introduction, the problem

Over the last few decades, there has been a growing interest in water scarcity issues in the MENA (Middle East and North Africa) region, especially in Egypt—the most populous Arab country. This article seeks to identify the origin of water problems, and argues that beyond existing scarcity due to environmental challenges, current socio-political conditions play a significant role.

Although water scarcity has been on the political agenda in Middle Eastern countries for decades, policy responses and governmental processes often lack long-term solutions and the implementation of clear-cut strategies. This is because water management is fragmented, influenced by different goals and vested interests, and subject to competition between different stakeholders. Moreover, this organizational challenge, coupled with the demographic boom (increasing number of people in general and higher population density in urban areas), is a common feature of every Middle Eastern country (Joffé 2016). As a result, the extensive growth in water demand contributes to the degradation of the natural environment and human living conditions. This negative feedback of increasing unsustainable water consumption and climate change points towards a demographic catastrophe and an emergency in migration, especially in countries with severe policy and resource problems in sustaining basic living conditions.

Water management constitutes a challenge for contemporary Egypt, as the country faces a water shortage that, in certain areas, might endanger the basic needs of people in the dry season (Ezz & Arafat, 2015). Today “Egypt has reached a state, where the quantity of water available is imposing limits on its national economic development” (Ouda & Zohry, 2016, p. 2), and soon, water shortage might reach 26 billion cubic meters per year under current circumstances (Omar, 2016). Therefore, it is not surprising that water-related problems have emerged as pressing issues for the contemporary narratives, and this condition has given rise to the expectation that policymakers and communities need to tackle this relatively new crisis.

Literature analysis

Concerning the impacts of water scarcity, scientific research examined various topics related to water management, such as agriculture, climate change, and governmental development plans. The Nile water degradation (both in quality and quantity) has received media attention lately (*Saving the Nile* 2020, *Death of the Nile*, 2017).

Although there are studies on the projection of water supply in Egypt in the upcoming years (Omar and Moussa 2016), they mainly concentrate on the statistical basis of their models and disregard the “factors of uncertainty” such as the political, economic, and social background of water management (Omar, 2016). Other studies only have the angle of political analysis (neglecting the technical and management-related issues) or ignore the potential negative impact of the Grand Ethiopian Renaissance Dam on Egypt. Studies dealing with the effect of the Ethiopian project usually neglect the domestic conditions of Egyptian water management. From the perspective of thorough examination, it is crucial to relate the technical background

of water management practices (Abdelsalam et al., 2014; Barnes, 2017; El-Ramady et al., 2019; Ouda et al., 2017) to the “socio-political reality” of Egypt and consider environmental factors as well. Water utilization is more than well-designed models. As Jessica Barnes writes, “the supply side of a national water budget cannot be captured in a simple summation of rainfall, groundwater, and surface water inflow. Instead, what water comes to be is the outcome of social, biophysical, technical, and political processes that produce particular quantity and quality characteristics in any given time and place” (Barnes, 2014, p. 3). Some literature points towards a direct connection between climate vulnerability, state fragility, and the Arab Uprisings (Ayeb & Bush, 2019; Werrell et al., 2015). There are extensive studies

on the cultural importance of the Nile as the primary source of water for Egypt. They also represent an important aspect of the difficult and complex issue of water management (Oestigaard, 2018).

However, investigations are missing from the literature to understand the relationship between the political and environmental aspects of the management practices dealing with water scarcity. Moreover, an updated version of the previous water management studies also makes this current investigation relevant, especially considering Egypt’s growing external and internal challenges recently. Compared to the existing literature, this research extends the scope of analysis to developments in previous years and provides current data on the issues discussed in this study.

Conceptual framework

The concept of water scarcity utilized in this study supports the claim that water issues are inherently connected to politics, economy, and society; therefore, the analysis of water management should cover these aspects for a comprehensive understanding of the phenomena. Three types of water scarcity can be distinguished:

1. Physical water scarcity means the (almost) total lack of water in a specific area that makes it virtually impossible for people to settle there. Egypt is a region dominated by vast deserts, which are characterised by physical water scarcity.
2. Economic water scarcity, however, is related to everyday water usage and is determined by the effectiveness of governance (both on political and technical levels), management (overconsumption, waste, and pollution), and (social) distribution of available water resources. Economic water scarcity encompasses all water-related activities connected to the producers, consumers, and authorities

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that are tasked with transmitting resources. Here, cultural and identity-related issues regarding water can also be mentioned. The author argues that some of the decrease in water resources can be attributed to economic water scarcity in Egypt.

3. Demographic water scarcity constitutes the third type of water scarcity based on the condition that a specific territory has a limited ecological carrying capacity. Therefore, the rapid increase in the population exerts severe pressure on the natural environment (especially on water resources) and challenges the existing (traditional) water governance structures. For example, more people in cities means a higher concentration of water demand in one specific area. This puts enormous stress on the water delivery infrastructure to provide potable water. Due to the accelerating effect of climate change, demographic water scarcity can eventually lead to physical water scarcity in the long-term. In Egypt, the demographic boom causes significant environmental degradation and unsustainable modes of consumption.

These three types of water scarcity shed light on the interconnected nature of water management. For example, climate-related difficulties escalate the water problems for human activity, which in turn require more extensive social and economic resources to be mitigated. Although climate and environmental conditions for an area (country) are predetermined, a dedicated and harmonized approach to social and economic activities helps reduce the adverse external effects of the environment and supports the implementation of sustainable and flexible water management practices. To achieve this goal, a community must build on a broad consensus of economic and political participation; otherwise, ineffective management patterns might reproduce themselves, causing vicious circles of environmental degradation and deteriorating human conditions.

Another concept that this research utilizes is political ecology. Political ecology deals with the interconnected issues of politics, society, and economy in an interdisciplinary way to analyze complex questions related to the natural environment. Therefore, this approach creates a nexus between the fields mentioned above and tries to create an integrated and comprehensive strategy to analyze the water problems and possible solutions for contemporary Egypt.² Beyond the apolitical studies of ecology, using this nexus is inherently political. It includes the management of the cooperation and cohabitation among the members of the society and social groups. By its nature, political ecology focuses on the social inequalities shaped by the uneven distribution of natural resources, environmental benefits, and costs. At the same time, it also deals with how the changing environment affects the social situation, thereby making a reciprocal relationship between society (polity) and nature (ecology).

Verhoeven (2015) grasped this nexus differently, arguing that water, food, energy, and climate are interconnected and anchored in political struggles. Verhoeven (2015) claimed that the spectre of modernization and the state-centered view of Egyptian

history and contemporary politics are part of the modern Egyptian state's aims to control, allocate, and develop national resources (such as water) through megaprojects. Molle et al. (2009) call this system "hydrocracy," which, in practice, means the domination of water resources by state institutions for the sake of the political and economic power of a minority (the elite) and to the detriment of the majority (the everyday users). Similarly, the current Egyptian government uses old patterns and launched large-scale capacity expansion measures (new desalination plants, land reclamation projects, building new cities) instead of allocating more resources on specific, local level policies to manage water consumption. Playing the politics of grandeur seems to be an incontestable part of Egypt and its long history of megaprojects.

Aims, questions, and methods

The study is designed to answer the following questions within the nexus of environment, economy, and politics:

- What are the environmental challenges that Egypt has encountered? (environmental and political nexus)
- How does Egypt manage its scarce natural resources? (political and economic nexus)

To answer these questions, this study is based on data provided by different designated ministries of water management (ministries of agriculture, environment, investment, local development, water resources, and irrigation). A SWOT analysis is conducted in the discussion section to analyze the existing conditions (strengths and weaknesses) and potentialities (opportunities and threats) for the Egyptian water management sector. In the SWOT analysis, the Egyptian water management sector is examined from three different angles:

- infrastructural background (the economic aspect)
- institutional basis (the political aspect)
- international impacts (the environmental aspect) (Dudlák, 2018)

It is expected that the example of Egypt shows the broader implications of government policies related to water poverty in different MENA countries and provides a basis for detailed, technical, and implementation studies for each recommendation with a possible way forward to tackle water scarcity in the region. The case study of Egypt can also be comparable to other countries across the world experiencing water crises. This research compliments other studies examining best practices of water management (both on institutional and individual levels) to counter water scarcity problems.

The research argues that there are three sets of factors that are responsible for the water crisis in Egypt:

1. natural (physical water scarcity): serious environmental challenges (deteriorating water resources both in quality and quantity, climate change)

2. political and economic (economic water scarcity): weak management with political factors having priority over economic rationale (old water usage techniques, inefficiency, lack of private investment)
3. human or social (demographic water scarcity): population growth (a sudden increase in demand)

In the following sections, the author provides historical, empirical, and statistical data on each of these challenges. In the analysis, there is a particular focus on the post-Arab Spring period to see how political turmoil over the past decade affected the nexus between social, economic, and environmental factors, and how internal and external factors created new conditions for and challenges to water management in Egypt.

Current conditions and environmental challenges

Water resources in Egypt

The Nile is the longest river on Earth, flowing 6695 km and collecting water from one-tenth of Africa's territory (an area of about 3.2 million km²) (*Atlas Nile Basin*, n.d.). Its location from the climatic perspective is unfavorable: its valley spans tropical, subtropical, and desert zones and it is overly exposed to deforestation, negative soil processes, general temperature increases due to global climate change, and extreme weather conditions. These harsh external conditions are accompanied by political diversity: eleven countries share one area of the watersheds. These countries are significantly different in their allocation and utilization of the Nile; however, they must cope with a drastic population increase. Therefore, the locals are extensively dependent on the river. The number of people who live directly in the Nile Basin is estimated to be 257 million, which is around 53% of the total population of Nile Basin countries (*Atlas Nile Basin*, n.d.). Rising population means rising demand for food, water, and energy—and the river has a limited capacity to meet these requirements. Another unfavorable condition regarding the internal circumstances of the region is that the Nile River valley is full of conflict zones with political and social instability (partly due to scarce resources and rising needs). These fights over resources constitute another factor in inadequate management and misuse of valuable resources.

Egypt is the largest consumer of water from the Nile, and its water supply is 96% dependent on this river. The remaining 4% of water resources are groundwater, minimal water supply from the Sinai Peninsula and the deserts, and some rain over the year (El-Nasha & Elyamany, 2018, p. 2383). Water utilization is manifold: drinking water, household consumption (washing, cooking, cleaning), agriculture, fishing, tourism, transportation, and energy production. The Statistical Office of Egypt (CAPMAS) states that the per capita water resources were 2,526 m³ in 1947, 1672 m³ in 1970, and only 663 m³ in 2013. According to a projection, by 2025, this number will be reduced to 582 m³ per person. The limit for absolute water shortages is 500 m³ water per capita per year (Water resources, 2014).

Currently, the amount of water used by irrigation agriculture in Egypt is 59 billion cubic meters (bcm) per year. It is estimated that only 60% of this amount is de facto consumed, and 40% is lost (Negm et al., 2019, p. 353). It is estimated that the total Egyptian water demand could reach 79.5 bcm per year. There is, therefore, a considerable difference between the amount of water available and the water demand (Ouda, 2016, p. ix).

Currently, Egypt's population is more than 100 million and it is estimated to rise to 120–150 million by 2050. Enormous population growth increases the need for food and significantly increases the size of built-up areas at the expense of agricultural activity. For example, between 1975 and 1995, Egypt lost roughly 220,000 ha of agricultural land along the Nile due to urbanization (Satoh & Abouloos, 2017, pp. 267–268).

Agriculture

In Egypt, the importance of agriculture goes beyond its traditional, historical role, constituting a significant part of the national economy today (14.6% of GDP and about 55% of the population are connected to the agricultural sector) (*Egypt's National Strategy*, 2011, p. 61). The agricultural sector is also the most significant water user (80–85%), which not only produces food for people but provides export income for the state and raw materials for industrial activities (El-Nashar & Elyamany, 2017).

In 1960, Egypt was completely self-sufficient in terms of basic food commodities. However, apart from wheat, there is now a gap between the production and consumption of basic food. This supply challenge lies in the center of food security in Egypt and determines its economic and social stability (Ouda & Zohry, 2017, p. 1). According to Ouda, Zohry, and Kamel (2017), “The concept of food security is based on three main pillars, food availability, food accessibility, and food stability” (p. 91). Accessibility means the reasonable and affordable price of basic food commodities.

The data indicate the social importance of wheat: one-third of the average daily calorie intake in Egypt comes from this food staple (Ouda, 2016, p. 34). After wheat, rice is also an essential source of food, and Egypt produces more rice than it consumes, making it a major export (Ouda, 2016, p. 70). Although it is not a food staple, cotton provides material for the textile industry and it has played an essential role in the extensive development of Egyptian agriculture since the 19th century.

Given the scarcity of water resources, in 2016 the Egyptian government decided not to allow rice cultivation in the country except for six provinces. This has reduced rice production by one-third, saving much water for other agricultural activities (Egypt decreases, 2016). Egypt loses 200,000 ha of land with every billion cubic meters of water loss. In the absence of irrigation, the desert takes over the cultivated areas.

The dependence on imports can become the catalyst for unfortunate events. Egypt is among the world's largest wheat importers. In 2010, when changing weather patterns led to wheat shortages globally, the Egyptian state could not secure wheat prices in rural areas as prices tripled. By early 2011, discontent had led to anti-

regime protests, which resulted in the fall of President Mubarak (1981-2011) (Werrell et al., 2015, p. 35).

Egypt has significant fish-farming capacities (ninth globally and the first in Africa) (Soliman & Yacout, 2016). The murky waters of the Nile are less conducive to fish farming. Half of the Nile species are extinct, partly due to the disruptive effect of the High Aswan Dam on the reproductive practices of aquatic organisms. Moreover, water quality has caused fish to be contaminated with heavy metals and inorganic nitrogen. The focus of fish management is shifting from the river to artificial lakes. However, this is not enough to satisfy local fish consumption, so imports are needed in this area as well.

The position of agriculture in this scarce water situation is challenging. Every time the country suffers from unmet water demand, more crucial sectors of consumption (such as the households and the industrial sector) are preferred to receive the water available for use. Water deficit is partly compensated by the excessive use of groundwater resources that are only partially renewable.³ The summer months are particularly trying. Due to the widespread drought and low water in the Nile, cities remain without water supplies for days, making it difficult for vital services such as hospitals to function effectively. In Cairo and other major cities, thousands were forced to illegally tap the official water network with their fabricated water pipes. Since water is a vital element of existence for citizens and legal access is mostly unaffordable, the authorities turn a blind eye to the situation. The problem is that the handmade water pipes are less efficient than when they are officially connected to the network.

The challenge of climate change

Agricultural activity in coastal areas of the Nile Delta is also at risk. On the one hand, the nutrient-rich sediment of the Nile does not make it to the sea, so the coastline is disappearing for the first time in thousands of years. On the other hand, the coastline is also threatened by rising sea levels (according to some measurements ranging from 3.7 to 7.7 mm per year). The advancement of the sea threatens agricultural production because it makes land and water salty in production areas (Mahmoud 2019). According to estimates, the salinity build-up problem in the northern part of the Nile Delta affects roughly 900,000 ha of land (Ouda, 2016, p. 108.) In coastal production areas, the danger is also exacerbated by the increasing number of strong winds and storms. Therefore, natural and artificial coastal natural protection (dunes) play a prominent role in reducing these adverse effects. Thus, any activity to reduce them (e.g., mining) is harmful (Malm & Esmailian, 2012, p. 482; Stanley & Clemente, 2016). Egyptian authorities say that due to rising water levels and seawater intrusion, the living environment and livelihoods of up to five million people could be at risk (Hussein, 2018).

As a result of increasing temperature, the level of evaporation and demand for water from agriculture and humans in general will continue to rise in Egypt (Ouda, 2016, p. 25). It is not clear how rising temperatures affect the origin of the Blue Nile

in Ethiopia (Barnes 2017) as the primary source of water for the region (the increase or decrease in precipitation during the wet season is key here). There is more precipitation in the Ethiopian Highlands than in previous decades, but the distribution of water is irregular and uneven. According to forecasts, fewer and fewer normal years will bring the expected water flow of 70–100 bcm. (Khedr 2019, p. 239).

The negative consequences of an increase in temperature include the significant disruption of certain plants' development period if they are exposed to temperatures that are too high during the summer months (Ouda, 2016, p. 70). The rise of temperature will have worse consequences in Upper Egypt than in Lower Egypt because it is closer to the Mediterranean and periodically receives rain in the coastal regions (Ouda & Zohry, 2016, p. 64).

Political and economic management of resources

The role of the military

In analyzing the water scarcity situation, major Egyptian political and economic stakeholders' interests must be considered. One of the major players in the political economy of Egypt is the army. The army and its joint companies are so embedded in managing people's daily lives that basic public services (water, sewage, garbage), transportation, and construction are carried out by specialized institutions linked to the military establishment. The army also operates restaurants, hotels, and shopping malls. The army has access to a substantial amount of agricultural land, and its subcontractors make remarkable profits from these resources because many of the goods they produce are exported abroad. The main problem is that while these businesses bring considerable benefits (in many sectors, the army enjoys a monopoly and receives most public procurements), these projects are tax-free and lack accountability entirely. Moreover, the army's revenues do not directly increase the budget but serve the enrichment of a narrow group (Abul-Magd, 2019, p. 57). The military is the primary beneficiary of Egypt's energy subsidies as they are massive investors in the energy-intensive economic sectors (Eibl, 2017). (Altogether, subsidies amount to an average of 10% of GDP every year. This is a quarter of the government budget.) (Khan & Miller, 2016, p. 5.)

Liberal reforms and politics of grandeur

Scarce resources and a challenging geographical environment call for serious strategic planning and organization for life in Egypt, which, in theory, confirms authoritarian governance tendencies. Currently, the military has an interest in all strategic sectors. Scarce resources and a political and economic culture allow for corruption to thrive. The experience of liberalization efforts is that while the ruling class accumulates large fortunes, it especially harms people with low income and socio-economic status (Abul-Magd, 2019, p. 56).

As part of the liberalization package, hundreds of public companies have been privatized since the second half of the 1990s. In the early 1990s, Egyptian authorities lifted import and export restrictions to create greater competition for the Egyptian

economy. Mubarak's economic liberalization program was highly praised by the World Bank and the IMF (Roccu, 2013, p. 43). In 1997 the implementation of the land law started, and as a result, almost a million peasants had to leave their lands, and more than 700,000 jobs were lost. Putting the law into force was a violent process, in which "more than 800 tenants were killed in land disputes following the full implementation of the new law, and more than 7,000 were arrested" (Roccu, 2013, pp. 47–48).

Since 2014, the situation for farmers has been made more difficult by constant water shortages and the current increase in the price of fertilizers. The cost of seeds doubled after the government phased out price subsidies. The state's compulsory pricing mechanism has introduced a tool to keep wheat prices low and create the possibility of buying and distributing wheat. However, this is detrimental to farmers' businesses (Rabie, 2019a). As a result of this uncertainty, the willingness to leave agricultural activity behind is very high, which affects not only the major cities of Egypt but also the developed countries of the Western world, which the new generation of Egyptians sees as a target area. Although Egypt's GDP is increasing by 5%, combating poverty would require a GDP growth of 7-8% a year, as the vast population growth significantly consumes real growth. Poverty has only increased since the revolution, standing at 32.5% according to 2015 figures (Kaldas, 2019).

It is commonly known that Egypt is the land of megaprojects. The Pyramids of Giza, the Suez Canal, and the Aswan High Dam are hallmarks of Egypt's ability to create monumental structures during different historical periods. The construction of the latter signified the capabilities of the new nation right after its independence (Mossallam, 2014). The Aswan High Dam provides Egypt with continuous irrigation, as water can be released from the dam's reservoir throughout the year. The dam has enabled agricultural production and production areas to expand significantly. This has also allowed for a double (sometimes triple) annual harvest, which as a negative consequence increased water usage (Negm et al., 2019, p. 353). The power plant connected to the dam provides electricity and the regulated river serves as a

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predictable shipping route for the population. Among the side effects, the river's fertile mud cannot reach the agricultural lands as it did for thousands of years. The dam also increases the number of aquatic weeds in the irrigation canals and contributes to the decay of the Delta's northern shores (Satoh & Aboulroos, 2017, p. 63).

Relying on the steady water flow provided by the Aswan High Dam, the Mubarak government launched the Toshka project in 1997. It uses a 320 km long canal from Lake Nasser into the Western Desert to develop agricultural production in the Toshka Depression. Initially, the project intended to utilize approximately 200,000 ha for agricultural land. The low quality of the land in the target area and considerable evaporation did not make the project feasible. Only a fraction of the expected population settled in the oasis created in the middle of the desert.

Since President Sisi came to power, Egyptian discourse has been dominated by the narrative of megaprojects: the construction of giant desalination plants (*Egypt pledges \$51 billion*, 2018), massive ports, an enormous land reclamation project (an additional 1.5 million feddan,⁴ an increase of 20%) (Galal, 2017), and many social housing projects. The problem with these massive investments is that they are too slow to bring financial return in exchange for too much effort. In fact, in recent decades, it is difficult to find successful examples of urban investment. New cities such as New Qena, New Fayoum, New Toshka, New Sohag, and New Ismailia are still uninhabited or sparsely populated (Rabie, 2019b). In 2015, the new regime started a capital city project east of Cairo. The gigantic project is partly financed by Chinese loans and intends to create a home for 6.5 million people around the new administrative buildings of the government of Egypt. Critics say that the government aims to escape from the overcrowded city of Cairo and distance itself from ordinary people whose presence might severely challenge the government.

Massive projects need huge investments, and the current Egyptian leadership has friends both at the international financial institutions (World Bank, IMF), the Gulf countries, and China. Between 2016 and 2019, the new Egyptian regime borrowed 12 billion USD from the IMF. However, there is a significant price for this support, and the price tag is attached to the poorest people in Egypt. To rationalize the economy, Sisi gradually tried to eliminate food, gas, and medicine subsidies, which made the lives of ordinary Egyptians challenging (Abul-Magd, 2019, pp. 60–61). The government does not wish to open a debate within Egypt that would look at how local socio-economic factors determine how water is utilized, thereby targeting the prerogatives of the local elite (the military-industrial establishment). Instead, Egyptian government policy tries to channel the negative emotions of Egypt's public sentiment outward, claiming that the source of water problems cannot be found in Egypt.

SWOT analysis of the political-ecological environment in Egypt

Based on the previous data and empirical understanding of the situation, the author analyzed the existing and possible factors that can influence Egyptian society's capabilities to overcome political, human, and environmental challenges. These factors are related to infrastructural, institutional, and international factors.

Strengths

- Egypt has a world-class agricultural sector relying on modern technologies and current experience
- Egypt has a vibrant population youth as a result of a demographic boom. Youth can become the core of a dynamic job market, innovation, and economic growth.
- Egypt demonstrates relative governmental stability and organizational capacity of its army compared to other MENA countries.
- Egypt's geopolitical situation makes the country valuable for international interests (trade, investment) beyond agriculture.

Weaknesses

- The land and water resources are limited within Egypt
- Continuous attempts at agricultural modernization produced ambiguous results and controversial megaprojects.
- Monopolized, hegemonic methods of governance centered around political leader and the dominance of the army in politics and economics.
- The majority of the Egyptian population has lost confidence in civil society and relies on state institutions instead (Hamzawy, 2019, p. 160).
- Egypt's agricultural and water policy management faces administrative challenges because the delineation of authority among the designated institutions is obscure, as they have overlapping institutional boundaries (Barnes, 2014, p. 17; Tutwiler, 2021, p. 340.) However, like other sectors in the economy, management of the water sector is highly centralized (Luzi et al., 2008).
- Significant inequalities within society contribute to unequal distribution of land and resources.

Opportunities

- Egypt has far-reaching experience in agricultural technologies
- Egypt developed friendly relations with many powerful countries and international organizations. The country has vested interests in keeping the system alive as the country is too big to fail.
- Natural resources such as gas, wind, and solar power

Threats

- The filling-up period of the Grand Ethiopian Renaissance Dam's reservoir (since summer 2020) will increase water shortages and might lead to political turmoil within Egypt and between Egypt and Ethiopia (Tutwiler 2021, p. 344).
- The dominance of a state-centered tradition: unfeasible megaprojects distract valuable resources from specific, problem-centric local solutions
- Unresolved social conflicts generated by inequalities and religious extremism
- Population increase puts a significant burden on the existing economic system and the environment. The continuous rise of young population can cause social

tensions as the job market capacity to create new positions is too minimal in Egypt.

- Climate change cause environment damage and strengthen existing social inequalities (Jawadi, 2015)
- Security threats from neighboring regions and colliding international interests inside Egypt
- Egypt's reception of international support (politically and financially) might contribute to maintaining an archaic political-economic system that is unsustainable

As it can be seen from the SWOT analysis, certain phenomena encompass opportunities and threats at the same time. In these cases (such as increases in the youth population, the organizational capacity of the army, and the international embeddedness of the country) the successful utilization of strengths and opportunities depends on the management capacity in Egypt or the way human agency plays out during competition between different stakeholders.

7. Recommendations and conclusion

Many research projects have analyzed the ways and methods by which Egyptian society could deal with water scarcity. They formulated several important points for consideration. Mitigating climate change effects can be interpreted as a transformation process, which requires the transition of serious industrial and processing capacities and a break with old production traditions. The best strategy for the government and society is to implement the recommended steps simultaneously, progressing in several ways towards greater efficiency in water management. As a conclusion of this study, the most important strategies of efficient water management are highlighted.

For mitigating the negative impacts of climate change and a decreasing amount of water available, some studies recommended that the Egyptian agricultural system must implement inexpensive and simple water-saving cultivation methods and techniques that help increase production, reduce the amount of water used, enhance the quality of soil, and decrease the emission of greenhouse gases (Ouda, 2016; Satoh & Aboulroos, 2016).

In the field of agriculture, the most important steps are technical. For example, intercropping has many advantages, notably improving soil quality, nutrient content, water efficiency, and productivity. There are variants of intercropping that can be introduced to farmers at nearly no additional cost while increasing efficiency. Crop rotation for two or three years utilized on the same land effectively increases plant yields, and through biodiversity, it contributes to the fertilization of the soil. According to agricultural research, "changing cultivation methods to raised beds can save 20% of the applied irrigation water and increase wheat yield by 15%" (Ouda et al., 2017, p. 92). This method does not include any extra cost; on the contrary, it requires fewer fertilizers and less fuel for irrigation pumps (Ouda, 2016, p. 50).

By curbing rice production, large quantities of water can be released, as the plant's cultivation in the growing period requires large amounts of water (Negm et al., 2019, p. 355). Sugarcane is also a high water-consuming crop mainly because of its long growing season (Ouda & Zohry, 2016, p. 67). Using biotechnology, Egyptian authorities should further increase the quality (nutrition value) of the agricultural products and the soil compounds (removing toxic materials). A higher level of biodiversity increases the ecological system's effectiveness, contributes to natural sustainability, and enables farmers to be more flexible during crises.

Land reclamations have specific limits as they require excess water usage from the Nile, where water shortages are common. The Egyptian government has been focussing on breathing new life into desert areas, attempts that has not yet been unambiguously successful. However, reclaiming lands beyond the Nile alongside the Mediterranean coast, where rainfed agriculture can be maintained, has some potential. (Negm et al., 2019, p. 357)

As for water management, the development of the water distribution network is of paramount importance; technical improvement prevents leakage, the installation of accurate meters disincentivizes overconsumption, and constant monitoring of the network can reduce losses. Raising citizens' awareness of conscious water consumption is particularly important. Overconsumption should be reduced through regulation (Egypt's National Strategy, 2011, p. 84). Farmers' water-saving techniques should also be incentivized, as those who have daily experience dealing with water and land can be highly adaptive to the negative consequences of climate change (Ouda, 2016, p. 119). Cooperation among the governmental, nongovernmental, and local farmer organizations is essential for introducing new technologies, raising awareness, and managing scarce land and water resources.

There is constant development in the reuse of treated wastewater and drainage water. While only 2.8 bcm of drainage water was used per year in the 1980s, the figure rose to 4 bcm in the 1990s and 7.5 bcm in 2011 (Abdelsalam et al., 2014, p. 655). Increasing wastewater treatment can provide solution to local water supply problems and therefore is crucial for the sustainability of the whole water management system.

Evaporation is a significant factor in Egypt as the country is subject to extreme heat in the summer. Covering the irrigation canals of the country (the estimated length is 31,000 km) would reduce evaporation loss, and irrigation at night could also save water (Omar & Moussa, 2016, p. 407). The introduction of drip irrigation bears enormous costs, but a significant amount of water can be saved and the production yields can rise.

The Egyptian leadership needs to implement changes in the infrastructural background and the economy's institutional basis to address the environmental impact on economic sectors. Egypt needs to fully utilize its existing strengths and potential opportunities to address domestic and global challenges. For that purpose, there is a need for social consensus and more involvement of different social and political actors. Otherwise, structural problems will continue to reproduce themselves.

Even if the long-standing authoritarian forms of governance in Egypt are responsible for the degradation of the political–environmental–economic nexus, because of the fear of state collapse and the ensuing instability (migration, radicalism, poverty), there is only one solution to this Egyptian dilemma: keeping the system alive and reforming it step by step from the inside. This reform process could foment a transition to Egypt’s new political ecology if the deterioration of water resources and other environmental concerns are effectively addressed. ☀

Notes

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- ² Treating these issues separately can be a narrative tool for political leadership to monopolize discussion on the possible solutions of the problems and frame them in simplistic ways needing simplistic answers. For example, in the case of the impact of the Grand Ethiopian Renaissance Dam (completed soon) in Egypt, the Egyptian government overemphasizes the external pressures (magnifying the negative attitude of Ethiopia towards Egypt) and marginalizes the importance of the long-lasting internal crisis that is connected to the ineffective water management policies inside the country.
- ³ There is a specific interaction between the river and the groundwater resources of the Nile Valley: the more effective water use from the river is, the fewer remains for recharging the groundwater reservoirs. (Satoh & Abouloos, 2017, p. 272)
- ⁴ One feddan is equal to 4168.27m².

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