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Technology, Research and Development and Innovation: Towards the adoption of the Water-Energy-Food Nexus in Egypt

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Abstract

The Egyptian government seeks to foster a creative and innovative society generating science, technology and knowledge, within a comprehensive system guaranteeing the developmental value of knowledge and innovation and using their results to address challenges and achieve national objectives. This is reflected in the country's strategic vision for knowledge, innovation, and scientific research to 2030 (Vision 2030). At the same time, Water-Energy-Food (WEF) represent some of the major challenges facing the country as it strives to fulfil the demands of its growing population within a challenging environment and external shocks (including the implications of the COVID-19 and the war in Ukraine). It is clear that relying on innovative measures could represent the way forward for this country as technology and research and development play an important role in pursuing its ambitious climate action. However, Egypt's ability to adopt a water-energy-food nexus (WEFN) approach that takes into account the environment is highly constrained by the lack of a stimulating environment conducive to innovation, such as the unavailability of appropriate technologies, insufficient economic and financing incentives for innovation and the lack of valorisation of the results of scientific research. This white paper calls for the need to carry out legal reforms related to knowledge and innovation, to develop and restructure the knowledge and innovation system in Egypt and to adopt a comprehensive program to foster an innovation and knowledge culture and stimulate innovation activities by small and medium-sized enterprises in the field of WEFN which will require strengthening the partnership between the public and private sectors to increase the volume of investment in innovation.

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1. Introduction

Knowledge, innovation and scientific research represent some of the cornerstones of the Egypt Vision 2030, launched in 2016. This Vision has created a momentum, which triggered numerous national initiatives and programmes that promote technology and innovation. These efforts were reflected in the improved ranking of Egypt in the Global Innovation Index (GII) jumping 18 places between 2016 and 2022[4]. This demonstrates the country's determination to move forward towards realizing the goals of sustainable development and raising the quality of life of its citizens.In fact, the innovation and technology industry and manufacturing sector, accounts for around 15% of total GDP playing a prominent role in the country's economic development agenda, which emphasizes innovation and sustainability. Indeed, scaling up innovation and technology as a policy priority will have a positive spillover effect on the country's structural transformation as the economy shifts from low-value-added to high-value-added, technology-intensive manufacturing segments.

However, the growing environmental and technological complexity and challenges as well as the depletion of limited natural resources available can represent a challenge for these ambitions and call for innovative actions. As high population growth rates increase the demand for water, energy and food, the renewal rates of these natural resources are on a decline and impose enormous pressure on the economic, social, and environmental dimensions of sustainable development. According to UN population prospect reports, it is expected that the population annual growth rate will remain over 2% until 2040, where the Egyptian population is estimated to reach 116 million[5]. Added to this, are the adverse effects of climate change, which will continue to negatively impact agricultural production and productivity and will exacerbate water shortages due to the long-term reductions in the River Nile's flow, further intensified by inefficient irrigation and pollution which will weaken agrifood chains. Although Egypt was one of the few emerging market countries that demonstrated resilience in the face of the COVID 19 pandemic and experienced a positive growth rate in 2020, the country had shown vulnerability as it faces economic shocks due to the Ukraine war which led to a sharp rise in food and fuel prices. Moreover, other geo-political tensions have hampered this recent progress while threatening the country's ability to ensure energy and food security.

Evidently, addressing these pressing challenges in an effective manner essential for achieving sustainable development requires the adoption of an integrated Water-Energy-Food Nexus (WEFN) approach, which cannot be achieved without the important role played by technology, research and development and innovation.

[4] The World Intellectual Property Organization (WIPO) - Global Innovation Index 2022. https://www.wipo.int/edocs/pubdocs/en/wipo_pub_2000_2022/eg.pdf

[5] Egypt. 2017. "Egyptian Intended Nationally Determined Contribution".

2.Strategic Vision for Knowledge, Innovation, and Scientific Research to 2030

Undoubtedly, research on the water-energy-food nexus as well as the need to accelerate the diffusion of innovation are essential to address the major sustainability challenges facing these three major resource areas and the tensions related to their management.

Egypt Vision 2030 and its roadmap represent a fundamental step in the country's efforts towards sustainable and inclusive development aimed at eradicating poverty and ensuring prosperity for future generations while striving to mitigate the impact of climate change (thus achieving the Paris Agreement), and to guarantee food security, access to water and availability of clean energy. It recognizes the circular economy model as a new development strategy aimed at environmental preservation, pollution prevention and sustainable development according to the "3R" principle—materials and energy reduction, reuse, and recycling. It aims to achieve a competitive, diversified, and knowledge- based economy, characterised by justice, social integration and participation, with a balanced and diversified ecosystem for a better life for all Egyptians.

The National Strategy for Science, Technology and Innovation 2030 constitutes another main pillar of the national vision aimed at stimulating knowledge production by improving the legislative, investment, and financing environments and providing the fundamental infrastructure. This strategic vision seeks to identify sectoral priorities, their challenges and how to address these challenges by increasing innovation spending across various sectors, focusing on private sector outputs, and increasing the percentage of sectoral local content. In this regard, as part of the role of the Ministry of Scientific Research in preparing an enabling environment for invention, a set of legislations supporting science, technology and invention have been concluded. For instance, the issuance of law no. 23/2018, and its executive regulations in 2019[6] provided incentives to science, technology and innovation applicable to all higher education institutions and scientific research bodies. Another example is the amendment of the Fund for the Care of Innovators and Geniuses, law no. 1/2019, which is a continuation of the gifted and talented young people support process, aimed at supporting and sponsoring researchers and innovators and financing science, technology and innovation projects while finding new sources of non-governmental funding

Furthermore, this strategic vision seeks to establish and develop a comprehensive **national system for innovation**, capable of transforming knowledge into a developmental value by enhancing primary education, higher education, as well as research, encouraging innovative production, increasing links between innovation and needs, and strengthening the companies' ability to innovate in order to maximize knowledge impact.

[6] Ministry of Higher Education and Scientific Research. 2019, National Strategy for Science, Technology and Innovation 2030. https://mohesr.gov.eg/en-us/Documents/sr_strategy.pdf

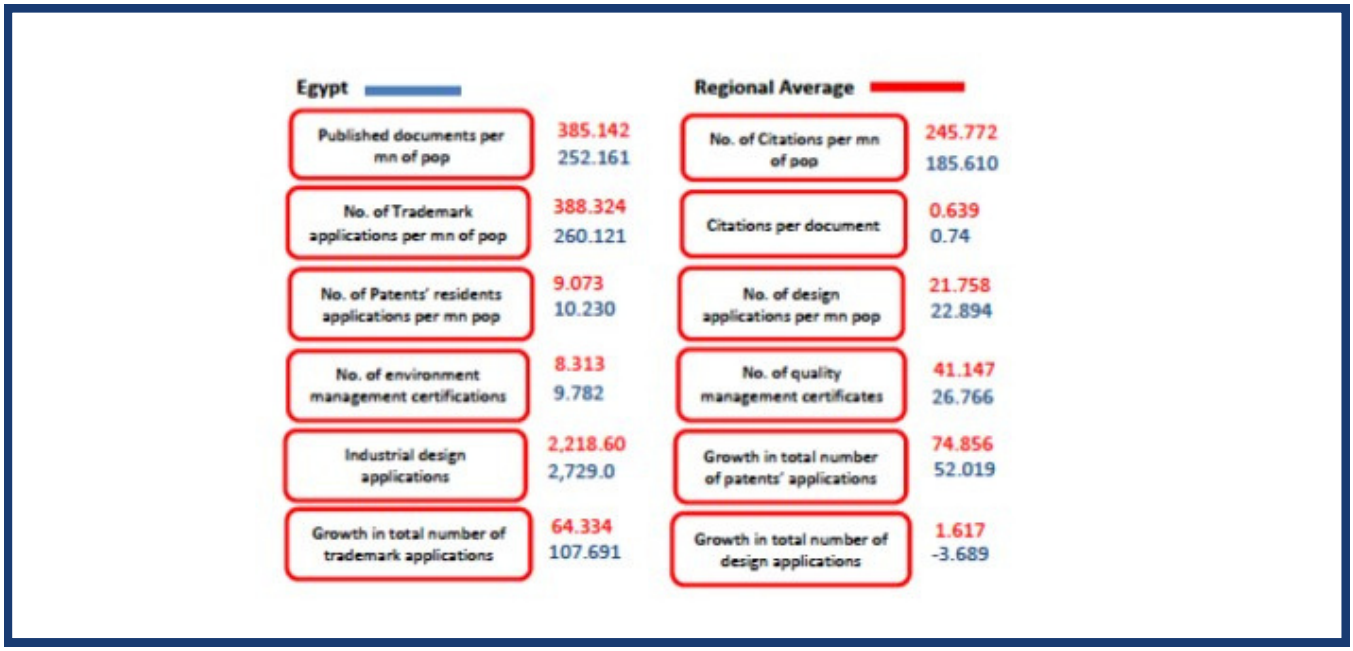
It is worth noting that the information technology (IT) and communications sector is one of the driving sectors in Egypt in promoting innovation and knowledge. Due to the annual growth rate of the number of companies operating in these fields (reaching 13.5%[7]), it was required to accelerate the development of IT infrastructures throughout the country and to increase the number of graduates from engineering and IT educational institutes. There is no doubt that the higher education system in Egypt has undergone significant development over the past 50 years growing from one government university (Cairo University) and one private university (American University)[8]to 27 public universities, 27 private universities, 20 semi-private universities, 10 technology universities, and branches of six foreign universities in 2023, serving a total of 3.6 million students[9]. These efforts are reflected in the total number of researchers[10], which has increased in recent years, with the number rising from 108,504 in 2012 to 138,491 in 2018, mainly from the higher education, with an annual growth rate of 3.9%[11].

Moreover, as agriculture still represent an important contributor to Egypt's economy, there has been a clear and growing interest in agricultural sciences. The past five years have witnessed growing research papers specialized in biochemistry, general chemistry, geophysics, geology and water sciences. Additionally, when examining the impact of research, the field of computer science was found to be the most influential field over the past five years, followed by mathematics and energy.

Despite recent efforts, Egypt is still facing numerous challenges when it comes to encouraging innovation, knowledge diffusion and scientific research. While the law no. 23/2018 is believed to encourage scientific research, there are still limitations when it comes to implementation. This includes the Intellectual Property Laws in Egypt to motivate and protect innovation. Egypt is scoring lower than the South med regional average (Figure 1) in 2020 in terms of the number of trademark applications (260 vs 388 per mn population), the number of published documents (252 vs 385 per mn of population), while it is scoring higher in terms of the number of industrial design application (2,729 vs 2,218) and number of ISO 14001 environment management certifications (9.7 vs 8.3 per mn population).

[7] Egypt. 2016. Sustainable Development Strategy: Egypt's Vision 2030. https://andp.unescwa.org/plans/1134
[8] Ministry of Higher Education and Scientific Research. 2019
[9] Egypt Today, 2023. Egypt has 90 universities serving 3.6M students: Higher Education Minister. https://www.egypttoday.com/Article/1/121838/Egypt-has-90-universities-serving-3-6M-students-Higher-Education#
[10] This includes the higher education sector, government and business enterprises
[11] Ministry of Higher Education and Scientific Research. 2019

Figure 1. Selected indicators of Innovation and Knowledge Diffusion (2020)



Source: Source: *The South Med innovation Scoreboard*, 2021

It is clear that the lack of coordination between social needs and innovation which can be observed in the low proportion of local content in several vital sectors as well as the lack of valorisation of the results of scientific research to deal with the main challenges facing Egyptian society.

In addition, the scientific research and innovation system in Egypt is hampered by inefficient sectorial planning, lack of a comprehensive mechanism linking knowledge to innovation (in fact, the inadequacy of the development of curricula and educational methods for the production of beneficial social or economic innovations have led to significant imports of technology), insufficient economic and financing incentives for innovation which has a negative effect on knowledge production (thereby compromising the ability of medium and small companies to produce and market innovation), poor culture of innovation in society and awareness of the importance of intellectual property and its protection.

These challenges have surely made an important impact on how Egypt can respond to the growing demands of its water, energy and food sectors, given their scarcity. It is clear that this will require upgrading the country's innovation and technology capacities.

3. Challenges facing the Water-Energy-Food sectors in Egypt

In Egypt, **water** scarcity, energy inefficiency and food imports remain major challenges.
With increasing water consumption due to a fast-growing population (now at around 102 million) and rising temperatures, annual freshwater resources available per capita have decreased sharply from 1,972 cubic meters per year in 1970 to 570 cubic meters per year in 2018 and are expected to fall to 390 cubic meters per year by 2050, bringing the country closer to the threshold of severe water scarcity[12]. The total water requirement is estimated at 114 billion cubic meters (BCM), while the River Nile, which is Egypt's main source of fresh water, provides only 55.5 BCM per year, in accordance with the agreed share by international treaties. To increase the total water resources available annually to 59.25 BCM, the country must resort to additional marginal quantities supplied by non-renewable deep underground aquifers, limited rainfall and desalination and depend on the reuse of agricultural drainage and treated wastewater equivalent to 21 BCM to fill the gap. Since its renewable water sources come from outside its territory,

[12] Egypt. 2022. "Egypt's First Updated Nationally Determined Contribution". *https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated%20NDC.pdf.pdf*

Egypt has a dependency rate of 97%, which increases its vulnerability to external influences and affect its water security significantly, such as the diversion of River Nile water by upstream countries of the Nile basin which are determined to exploit their potential for hydropower and irrigated agriculture (e.g. the Grand Ethiopian Renaissance Dam).

As Egypt's water access shrinks, resources for foodproduction will becomeincreasingly scarce. Evidently, it is estimated that most **Egyptian irrigation systems** operate at only 50% efficiency[13] due to wasteful irrigation practices (i.e. planting crops with high water consumption needs, such as rice, in quantities in excess of allowable limits), deficient water distribution infrastructure and pollution (resulting in deterioration of water quality), which are additional factors affecting the amount of water available in the country. Moreover, most land reclamation projects are in desert areas and are often irrigated with fossil groundwater, which is only an unsustainable and short-term solution[14]. In fact, only 6% of the total irrigated areas uses enhanced irrigation systems, placing Egypt at the bottom 10% of MENA countries in terms of irrigation efficiency[15]. In addition, the lack of water treatment facilities and lax regulations lead to the dumping into the River Nile of agricultural runoffs containing pesticides, industrial effluents and untreated sewage, making its water gradually harmful to human consumption[16].

These water shortages reveals Egypt's vulnerable food security system which springs from the inability of the agricultural sector to produce sufficient cereal grains, especially wheat, and oil seeds to fulfill the country's domestic demand and thus depends on large volumes of heavily subsidized imports to guarantee an adequate supply of bread and vegetable oil for its rapidly growing population. In this regard, studies forecast that due to climate change impacts, Egypt's cultivated area will be decreased to nearly 0.95 million acres (about 8.2% of the Egyptian cultivated area) by 2030 and the Delta will lose up to a minimum of 30% of its food production[17]. Although the government plans to expand the current agricultural land by 20% to ensure food security, these efforts are constrained by the existing limited water resources (mainly the Nile)[18]. Undoubtedly, increased frequency of droughts and floods, in addition to illegal construction on agricultural land, conventional agricultural practices and poor monitoring of agricultural inputs, especially fertilizers, seeds, and agricultural chemicals, coupled with land fragmentation will reduce crop and livestock productivity thus having an additional impact on national food security. The productivity of two main crops in Egypt,

[13] El-Gindy, 2011
[14] Lahham, Nisreen, 2019
[15] Power, 2014; Soussa, 2010
[16] Dakkak, 2016; El Bedawy, 2014
[17]Egypt. 2022. "Egypt's First Updated Nationally Determined Contribution". https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated%20NDC.pdf.pdf
[18] Lahham, Nisreen, 2019

namely wheat and maize, is expected to decline by 15% and 19%, respectively, by 2050[19]. Not to mention that the decreased water allocated for agriculture purposes, which consumes about 80% from the total water budget (Table 1), will negatively affect the livelihoods of more than 25% of the Egyptian workforce in the agricultural sector[20].

Table 1: Water uses for different sectors in Egypt from 2000 to 2020

Water uses	2000	2010	2020
Agriculture as % of total water withdrawal	86.38	85.9	79.16
Industry as % of total water withdrawal	5.86	2.56	6.97
Municipal as % of total water withdrawal	7.76	11.54	13.87
Total water withdrawal (10^9 m³/year)	68.3	78	77.5
Total water withdrawal per capita (m³ /inhab/year)	992.28	942.47	757.32

Source: FAO AQUASTAT database, 2020

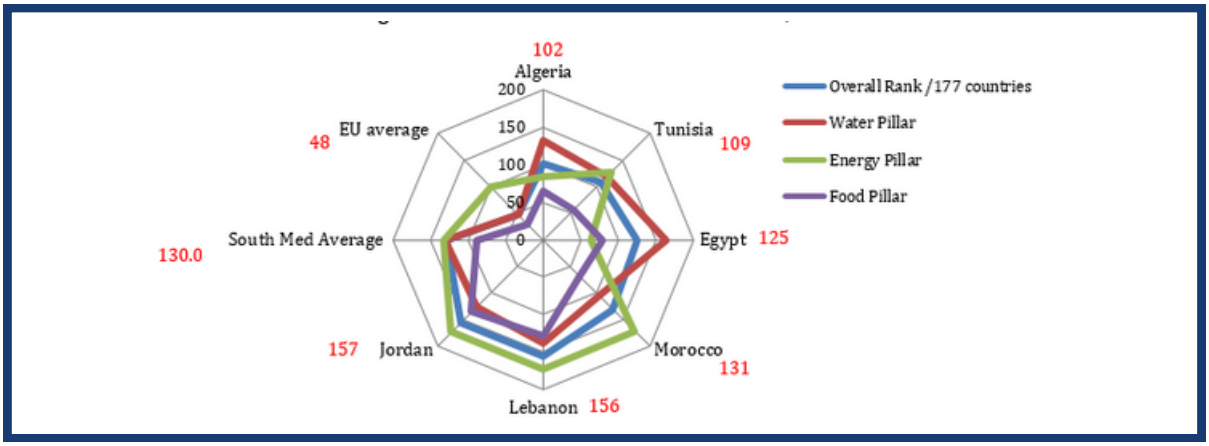
Undoubtedly, the Covid-19 crisis and the ongoing war in Ukraine, which have driven up the prices of supplies such as wheat (by 40%) to unsustainable levels for Egypt, have significantly exacerbated **food insecurity** and accentuated the occurrence of poverty, in addition to the recent loss in the value of the Egyptian Pound due to further liberalization of the exchange rate. However, Egypt has made noteworthy progress towards establishing a more integrated and inclusive social protection system, namely the Takaful and Karama Program (TKP), which as of June 2022 covers 3.69 million households (about 12.84 million individuals), with women accounting for approximately 74% of cardholders/direct beneficiaries[21].

In addition to facing rising prices of raw materials and agricultural inputs, the country also has to deal with a lack of fuel used in the operation of machinery and equipment as agriculture is extremely carbon-intensive, from the manufacture of agricultural inputs to mechanization. In fact, Egypt's **energy sector**, which contributes nearly 20% to GDP, especially through direct foreign investment, faces the dual challenges of heavy reliance on fossil fuels, particularly natural gas due to the expansion of explorations for new gas fields in the Western Desert and offshore, and increased energy demand in all sectors. The country is the largest user of oil and natural gas in Africa, with an energy consumption growth rate of over 6% per year resulting in frequent power outages[22], further aggravated by a decline in their production rates in recent years due to general political and economic unrest, as well as unsigned concession and exchange agreements during the years 2010-2012.

[19] Egypt. 2017. "Egyptian Intended Nationally Determined Contribution".
[20] Egypt. 2022. "Egypt's First Updated Nationally Determined Contribution".
[21] The World Bank, 2022
[22] Mondal MAH, Ringler C, Al-Riffai P, Eldidi H, Breisinger C, Wiebelt M., 2019

To this effect and despite scoring better than the regional southern Mediterranean average in the WEF Nexus index[23], the country's ranking is still considered low with an overall ranking of 125 (over 177 countries)[24]. While the food and energy indices scored relatively high (64th and 78th respectively), the water index is alarming (164th). (Figure 2)

Figure 2. WEF Index for South Med countries, 2021



Source: WEF index, 2021

This is due to a number of major challenges including, but not limited to, insufficient financial resources, inadequate supporting legal framework and limited practical experience to guide successful implementation. In addition, data availability and accuracy is limited as well as institutional capacity to undertake improved climate planning through effective cross-sector coordination, including policy making at all levels. Despite promises of enhancing cooperation, mandates and objectives differ considerably across ministries. For instance, with respect to the water sector, there are several reported ministries dealing with water resources, comprising the Ministry of Water Resources and Irrigation (MWRI), the Ministry of Agriculture, the Ministry of Interior, the Ministry of Foreign Affairs, the Ministry of Environment and the Ministry of Health, in addition to other stakeholders such as the Ministry of Electricity and Energy and the Ministry of Industry and Foreign Trade as water is used to produce electricity while being an essential element in industries like cement, ceramics and textiles. Moreover, the MWRI's ability to advance and implement comprehensive sustainable water development strategies is often challenged by organizational routines as well as conflicts of interest between sectors and levels of government[25].

4. Egypt's Vision 2030: The country's national initiatives and programs

Despite challenges, Egypt was still able to embark on a broad range of climate policies and projects that reflect its ambitious contribution to the global efforts as reflected in its vision 2030.

[23] The Water-Energy-Food (WEF) Nexus Index is a national-level composite indicator founded on 21 relevant indicators for 3 pillars: Water, Energy and Food with regards to their access and availability. https://wefnexusindex.org/

[24] Louis, Maryse & Dahdouh, Sophie, 2022

[25] Luzi, 2010.

As part of the country's efforts to tackle the challenges related to the on-going water scarcity, a set of policy actions and measures in water resources and irrigation will be implemented such as the development of non-conventional water resources to compensate for the increase in demand in drinking water (aiming for a total design capacity of 4 million m3 daily for water desalination[26]), water conservation measures in agriculture, industry, and municipal supplies, including lining of 20,000 km of irrigation canals to decrease water seepage and evaporation losses and rehabilitation of drainage systems in the agriculture sector. These measures will be complemented by the implementation of programs to enhance water quality and sanitation, and strengthening cooperation with Nile Basin countries to stimulate efficient use of water resources that would benefit all the countries. Moreover, attention is directed towards raising public awareness to the need to rationalize water use and enhance precipitation measurement networks in upstream countries of the Nile Basin.

At the national level, the most promising adaptation measures with regards to agriculture security are changing sowing dates and good management practices (such as changing cultivars to those that are more tolerant to heat, salinity and pests, and changing crop patterns). Additionally, the Egyptian authorities consider the use of different multi-level combinations of improved surface irrigation systems and applying deficit irrigation as successful means of increasing surface irrigation system capacity in traditional lands to overcome the negative impacts of climate change.

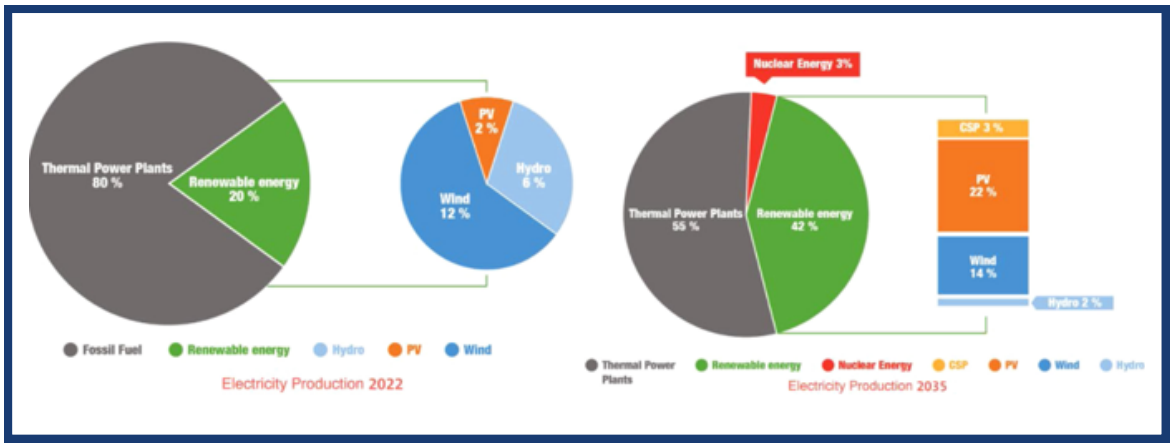
Despite the country's negligible responsibility for the world's historical GHG emissions, the Egyptian government has successfully managed to bridge the gap between production and consumption by importing liquefied natural gas (LNG) and building new power plants with the private sector's participation in recent years. Moreover, one of the most prominent renewable energy accomplishments in the power sector were the launch of Benban Solar Park, a complex of 41 solar power plants and currently the fourth largest solar power plant in the world[27] (total of 1,465 MW), Assuit hydropower plant (32 MW), Kom Ombo Solar PV Plant (26 MW), and Gabal El-Zeit Wind Power Plant (580 MW).

Moreover, in order to maximize energy production from local resources and diversify supply, decrease the intensity of energy consumption, and enable transition to low carbon pathway in the electricity sector, the country plans to install additional renewable energy (RE) capacities to reach electric power contribution target of 42% by 2035. This will be in line with Egypt's Integrated Sustainable Energy Strategy 2035 with wind energy accounting for 14%, hydroelectricity making up 2%, and solar energy accounting for 25% of the total electricity generated by renewable energy resources, as shown in Figure 3.

[26] Egypt. 2022, "Egypt's First Updated Nationally Determined Contribution".
[27] World Bank, 2020

This implies the necessity to transform the electricity grid to “smart grid” through modern digital technology, smart metering, and flexible solutions appropriate to the local context, extend on regional interconnections and enhance the energy efficiency of electricity generation by the maintenance, upgrade, and replacement programs for obsolete power plants. Moreover, Egypt will implement an integrated transformative program to modernize the oil and gas sector (comprising adopting energy efficiency and low carbon technologies in the upstream and downstream activities) which aims to improve the standard of living of citizens through access to clean fuel in households under the umbrella of Decent Life Initiative’s ‘Hayah Karima’ launched in January 2021

Figure 3: Electricity production future plan classification



Source: A. Moharram Nour, Bayoumi Seif, Gaber Mohamed, Tarek Abdelrahman. 2022

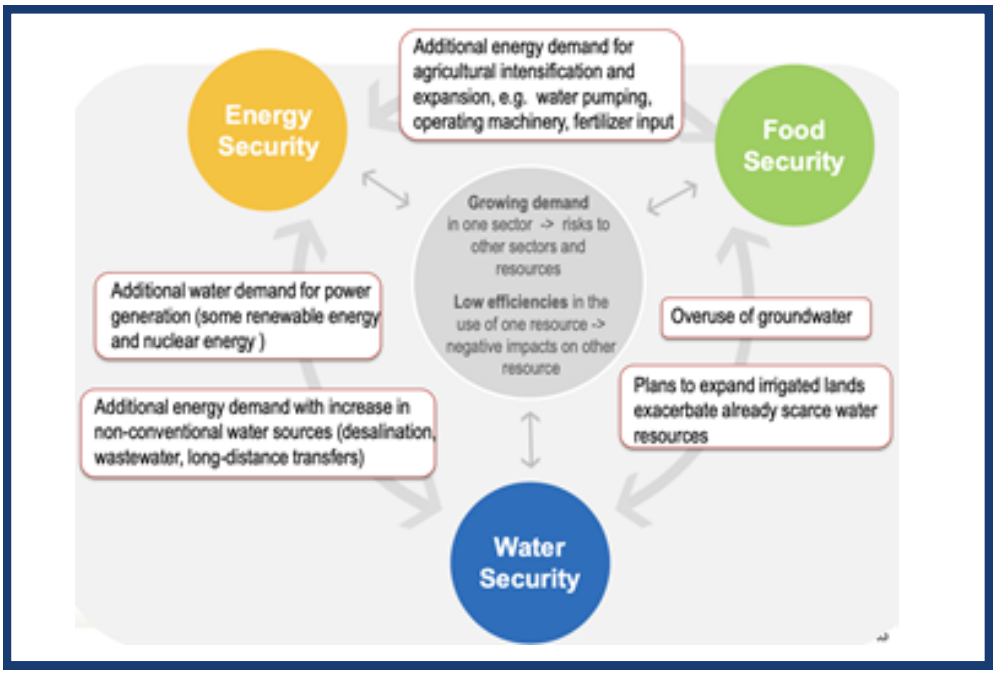
Furthermore, in line with Egypt’s Vision 2030, 2050 National Climate Change Strategy and commitment to accelerate the implementation of its Nationally Determined Contributions, the Egyptian government has launched the “Nexus of Water, Food and Energy” (NWFE) at the 27th United Nations Climate Change conference (COP27), an innovative and ambitious programme that represent mitigation and adaptation priority projects spanning the water, food, and energy sectors. Investments worth US$14.7 billion will finance implementation of 5 projects for food security and agriculture, 3 irrigation and water projects and 1 main energy project which constitutes a milestone in Egypt’s green energy transition bringing together a consortium of international partners confirming their support for network investment, a just transition and implementation. At least US$10 billion in private investment will be allocated to installing 10 GW of solar and wind energy by 2028[28]. In addition to mobilizing support from the United States and Germany, the initiative which will also include the retirement of 5 GW of inefficient fossil-fuel capacity by 2025, leading to a substantial decrease in natural gas consumption and greenhouse gas emissions of approximately 17 million tonnes of CO2 per year will deploy more than US$ 300 million in grant and concessional finance from the European Commission, France, the Netherlands, Denmark and the United Kingdom, as well as donors to the European Bank for Reconstruction and Development’s High Impact Partnership on Climate Action.

[28] European Bank for Reconstruction and Development. 2022, Egypt’s NWFE energy pillar gathers international support. https://www.ebrd.com/news/2022/egypts-nwfe-energy-pillar-gathers-international-support.html

5. The adoption of a WEF Nexus Approach in Egypt: Challenges and Opportunities

Evidently, sustainable development can only be restored when water, energy and food needs are carefully examined to meet critical challenges such as rapid population growth and global warming and their adverse effects. These sectors are very much linked to one another as their mutual impact is evident in any action taken[29][30]. It is therefore vital to harness these resources to limit the problems and mitigate negative impacts (Figure 4). Since water is irreplaceable, there is a need to prioritize its preservation and assess the long term renewable and stored water resources and consider alternative solutions for food production and energy use that take water security into account to ensure sustainable agriculture[31]. A WEFN approach can improve sustainability, community well-being, social justice, and ensure maximum fulfilment of the green economy while building an Ecosystem where all stakeholders will be involved, enabling collaboration with Neighbouring countries.

Figure 4: Tradeoffs and risks related to silo approaches in EGYPT



Source: Lahham, Nisreen, 2019

Although the government strives to control water pollution in order to increase the amount of usable water resources, water quality control is generally not a top priority in the various ministries and their departments dealing with the issue and often lack internal support (outside the MWRI and the Ministry of Environment). Moreover, the Ministry of Environment has only limited influence in the water sector and, more generally, few resources (estimated at 0.4% of public expenditures) are allocated to environmental protection[32].

[29] FAO Home. 2022. Home | Food and Agriculture Organization of the United Nations. [online] Available at: https://www.fao.org/home/en.
[30] Louis, Maryse & Dahdouh, Sophie. 2022
[31] Ganoulis, Jacques, 2021.
[32] UNEP, 2014

6. Conclusion & recommendations

It is clear that relying on technology and research and development while addressing pressing water, energy and food challenges in an integrated approach could be the way forward for Egypt in pursuing its ambitious climate action to achieve sustainable development and national objectives. The adoption of a WEF integrated approach implies the formulation and implementation of national policies capable of effectively addressing issues determining the utilization efficiency, productivity, and protection of natural resources.

In Egypt, WEFN opportunities involve ensuring efficient and re-usage of water, reducing water-intensive crops (i.e precision agriculture) and switching to more efficient irrigation systems using renewable energy including for production of biogas and biosolids and desalination.

However, addressing the WEF challenges in an integrated approach requires **first and utmost** to improve the legal framework related to the use of these natural resources. These reforms need to ensure the integration of climate change objectives into national legislations and to remedy the inadequacy of the existing institutional framework to enhance cooperation between different relevant ministers and national agencies while creating an enabling environment for allocating part of the sectoral national budget to climate change adaptation and mitigation efforts.

Second, at the sectoral level, it will be necessary to:

1. Contribute to the achievement of water security by planning water resources development on the basis of hydrological boundaries, examining the linkages between water quantity and quality while taking into account the various functions of water in different sectors and in different ecosystems, and fully integrating demand side management approaches. This implies increasing the efficiency of irrigation water use which will help maintain crop productivity, thus ensuring sustainable food security to meet current and future needs and adopting strict efficiency measures of energy use in the water sector while reducing the need for coal and nuclear-related imports in order to strengthen the country's energy security.
2. Review new and existing land use policies and agricultural expansion programs to take into account the possibilities of land degradation in the delta and other affected areas resulting from Mediterranean Sea level rise and developing systems, programs and policies to protect the rural community and support its ability to adapt to the expected trend of land use change, crop and animal production and internal migration resulting from climate change.
3. Examine pathways to achieve high levels of CO2 emissions mitigation such as the wide dissemination of locally-appropriate low-carbon energy production technologies, with substantial reductions in energy intensity, comprehensive mitigation plans covering all major sources of emissions and locally appropriate technology transfer and financial flows from industrialized countries to support carbon emissions reduction in accordance with the principles of the United Nations Framework Convention on Climate Change (UNFCCC).

Third, it will be vital to promote cross-sectoral collaboration between the water, energy, and food sectors to ensure coherent and synergistic policies and strategies that address interdependencies and trade-offs among these sectors. This will entail:

1. The need to increase awareness of practitioners and the general public about the inter-links between the three sectors and the negative impacts of climate change.
2. Involving multiple stakeholders in decision-making processes to contribute to the successful implementation of WEFN strategies**.**
3. Developing a comprehensive program and a culture of innovation to stimulate creative thinking among young people and the community.
4. Creating a number of motivating initiatives such as the development of educational curricula and the expansion of the application of methods and tools to promote innovation in the field of WEFN.
5. Fostering a dialogue among the different stakeholders on the opportunities and challenges of adopting a nexus approach to support integrated natural resource management and the exchange of practices on how to upgrade infrastructure and improve efficiency.

Fourth, there is a need to ensure a motivating environment for innovation, which would impose:

1. The revision of intellectual property legislation and implementation methods to promote the protection principles of knowledge, scientific research, and innovation
2. The improvement of the legal framework for public-private partnerships to facilitate private sector involvement in WEFN research and development following innovation clusters and knowledge innovation communities approaches.
3. Improve the efficiency of knowledge and innovation management systems through the restructuring and implementation of adequate governance rules and regulations to ensure coordination and better integration of the strategic priorities for sustainable development.

Fifth, and to promote innovative solutions to the WEFN challenges, it will be essential **to support the scientific research and innovation system** in this field by:

1. Improving the clarity and accessibility of feed-in tariff policy[33] to incentivise renewable energy production, especially in the water and agriculture sectors. This implies promoting the adoption of precision agriculture[34] techniques and practices, including measures to incentivize adoption, build capacities and skills acquisition and promote the use of resources (such as Egypt's remote sensing resources).
2. Encouraging the rapid adoption and inflow of knowledge and expertise for innovative solutions to address challenges in the WEFN field, particularly in new cities like the "New Administrative Capital", including the development of support package to incentivize new technologies such as smart fertigation, multipurpose application of solar power, biomass integration, etc.
3. Promoting the development of a Smart Specialization Strategy focusing on leveraging regional strengths and assets to identify and prioritize key areas of the WEFN field with high growth potential, thereby contributing to the sustainable development and competitiveness of Egypt's WEFN field.
4. Integrating WEFN-related research and innovation into existing research agendas and priorities at institutional and research council levels.
5. .Creating a national WEFN innovation platform to foster collaboration among stakeholders, showcase achievements, disseminate best practices, and coordinate research efforts.
6. Promoting the establishment of a dedicated WEFN research and innovation fund or specialised program at the public funding agencies emphasising the interdisciplinarity of WEF sectors to finance research projects and technology development. Measures should be taken to promote the portfolio of the funded projects with Monitoring and Evaluation (M&E) and a commercialisation strategy in place to support key solutions and outputs.
7. Promoting a targeted financial support program for WEFN-linked SMEs, offering grants, loans and incentives (such as tax breaks) to encourage innovation and technology adoption as well as technical assistance, including access to research infrastructure, technology transfer support, and business development services.
8. Fostering networking and collaboration among WEFN SMEs through dedicated platforms and events, enabling knowledge exchange and partnership opportunities.

There is also no doubt that regional cooperation around the WEF will be beneficial for Egypt and all countries in the MENA region in their efforts to improve and transform their economies into knowledge-based economies. It would be essential to create a regional WEF committee across the region at a high level (ministers) to exchange on practices for modernizing infrastructure and improving efficiency, raising awareness of water scarcity and changing the culture regarding WEF consumption while initiating platforms involving the public and private sectors, experts and civil society to deliberate on the opportunities and challenges of adopting a nexus approach and creating more synergy with technical knowledge, as well as in transboundary issues[35], with the aim of developing innovative and inclusive solutions in the region in the face of insecurities. It would clearly be beneficial to mobilize resources and initiate projects that reduce the misuse and loss of water and to establish integrated agricultural and food cooperation where countries with fertile land partner with countries with good water levels and countries with agricultural technologies.

[33] This is a policy aimed at supporting the development of renewable energies by offering producers a guaranteed price above the market.
[34] Precision agriculture involves the use of advanced technologies, such as satellite imagery, sensors, drones, and data analytics, to optimize crop production, reduce resource consumption, and minimize environmental impacts.
[35] The region shares most of its natural resources. For example, 60% of surface water resources in the MENA region are transboundary.

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