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Opportunities for an Integrated Water-Energy-Food Nexus approach in the MENA region: Egypt, Jordan, Lebanon & Tunisia

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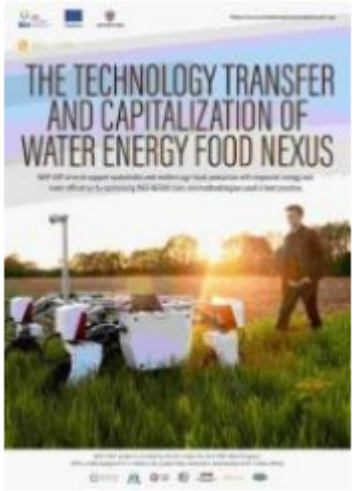
WEF - CAP

The WEF-CAP project aims to support sustainable & resilient agri-food production with improved energy & water efficiency by capitalizing WEF Nexus tools & methodologies used in best practices.



Executive Summary

Through integrated management and governance, the Water-Energy-Food Nexus (WEFN) approach has the potential to improve resource use efficiency while decreasing pressures on the environment and natural resources. However, few, if any, countries in the South Mediterranean region have made progress in adopting such an approach, which is urgently needed, given the serious challenges they face. This policy brief examines the interlinkages between the water, energy and food/agriculture sectors in selected South Med countries namely, Egypt, Jordan, Lebanon and Tunisia, as well as the main environmental challenges these countries face. The brief calls for the adoption of the WEFN approach which will bring significant benefits for the region in its pursuit of attaining the Sustainable Development Goals (SDGs) and mandates of the 2015 Paris Climate Change Agreement. Improving and strengthening governance and institutional structures in the region will enable more effective and integrated resource management. This requires examining existing national institutional arrangements for better understanding of the weaknesses that obstruct the implementation of the WEFN approach in each country of the southern Mediterranean. A transition to "resource-efficient" economies where societies value water, energy and food resources and their efficient management through the WEFN approach and participate in decision-making processes is evidently crucial.

This brief first presents an overview of the Water-Energy-Food Challenges in the South Mediterranean region, then examines the challenges and opportunities for the adoption of an Integrated WEFN approach in the 4 studied countries to provide some insights on the enterprise of future nexus projects in the region and for integrated governance. The brief finally provides evidence-based recommendations on ways to move forward and adopt the WEFN approach.

1.Introduction

In line with their commitments to achieve the Sustainable Development Goals (SDGs) and the mandates of Paris Climate change agreement, most Southern Mediterranean countries[1] (SMCs) have made notable progress in ending extreme poverty and moving towards a green transition. A number of national initiatives have been implemented with new investments aimed at increasing energy efficiency and renewable energy by diversifying the energy mix to mitigate the impact on climate. However, despite this progress, climate related challenges in the region still persist and require urgent responses.

In fact, many countries suffer from **water scarcity** as the whole Middle East and North African (MENA) region is considered the most water-scarce region in the world, with 18 out of the 22 countries of this region below the renewable water resources scarcity annual threshold of 1,000 m3 per capita per year[2]. The shortage of freshwater in the region is aggravated by reliance on transboundary water resources, poor water quality, barriers to accessibility due to occupation and conflict, climate change, inefficient use of water (with agriculture already consuming almost four fifths of the region's freshwater[3]) and rapid population growth. At the same time, the region is faced with serious threats with regards to its food security.Countries of the region depend heavily on imports of their cereals[4], which are witnessing soaring prices due to the war in Ukraine, while they have to deal with crop failures and overall yield reductions due to extreme weather conditions. According to FAO, the number of severely food insecure people[5] in North Africa has increased from 21.1 million in 2019 to 28.3 million in 2021[6]. Even more, those that are facing moderate food insecurity have increased from 48.7 million in 2019 to 57 million in 2021. Not to mention that energy consumption in the region has more than doubled between 1971 and 2011 and continues to increase[7].

These challenges when combined with soaring energy prices will have significant repercussions on the population and economic development if not addressed quickly. This is raising an alarm that SMCs need to find solutions to meet the growing demands from natural resources and securing food sustainability by taking into account the interlinkages between water, energy and food security as they strive to achieve progress on the SDGs.

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[1] For the purpose of our policy brief, the South Med region includes the following 7 countries: Algeria, Egypt, Jordan, Lebanon, Tunisia, Morocco and Palestine.

[2] ESCWA, 2016

[3] Ibid.

[4] FEMISE-CMI, 2022. https://www.femise.org/wp-content/uploads/2022/02/FEMISE_CMI-COVID_EN_FINAL2022.pdf

[5]According to the Fao definition:"these are people who have run out of food and gone a day or more without eating". In other words, they have most likely experienced hunger. Severe food insecurity is one extreme of the scale, but even moderate food insecurity is worrisome.

[6] FAO, 2022. The State of food security and nutrition in the world 2022.https://www.fao.org/3/cc0639en/online/cc0639en.html

[7] ESCWA,2016

2.Water-Energy-Food Challenges in the South Med region

As one of the regions most affected by climate change, governments in the SMCs have made pledges to mitigate global warming through green transition. At the same time, water, energy and food insecurities in the region have been intensifying across the decades with the persistent long-term impacts of: growing population (now at 2% per year), climate change related challenges leading to heat-waves, droughts which are affecting the availability of freshwater, stagnant economic growth and increasing in urbanization rates. It is expected that the region will witness an increase in temperatures ranging from 0.3C to 2.4C in the moderate scenario and 1.1C and 3.4C in the worst-case scenarios by the end of the century and both scenarios forecast a reduction of the average monthly precipitation reaching 8-10 mm, with Morocco being one of the most affected countries, according to RICCAR report[8].

Water scarcity is undoubtedly expected to aggravate as an outcome of climate change in the region. As stated by FAO, if present consumption patterns prevail, evidence suggests that two-thirds of the world population could be living in water-stressed countries by 2025[9]. This is already the case for many SMCs (see Table 1) with the highest percentage in Egypt of 141.2%. The impacts of a changing climate are indisputable to farmers and water managers across the SMCs given the importance of rainfall to agriculture and water resource systems. Some countries like Morocco are even facing volatile economic growth rates due to severe climate issues. The earlier drought of 2016 triggered a decrease in national economic development of more than 3% due to the decline in agricultural production and necessary aid measures[10]. This led to increasing water withdrawal reaching 331.2 m3 per capita for the South Med population, with Egypt having the highest share (Table 1).

At the same time, an evaluation of **food security** in the South Med region reveals its vulnerability and its dependence on food imports to sustain access to quality food for all. This is due to the fact that most of the region's land is unsuitable for agriculture (only 14.6% of the land in South Med region is cultivated), while the demand is increasing exponentially. The Covid-19 crisis and the on-going war in Ukraine, which has contributed to the increase in the prices of supplies such as cereals while hampering trade, have exacerbated this fragility and accentuated the occurrence of poverty. The region's dependency on cereal imports is about 73.4% which means that most of their consumption of cereals is imported, alarming figures observed for Jordan and Lebanon (Table 1).

Table 1. Indicators of WEF Nexus vulnerability in South Med region

Country	Water scarcity		Fuel and energy dependency		Food insecurity	
	Water Stress[(a)]% (SDG 6.4.2)[1] (2020)	Water withdrawal[2] (m^3/capita) (2020)	Imports of Fuels (% of merchandise imports)[3] (2018)	Energy imports, net (% Energy use)[4] (2014)	% of total area cultivated [1] (2012)	Cereal import dependency ratio[(b)] (3Y- average) (2016-2018) [5]
Algeria	137.9	238.6	4.0	-177.0	3.5	70.8
Egypt	141.2	757.3	14.0	-7.0	4.0 (2020)	48.2
Jordan	104.3	108.3	10.0	97.0	3.4	100.0
Lebanon	58.8	269.6	28.0	98.0	24.7	99.0
Morocco	50.8	282.6	12.0	91.0	21.1	56.9
Tunisia	98.1	303.5	17.0	36.0	31.3	65.6
Regional average	98.5	331.2	14.2	23.0	14.6	73.4

Notes: (a) Water stress is defined as freshwater withdrawal as a proportion of available freshwater resources; (b) The cereal imports dependency ratio tells how much of the available domestic food supply of cereals has been imported and how much comes from the country's own production.
Sources :(1) & (2) FAO AQUASTAT database (2020); (3) (WITS) for imports of petroleum oils & bituminous minerals, crude & imports of cereals; oats (2018); (4) World Bank data based on IEA Statistics; and (5) FAO Statistics

8] United Nations and League of Arab States, 2015.
[9] FAO, 2019- http://www.fao.org/faostories/article/en/c/1185405/
[10] Economist Intelligence Unit, 2016.

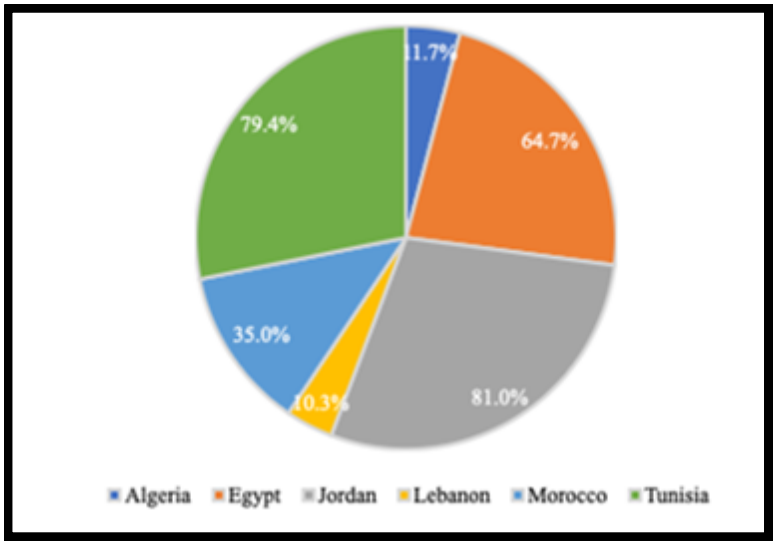
There is no doubt that the rise in oil prices affects those of agricultural products, as agriculture is likely to be extremely carbon intensive, from the manufacture of agricultural inputs to mechanization. The persistent increase in **energy demand** due to economic progress, urbanization and population growth meaningfully impacts the primary energy consumption from fossil fuels, which is already suffering from shortage. As stated by the World Bank, approximately 28 million people in the MENA region still lack access to electricity, mainly in rural areas[11]. Furthermore, it is likely that the region will experience a doubling of its energy needs by 2040[12]. This is the case for most countries in the region, which are net importers of hydrocarbons, particularly Jordan, Lebanon, Morocco and Tunisia (Table 1). Moreover, investment in the energy sector has been reduced dramatically in the South Med region as a repercussion of the Covid-19 pandemic. The war in Ukraine came to add an additional pressure to a post-pandemic struggling global economy confronting an energy crisis with exorbitant energy prices and a stark energy supply shock that forced national governments in the region to intervene by more intense subsidized programs (maybe with the exception of Egypt that is gradually lifted subsidies on this sector as part of reform programs).

3. Challenges and opportunities for a MENA WEF Nexus approach

Evidently, ensuring sustainable agriculture[13] requires addressing water-energy-food challenges in an integrated approach rather than individually while prioritising the preservation of water, which constitutes a finite and irreplaceable resource fundamental for human well-being. This implies evaluating the long-term renewable and stored water resources and considering alternative solutions for food production and energy use that take water security into account. That said, the WEFN process proves unsustainable if the use of water to maximize food production leads to overconsumption of water and energy.

In this regard, it is clear that SMCs are still lagging behind in terms of their WEF Nexus index[14]with the water sector remaining the biggest challenge[15]. According to UNICEF[16], approximately 9 out of 10 children in the MENA region live in areas of high or extremely high-water stress with negative impacts on their health, nutrition, cognitive development and future livelihoods and an estimated 66 million people lack basic sanitation and very low proportions of wastewater are well treated. In fact, according to the WEF-CAP Observatory, some SMCs have less than 12% of their population with access to safely managed sanitation services (Figure 1).

Figure 1: Percentage of people using safely managed sanitation services in SMCs in 2022



Source: WEF Nexus Index - Data can be found in the WEF-CAP Observatory

[11] The World Bank, 2010- https://web.worldbank.org/archive/website01418/WEB/0__CO-46.HTM
[12] IEA, 2020- https://www.iea.org/reports/global-energy-review-2020
[13] Ganoulis, Jacques, 2021
[14] 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/
[15] Louis, Maryse & Dahdouh, Sophie, 2022.
[16]UNICEF report, 2021. Running Dry: the impact of water scarcity on children in the Middle East and North Africa. https://www.unicef.org/press-releases/running-dry-unprecedented-scale-and-impact-water-scarcity-middle-east-and-north

In the following subsections, the challenges and opportunities for the adoption of an Integrated WEFN approach in Egypt, Jordan, Lebanon and Tunisia to alleviate the pressure on these countries will be examined in more detail with the aim to provide some lessons for the enterprise of future nexus projects in the South Med region and for integrated governance.

3.1. EGYPT[17]

In Egypt, water scarcity, energy inefficiency and food imports constitute major challenges. While Egypt is benefiting from the Nile water (representing 87.3% of its water resource), with population growth, annual freshwater resources available per capita have decreased sharply from 1,972 cubic metres per year in 1970[18] to 757.3 cubic metres per year in 2020[19] and are expected to fall to 390 cubic metres per year by 2050, bringing the country closer to the threshold of severe water scarcity. This is in addition to climate change impacts and geopolitical factors that are expected to intensify water stress in the country[20]. Undoubtedly, wasteful irrigation practices such as planting crops that require high water consumption in amounts above the allowable limits (e.g. rice), deficient water distribution infrastructure and pollution that leads to deterioration of water quality are additional factors affecting the quantity of water available in the country.

Furthermore, studies anticipate that due to climate change impacts and in no further actions are put in place, Egypt's cultivated area might decrease to nearly 0.95 million acres by 2030 and the Delta will lose up to a minimum of 30% of its food production[21]. It is clear that increased frequency of droughts and floods, in addition to illegal construction on agricultural land, conventional agricultural practices and poor monitoring of agricultural inputs coupled with land fragmentation will undoubtedly reduce crop and livestock productivity. However, in the past 20 years, Egypt has managed to increase its agriculture land from 3.3mn hectares in 2000 to 3.97 hectares in 2020 (now representing almost 4% of the land area) [22]. However, the increase will still not be enough to create the required food sustainability.
However, in order to adapt to decreasing water resources or increasing Nile flows, the Egyptian government has considered several measures such as maintaining water level in Lake Nasser, increasing water storage capacity, developing new water resources through upper Nile projects as well as improving irrigation and draining systems. 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.

That said, it is clear that the country will benefit from promoting efficient and re-usage of water, reducing water-intensive crops and switching to more efficient irrigation systems using renewable energy including for production of biogas and biosolids and desalination[23], which is part of the strategic planning for Egypt Vision 2030. It is worth noting that the country inaugurated the world's largest wastewater treatment plant, Hammam plant, which aims to reclaim new plots of agricultural land in Western Delta employing treated agricultural drainage water, and Al Mahsamah plant, located in Ismailia, which will produce enough clean water to irrigate 70'000 acres (283 square kilometres) of agricultural land[24]

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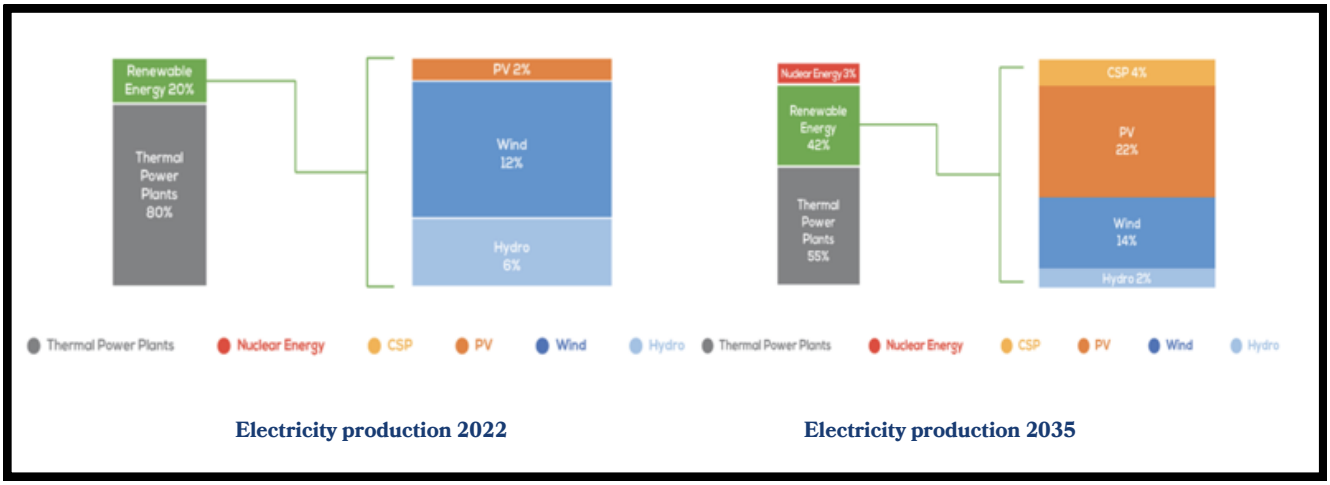
[17] For more details about the WEF status for Egypt, please refer to Louis, Maryse; Radwan, Amr and Dahdouh, Sophie, 2023
18] Egypt, 2022. "Egypt's First Updated Nationally Determined Contribution".
https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated%20NDC.pdf.pdf
[19] FAO AQUASTAT database (2020)
[20] Egypt, 2022. "Egypt's First Updated Nationally Determined Contribution".
https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated%20NDC.pdf.pdf
[21] Ibid
[22] Statistica Data on Agriculture land: https://www.statista.com/statistics/1303930/agricultural-land-in-egypt/
[23] Lahham, Nisreen, 2019
[24] Sulzer. 2021, High efficiency pumps play a central role in Egypt's Al Mahsama agricultural drainage treatment, recycling and reuse plant. https://empoweringpumps.com/sulzer-high-efficiency-pumps-play-a-central-role-in-egypts-al-mahsama-agricultural-drainage-treatment-recycling-and-reuse-water-treatment-facility/

Egypt's energy sector, which contributes nearly 20% to GDP, especially through direct foreign investment, faces the dual challenges of strong dependence 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. Being the largest user of oil and natural gas in Africa, the country has an energy consumption growth rate of over 6% per year which leads to frequent power outages[25], in addition to the lack of fuel used in the operation of machinery and equipment in agriculture.

Figure 2: Electricity production future plan classification



Source: Data from the Ministry of Electricity and Renewable Energy, cited by A. Moharram Nour, Bayoumi Seif, Gaber Mohamed, Tarek Abdelrahman, 2022

However, the Egyptian government was still able to embark on a broad range of projects that reflect its ambitious contribution to the global efforts such as building new power plants with the private sector's participation in recent years. The most prominent renewable energy accomplishment in the power sector was the launch of Benban Solar Park, a complex of 41 solar power plants and currently the fourth largest solar power plant in the world[26]. 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 also 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 2.

3.2. JORDAN[27]

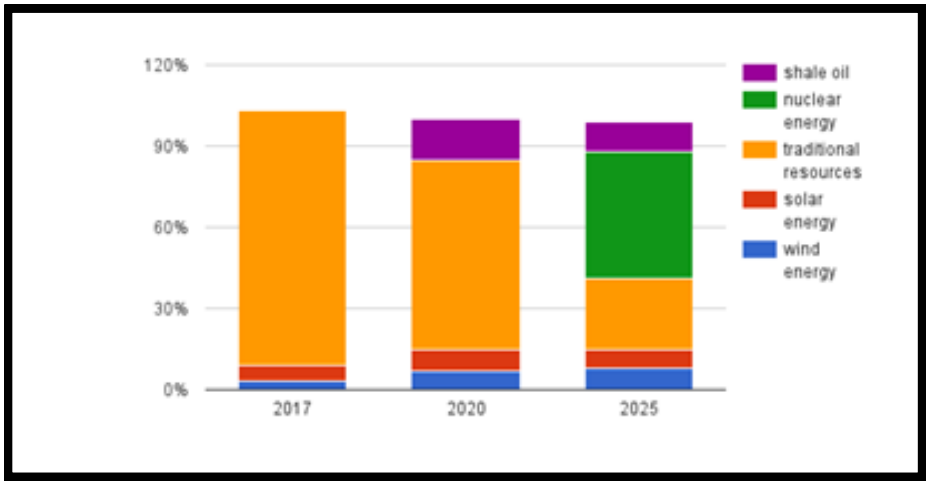
One of the major challenges that Jordan is facing is its **water scarcity** (being one of the water poorest countries in the world[28]), due to the limited available water resources, even more exacerbated by population growth, the region's geopolitical situation and climate hazards that the country faces: significant temperature increases, precipitation decreases, increased frequency of drought and evaporation. The decrease in winter rainfall and increase in mean annual temperature are expected to reduce the renewable water supply, estimated at around 780 million m3, of which 275 million m3 is groundwater, with the rest springing from surface water sources, and thus further intensifying the water shortage in the country. According to the Ministry of Water and Irrigation, the agriculture sector consumes about 51.6% of the total water withdrawn with the domestic sector consuming 45%[29].

[25] Mondal MAH, Ringler C, Al-Riffai P, Eldidi H, Breisinger C, Wiebelt M., 2019
[26] World Bank, 2020
[27] For more details about WEF status for Jordan, please refer to Louis, Maryse; El-Sharif, Shada &Dahdouh, Sophie, 2023
[28] Albatayneh, Aiman & Hindiyeh, Muna & AlAmaw, Rana, 2022.
[29] FAO, 2020. Environmental & Social Management Framework. Building resilience to cope with climate change in Jordan through improving water use efficiency in the agriculture sector (BRCCJ) https://www.fao.org/3/cb3276en/cb3276en.pdf

Moreover, the agriculture sector is fragmented leading to small-scale landholding, generating an inefficient sector with limited productivity of crops. This low productivity and the high cost of utilities negatively impact Jordan's competitiveness in meeting the high food demand in the region. Not to mention that over 97% of Jordan's cereal food and feed requirements in 2022 are met by imports[30], increasing the country's vulnerability to external shocks (as evidenced by the recent COVID-19 pandemic and the Russo-Ukrainian war).

In addition, the demand for energy has increased hastily and Jordan's energy sector is highly import-dependent, resulting in high energy costs. According to statistics of Ministry of Energy and Mineral Resources, Jordan presently imports approximately 93% of its energy (around 8% of GDP)[31], which represents a slight decrease compared to 2014 when energy imports reached 97%. It is clear that the country is committed to the **National Energy Strategy (2020-2030)** which is a ten years' plan with the aim of reducing dependence on costly foreign fuel imports that hinders the country's economy. The country is working on increasing self-sufficiency through exploitation of domestic natural and renewable resources (such as hydrogen), as well as expansion of existing energy developments. This strategy offers opportunities to diversify the fuel types to operate the industrial and transportation sectors by fostering the use of natural gas (as an alternative greener and lower-cost fuel), particularly in industrial operations to decrease the production costs and enhance competitiveness of the national products (Figure 3).

Figure 3: Jordan's predicted energy mix



Source: Data from the Jordan's Energy Sector Strategy 2015-2025 report

Evidently, using renewable energy for desalination of seawater for cooling of greenhouses in integrated production systems can improve water availability, foster crop productivity and engender co-products and co-benefit. **The Sahara Forest project** integrated production system initiated both **in Jordan and Tunisia**, which has to deal with a decline in national primary energy resources in the face of a constantly increasing demand with an average annual growth rate of 4%[32], aims to make electricity production from solar power more efficient. It involves operating energy- and water-efficient saltwater-cooled greenhouses for growing high value crops in the desert and sequestering CO2 through revegetation of desert lands, thereby improving water availability and agricultural/biomass production while providing new employment opportunities. The multi-sectoral planning and investments requested to face the WEF challenges impose the need for cooperation among the water, agriculture, and energy sectors and an active engagement of local actors, private companies, and investors. Also, water, energy, and climate-smart municipalities in Jordan can stimulate their overall resource productivity, create further employment, foster economic growth, and improve human well-being.

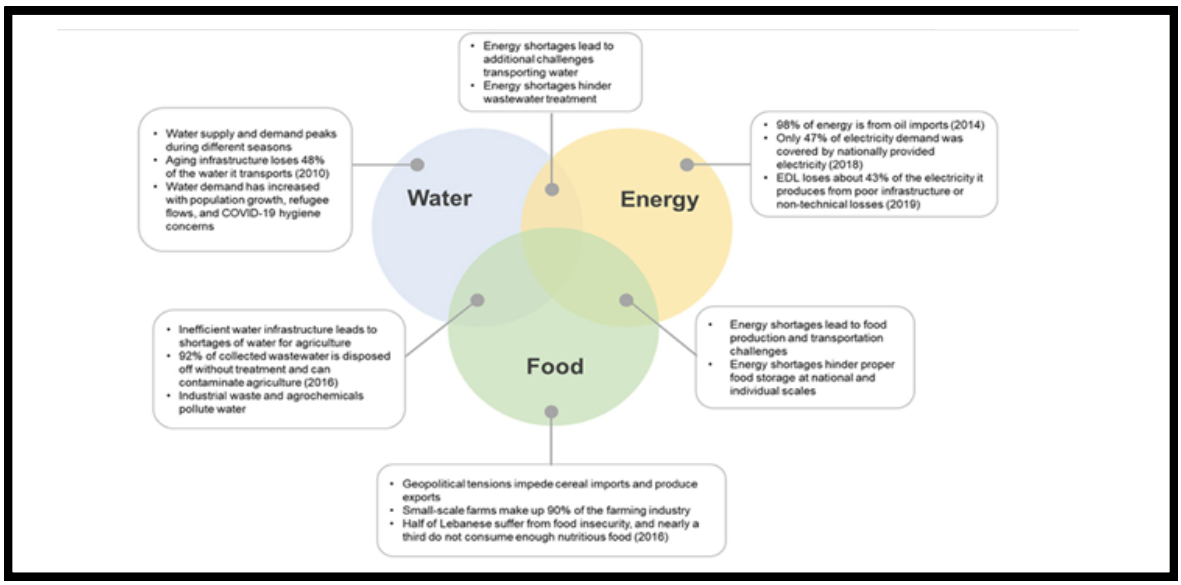
[30] FAO, 2022. Country brief on Jordan- https://www.fao.org/giews/countrybrief/country.jsp?lang=fr&code=JOR. It is important to note that this figure represents a slight decrease compared to 2018 when imports reached 100%.
[31] Jordan, 2021. "Updated submission of Jordan's 1st Nationally Determined Contribution". Final Jordan's updated NDC 26OCT (31%)-Clean version (unfccc.int)
[32] Ghezal, Abdelkarim; Keskes, Tarek & Zahar, Hakim, 2019

3.3. LEBANON

Lebanon experiences a number of key challenges when it comes to its water, energy and food sectors as summarised in figure 4. As much as these sectors are interlinked in their nature, so are the challenges facing these sectors.

The water sector is faced with numerous challenges such as overexploitation and mismanagement of water resources, water quality deterioration, continued loss of agricultural land to urban expansion or rural-urban migration, energy shortage and insufficient government electricity supply, further intensified by climate change impacts. Lebanon faces seasonal water imbalance further exacerbated by very low water storage capacity (6% of total resources, compared to MENA average of 85%)[33], deficient water supply networks and rapid rising demand from the municipal and industrial sectors. These seasonal mismatches would lead to a chronic shortage of water. Not to mention that agriculture is the highest consumer of available freshwater, consuming almost 60% (while the remaining 40% is divided between domestic use (29%) and industrial sector (11%))[34].

Figure 4. Summary of the key challenges within and across the interconnected resource systems in Lebanon



Source: Bassel Daher et al., 2022

Furthermore and in addition to the deficit in electricity supply, the Lebanese electricity sector is facing several problems such as load shedding, technical losses and the ageing of power plants. Climatic changes are expected to have diverse implications on Lebanon's environment, economy, and social conditions. Extreme weather events negatively impact public health, human settlements, infrastructure, agricultural output, power supply and the economy at large.

Moreover, a decrease in snow cover, water availability, agricultural productivity, including fisheries and aquaculture, and tourism would impose serious economic costs.

However, despite its hardships, Lebanon remains committed to fighting the climate crisis. The country is committed to its National Development Contribution (NDC)[35] under the Paris climate agreement to unconditionally increase its greenhouse gas emission reduction target relative to the Business-as-Usual (BAU) scenario from 15% to 20%, and conditionally increase its GHG emission reduction target relative to the BAU scenario from 30% to 31%. Moreover, Lebanon commits to unconditionally generate 18% of its power demand (i.e. electricity demand) and 11% of its heat demand (in the building sector) from renewable energy sources in 2030, compared to a combined 15% in 2015. Additionally, Lebanon conditionally commits to generate 30% of its power demand (i.e. electricity demand) and 16.5% of its heat demand (in the building sector) from renewable energy sources in 2030, compared to a combined 20% in 2015.

[33] IUCN ROWA, 2019
[34] Ibid.
[35] Lebanon, 2020. "Lebanon's Nationally Determined Contribution". Lebanon's 2020 Nationally Determined Contribution Update.pdf (unfccc.int)

Undoubtedly, water storage and treatment employing renewable energy, recycling of wastewater and agricultural residues in multi-functional systems can stimulate resource use efficiency and decrease pressure on water, land and energy while fostering agricultural productivity in the country. The advancement of a new national agricultural strategy and the on-going evaluation of the water strategy in Lebanon offer opportunities to capitalize aspects of a WEF nexus approach in harmonization with other involved stakeholders. This will entail policy and fiscal reforms to enable the improvement of these sectors through water and energy efficiency, the sustainable use of Lebanon's land and water resources, the reduction of polluting practices in agriculture, waste, and industry, and enhancing the resilience of communities and infrastructure

3.4. TUNISIA

In facing water scarcity, Tunisia has developed a complex and diverse water infrastructure allowing the country to mobilize and exploit available water resources in order to improve access to drinking water for the majority of the urban and rural population and to provide supplies for agricultural irrigation, as well as the industrial and tourism sectors. However, although conventional water resources management strategy is advanced, the demand for water is expected to increase due to population growth and improved living standards. In fact, water resources in the country are particularly exposed to conflicts of use, overexploitation of groundwater, declining water stocks, and degradation of water quality including salinization of coastal aquifers. The country is facing a decline in renewable water resources per capita, which amount to 303.54 m3/capita/year in 2020[36] and are expected to drop sharply further to 220 m3/capita/year by 2050[37]. Most of the exploitable renewable surface water is mobilized in dams and hilly dams and subject to a loss of storage capacity of up to 43% of their initial capacity[38]. Moreover, about 75.54% of the total water withdrawals in Tunisia are used by agriculture for irrigation[39].

This has led the Tunisian government to consider strategies and plans encouraging non-conventional water resources, namely treated wastewater and desalinated water. Various adaptation measures have already been implemented to improve water use efficiency in the country, such as the Djerba, Sfax, Zarrat, and Sousse desalination plants. However, energy demands remain high for irrigation, water transfers, pumping from deep aquifers, desalination processes and wastewater treatment.

Evidently, despite the decrease in total cultivated area in Tunisia from 31.3% in 2012 to 26% in 2018, the country still has one of the highest cultivated areas per capita in Africa[40]. It should be noted that rain-fed agricultural production, which is predominant in the country, has to cope with the arid climate, irregular rainfall and soil degradation. In fact,

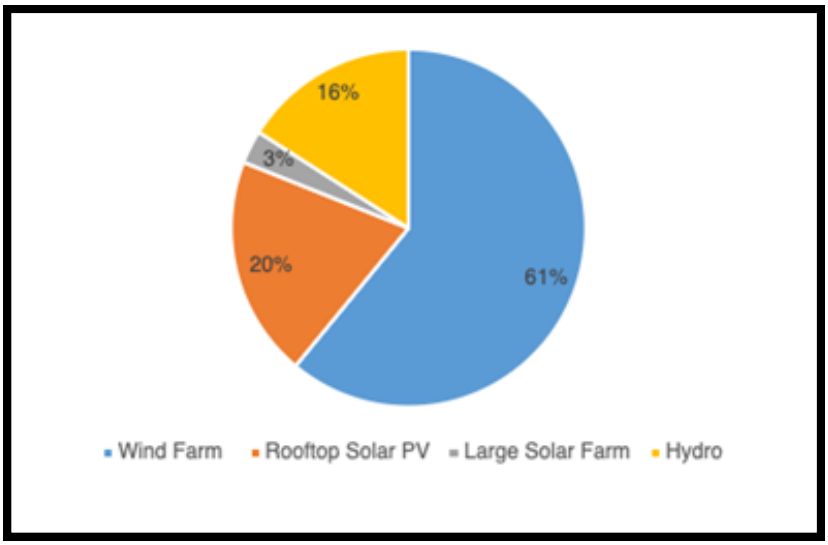
Tunisia has experienced a significant increase in temperatures over the past 30 years of around 0.37°C per decade as well as a decrease in rainfall of around 3%[41], which is expected to contribute to crop failures and overall yield reductions in the country by the end of the century and further threaten economic viability and sustainability of the agricultural sector.

Regarding the Tunisian energy landscape, the heavy dependence on fossil fuel reserves as well as the lack of political support has meant that, historically, the development of renewable energies has not been considered a priority for the Tunisian government[42]. In fact, renewable energy production remains very limited, being 1-3% of the primary energy resources[43] and is widely dependent on wind farms (61%) while large solar farms only represent 3% of renewable energy sources (Figure 5). Furthermore, the decline in national natural gas production poses a serious problem in terms of the security of electricity production, which is 97% dependent on natural gas[44].

[36] FAO AQUASTAT database, 2020
[37] Tunisia, 2021. "Updated Nationally Determined Contribution". https://unfccc.int/sites/default/files/NDC/2022-08/CDN%20-%20Updated%20-english%20version.pdf
[38] Ghezal, Abdelkarim, Keskes, Tarek & Zahar, Hakim, 2019
[39] FAO AQUASTAT database, 2020
[40] FAO. Water efficiency, productivity and sustainability in the NENA regions (WEPS-NENA: Tunisia). https://www.fao.org/in-action/water-efficiency-nena/countries/tunisia/zh/
[41] The World Bank Group, 2021. Climate Risk Country Profile: Tunisia. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-04/15727-WB_Tunisia%20Country%20Profile-WEB.pdf

Regarding the Tunisian energy landscape, the heavy dependence on fossil fuel reserves as well as the lack of political support has meant that, historically, the development of renewable energies has not been considered a priority for the Tunisian government[42]. In fact, renewable energy production remains very limited, being 1-3% of the primary energy resources[43] and is widely dependent on wind farms (61%) while large solar farms only represent 3% of renewable energy sources (Figure 5). Furthermore, the decline in national natural gas production poses a serious problem in terms of the security of electricity production, which is 97% dependent on natural gas[44].

Figure 5: Renewable energy mix in Tunisia



Source: Nouicer, Athir, 2022

On a positive note, Tunisia has recently developed an energy strategy that aims to ensure the security of the country's energy supply while guaranteeing access to energy at an affordable price for the Tunisian economy and population. This strategy focuses on the development of national hydrocarbon resources, in particular natural gas, the improvement of the refining, transport and distribution of petroleum products, the development of electricity production and the strengthening of interconnections and the transition towards better energy efficiency through the development of renewable energies. In this regard, Tunisia aims to reduce its primary energy consumption (by 30%) by reaching a share of renewable energies in electricity generation of 30% by 2030[45].

4.Conclusion & recommendations

Optimizing water, energy and food security in the South Med region cannot be achieved without tackling water, energy and agriculture challenges together and adopting an integrated approach based on the Sustainable Development Goals (SDGs), which will increase resource efficiency, identify and reduce trade-offs, leverage and create synergies, enhance collaboration and governance across sectors while enabling an active engagement of local actors, private companies, and investors.

It is clear that one of the major challenges that is facing the SMCs is related to water. In countries like Egypt, Lebanon, Jordan, Tunisia, improving the monitoring and control of water supply and demand management, reducing water losses, promoting water re-usages and finding new sources while adopting strict efficiency measures of energy use in the water sector will contribute to enhance **water security.**

[42] IUCN ROWA, 2019
[43]Nouicer, Athir, 2022
[44] El Amine, Yasmina, 2023
[45] IUCN ROWA, 2019

At the same time, it will be essential to introduce energy and water efficient techniques in food production to ensure sustainable agriculture, which will guarantee **food security** to satisfy present and future needs. This involves the use of renewable energy for the production of water, water distribution, wastewater treatment and water desalination plants, as well as for the cultivation of crops, irrigation systems, storage, food processing and agro-food industries, which certainly requires the need to move towards a sustainable, stable and strongly connected **energy sector.**

More particularly, there are WEFN opportunities that exist for each of these countries. The following are some examples that could be adopted:

- **In Egypt,** WEFN opportunities include desalination to increase national water supply, coupling wastewater reuse and energy recovery, and reuse of treated wastewater to recycle nutrients and reduce energy-intensive fertilizers.
- **In Jordan,** WEFN opportunities involve enhancing the efficiency of the urban water systems comprising reducing the loss rate, employing recycled water and treated wastewater for agriculture which can decrease pressure on natural resources and mitigate water scarcity, using renewable energy for desalination, recovering heat from waste water and increasing efficiencies in all sectors.
- **In Lebanon,** technical and economic Nexus solutions comprise irrigation with recovered wastewater, sludge reuse as soil substitute, use of agricultural by-products for energy, economic savings from renewables (solar and wind), use of photo-voltaics for electricity, for water pumping in irrigation and for cooling of agricultural products, improved water storage to mitigate climate extremes and prevent crop losses, and application of smart irrigation systems to enhance efficiency.
- **In Tunisia**, since the increasing use of unconventional water resources and the need to pump water over large distances and vertical gradients make the Tunisian water system very energy intensive, it is essential to enhance the energy efficiency of water utilities through the optimization and rehabilitation of infrastructure, to deploy photovoltaic technology for pumping and other uses in the water sector, comprising desalination, to use the energy potential of biogas and bio-solids in treatment plants to offset some of the energy needs; and install pumped and turbine energy storage stations near dams and canals, where possible.

Moreover, there are additional measures that could be undertaken by governments at both the national and regional levels, which could help achieve WEFN security goals in the region:

1.There is a need to reinforce mechanisms for effective resource management, as the institutional framework governing the elements of the WEFN in SMCs is mostly fragmented leading to a sectoral approach that affects policy planning and delays the comprehensive and inclusive management of these interrelated priorities. The regulatory framework should integrate environmental and social considerations and be developed in an integrated way across sectors to ensure supportiveness of regulations to the different sectors. This will foster complementarities and avoiding contradictions, while being supported by an effective compliance and monitoring mechanism to ensure the efficiency of resource allocation and use.

2.Mainstreaming the WEFN Approach at all levels of policy development could be achieved through established of water-energy-food (WEF) national committees at the senior government levels and integrate climate change institutions and the relevant multi-stakeholder bodies in a way to build a comprehensive national Water-Energy-Food Nexus (WEFN) strategy and interact and communicate across the different levels on the best approaches in facing the challenges within these inter-connected sectors.

3.Greater delegation to technical resource management agencies, utilities and local governments within the (WEFN) strategy could build legitimacy and trust in the state to manage the pressing challenges of water, energy and food.

4.The engagement of civil society in the nexus governance can be an essential asset in ensuring that the environmental and social needs of future generations find resonance in current policies and practices, thus producing better dialogues and bringing legitimacy and accountability to government institutions.

5.Regional institutions and initiatives such as those under the League of Arab states could play a vital role in supporting SMCs to integrate and implement the WEFN Approach and carrying out in-depth assessments of existing institutions and identifying entry points.

6.The South Med region could benefit from the establishment of a regional network of leading experts in the region to build more synergy with technical knowledge as well as on cross-border issues, international conventions and legal and institutional aspects.

7.As countries of the EU-MPC[46] face similar challenges when it comes to water, food and energy issues, there is an urgent need to establish a **Mediterranean Council** with high level representation from each country of the region with the aim to address these common challenges and exchange knowledge, experiences and best practices.

8.Stimulating sustainable consumption and production patterns is necessary to achieve the SDGs and to mitigate and adapt to climate change obligations and targets, as agreed at the Paris Climate Change Summit. It is therefore essential to raise awareness among the general public of the benefits and significance of adopting an integrated WEFN approach to policy-making. Since low prices and general untargeted subsidies in the majority of SMCs have led to domestic overconsumption of resources and lack of incentives to attain resource efficiency, reforming pricing systems would enhance the efficiency of resources, improve economic and climatic resilience and ease the burden on governments' budgets, while providing efficient supply to the growing demand.

9.There is still a gap of knowledge with regards to the inter-relations of the WEFN and it is essential to encourage a research and development (R&D) programme that looks into these interconnections in a way to benefit these sectors. This includes finding ways to promote integrated water, energy and food policies while strengthening national capacities to develop local technologies for local use and for export

10. There is a need to design programs and to stimulate training targeting different groups in different sectors. This includes training for policy and decision-makers, managers, professional staff, entrepreneurs,practitioners and workers to support the implementation of an integrated WEFN approach.

11.The establishment of entrepreneurship programs and initiatives will stimulate and support youngentrepreneurs to start new business in the WEF sectors adopting an integrated approach.

[46] The EU-MPC region includes the EU countries and the Mediterranean Partners Countries

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