ENABLING ENVIRONMENT
FOR INNOVATION IN CLEANTECH

WEF NEXUS

RESEARCH REPORT

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This research report is published by the Issam Fares Institute for Public Policy and International Affairs (IFI) at the American University of Beirut (AUB). It can be downloaded from the following website: www.aub.edu.lb/ifi

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Introduction

A major concern nowadays is ensuring food security while guaranteeing the sustainable use of resources. Food security is faced by important population growth, rapid urbanization, changing diets and economic development which are consequently factors driving increased demand for fresh water, energy. Demand on food is expected to increase by 60% within the coming 40 years. In parallel, global energy consumption is projected to grow by up to 50 % by 2050 (IEA, 2021) and by 105% in the MENA region. It is noteworthy that a quarter of the worldwide energy consumed is used in the agrifood sector as food production and supply. Total global water withdrawals for irrigation are projected to increase by 10 % by 2050 (FAO, Water for Sustainable Food and Agriculture, 2017)taking into consideration that agriculture is the highest consumer of freshwater counting for more than 70% of the water use.

Within a demanding environment, competition between resources will be increasing. In this context, the Water-Energy-Food Nexus (WEF) has emerged to describe the complex relation between water, energy and food showing to which extent they are interlinked and consequently interdependent and cannot be easily separated (ESCWA, Developing the Capacity of ESCWA Member Countries to Address the Water and Energy Nexus for Achieving Sustainable Goals, 2017). The importance of the WEF is to sustainably manage our limited resources leading to realize that the impact a decision can make on one sector can also affect another sector. The WEF nexus approach provides opportunity for building resilience to climate change, mitigating vulnerabilities through coordinated WEF infrastructure development, better understanding and analyzing the interactions between the natural environment and human activities improving the integrated management of natural resources addressing water, energy and food security in an economically efficient and environmentally sound manner (Shannak et al., 2018).

In Lebanon, the interdependencies of the water-energy-food (WEF) resources are evident in different sectors. One of the physical forms of the interlinkage of these three sectors are the dams with their dual role in both hydropower generation and irrigation schemes. Other than dams' different hydropower plants are installed on rivers and springs (Farajalla N., 2016). Energy consumption is another interlinkage between groundwater and energy sector in Lebanon, 1615 public wells pump water in the water network but in parallel more than 85000 private wells of which more than 50% are not licensed are distributed all over the countries making the amount of energy used to pump underground water unknown (MoEW, Updated National Water Sector Strategy (2020-2035), 2020). Interlinkage between water energy and food can be represented by the methods of irrigation in Lebanon, where 50% of irrigated areas uses surface irrigation being a water intensive practice but consuming very little energy, the other 50% irrigated lands use pressurized irrigation using lesser water but with higher energy needs. Machinery for agricultural practices consumes lesser energy since majority of the farms are small holding and use simple machinery for their practices, the main machines used in agriculture sector are the trucks for the transportation of goods. Energy for cold storage is another interlinkage between agriculture and energy in Lebanon. Agriculture negatively contributes to the water sector by consuming the highest share of fresh water and polluting the resources through the use of fertilizers and pesticides.

Overview of the Agri-Food sector

The Agri-food sector all over the world is undergoing an incredible growth, due to an increasing population, increase in GDP, urbanized population and increasing penetration of organized retail. At regional level, food consumption in the Arab countries is expecting to expand at an average annual rate of 4.2%. (IDAL, AGRI-Food Sector in Lebanon 2020 Factbook, 2020) This is related to the fact that countries in the Arab regions are facing demographic transformation characterized by high population growth rate and increasing urbanization, and in the coming years it is expected that 90% of the population growth rate will be in the cities. A change, that may have a dramatic impact of food security in terms of consumption but also on land use and availability. (ESCWA & FAO, Arab Horizon 2030: Prospects for Enhancing Food Security, 2017)

In Lebanon, the Agri-food sector is a major contributor to the economy, contributing by 38% of the industrial sector output in 2018 (IDAL, AGRI-Food Sector in Lebanon 2020 Factbook, 2020) making up to 2.9% of the economy (FAO C. , 2022). 1,400 agri-food companies constitute the largest share of total industrial firms and engaged in the production of dairy, confectionary, dried fruits and nuts, baked goods, olive oil and wine. Agri-food sector provides employment for a quarter of the industrial workforce and 24% of the total employment for both agriculture and agrifood industry. (FAO L. , 2020)

Lebanon has the second largest agriculture land share from its territory in the Middle East which is more than 50% of the total area. In parallel it is characterized by a high precipitation level averaging around 800 mm/year (MEW, 2012) and several agroecological zones allowing the diversification in both crop and animal production (more than 60 crops types and 10 livestock products). However, only around 50% of the arable area is cultivated covering less than 26% of the country's surface, and the total cultivated area in 2021 was around 271 000 ha of which 50% is irrigated (Agriculture, 2021) making domestic food production limited and insufficient to meet local food needs especially with the increasing demand from increasing population and urbanization. As shown in Figure 1, temporary crops in Lebanon cover a total area of around 135,000 ha and on the top of these are the cereals followed by vegetables. Figure 2 shows that permanent crops cover an area of around 134,000 ha, olive trees covering the largest area followed by pome and stone fruits (Agriculture, 2021). Animal production, consists mainly of livestock for milk and meat production, poultry for eggs and meat production and Honeybees.

WEF Nexus

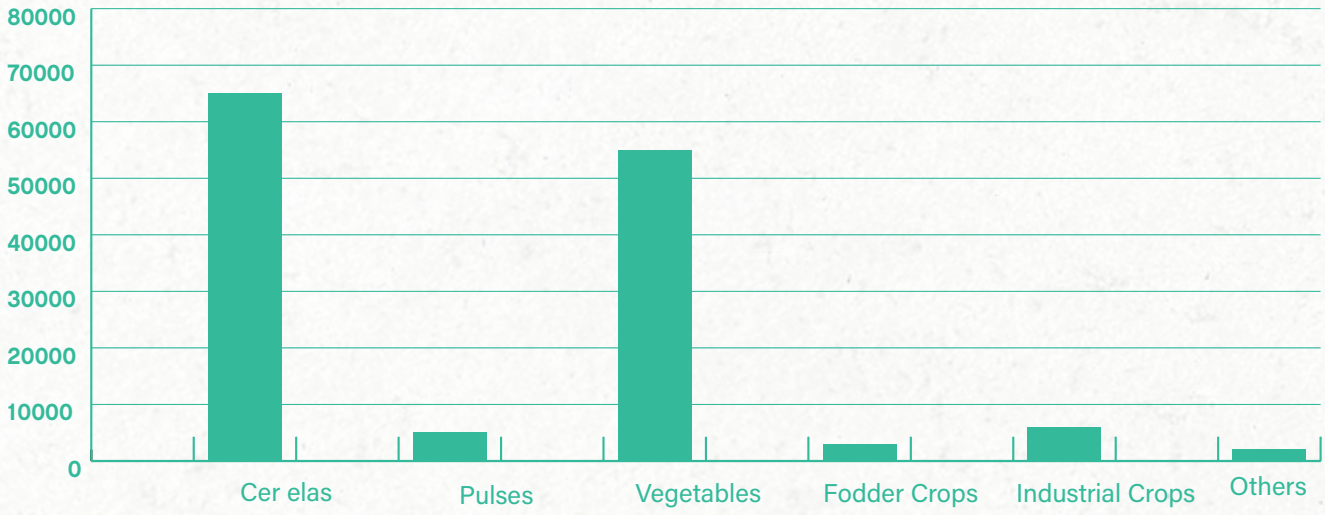

Figure 1: Figure 1. Temporary crops in Lebanon

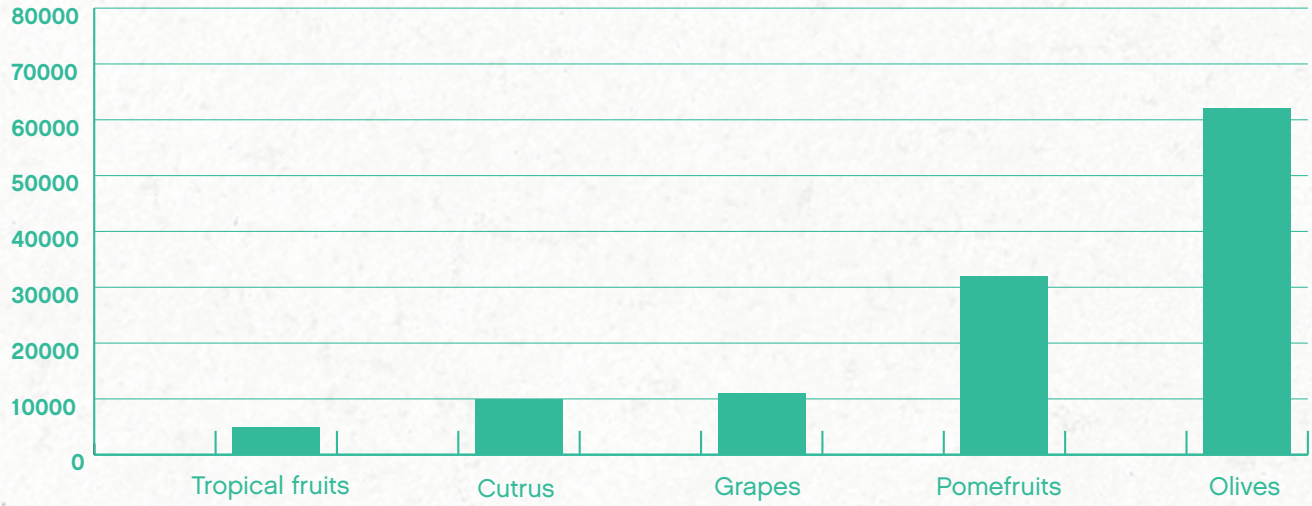

Figure 2: Figure 2. Permanent Crops in Lebanon

Local Agri-food production (excluding exports) is less than 20% of the needed food consumption, consequently the agrifood imports represent an important share of total imports accounting for 18% the total imports of the country. As a result, Lebanon has import dependency in most food products that in some cases is very high as for grains and sugar. Domestic cereal production covers, on average, less than 20 percent of the consumption needs. In the 2022/23 marketing year (July/June), the cereal import requirements, mainly common wheat for human consumption and maize to feed livestock and poultry, are forecast at 1.9 million tons (FAO, Country Briefs Lebanon, 2022).

Describing the capacity of our Agri-food sector, and the threats to our food security, it will be important to see what are the factors affecting positively or negatively this sector and how these challenges can be alleviated through a holistic WEF nexus approach and what are the possibilities with cleantech industry and innovations.

Challenges related to the food sector in Lebanon

Different challenges are facing the Agri-Food sector in Lebanon. Agriculture being the largest consumer of fresh water, out of the total water withdrawal 61% is used for agriculture, any gap in the quantity or quality of water will affect the food chain supply. On another hand, energy is an important factor when talking about food security, knowing that more than one-quarter of the energy used globally is consumed for food production and supply. Moreover agri-food sector in Lebanon is heavily dependent on imported inputs, seeds, fertilizers, materials, packaging equipment's, resulting in high production costs for agriculture and the agrifood industry, significantly affecting the food system (FAO C. , 2022). Other challenges facing the Agri-food industry are land availability and fragmentation, climate change, institutional and policy problems.

Focusing on two key resources used by the Agri-food sector in Lebanon:

- Water resources
- Energy

The main challenges related to these three resources can be summarized as follow

Challenges related to the water sector

Despite the relative abundance of annual rainfall (800mm), the investment of billions of US dollars in the water sector in Lebanon since 1990 and the several reforms throughout Lebanon's water sector history, the availability of water is still limited in quantity and quality due to poor management, aging infrastructure and inadequate investments. Widespread pollution and substandard water infrastructure have restricted the water utilities' ability to meet future water demands. Water resources in Lebanon are subjected to severe pressures acting on both the quantity aspect in terms of over exploitation and wasteful use and on the quality of resources with polluting practices proliferating in all sectors (Comair, 2008). Moreover, according to the Intergovernmental Panel for Climate Change (IPCC, 2008) the MENA region will experience for the next century drastic changes where rainfall will decrease by 10-25%, runoff will decline by 10-40% and evaporation will increase by 5-20%. Accordingly, the share of water withdrawal for agriculture is forecasted to decrease in the coming years and diverted for municipal and industrial use putting more pressure on the food production sector in Lebanon.

In addition to the climate change risk, the increasing levels of pollution are adversely impacting rivers, springs and groundwater, with contamination from raw sewage and other wastes (industrial and domestic) without proper regulation from the government. Also, in rural areas, the contamination is due to the infiltration of pesticide and fertilizer residues leading to further environmental degradation. Other than quantity and quality issues, water sector faces other challenges represented by the mismanagement of the resources and lack of transparency in the practices carried by the different sector stakeholders. The overlap in the roles and responsibilities within the various governmental institutions, the irregular permits provided for well digging and over-abstraction, the lack of national water information data, the absence of clear budgeting, and the human resources-related problems are the main challenges leading to the mismanagement of the water sector. These issues need to be resolved in order to create a healthy ecosystem and enabling environment for the water and wastewater sector in Lebanon.

Challenges related to energy

The food production and supply chain use about 30% of total energy consumed globally. Energy is required to produce, transport and distribute food as well as to extract, pump, lift, collect, transport and treat water. Agricultural production is sensitive to changes in energy prices, either through energy consumed directly or through energy-related inputs such as fertilizer. Agriculture and food production in Lebanon are highly sensitive to the energy prices and availability such as change in the oil and natural gas markets since it mainly relies on fossil fuel resources for the generation of energy. Higher energy-related production costs would generally lower agricultural output, raise prices of agricultural products, and reduce farm income (Sands, 2011). The energy sector in Lebanon faces several challenges. These relate to the limited endowment of fossil fuel resources to supply the thermal power plants which supply almost 90% of Lebanon's electricity. Other sources of energy come from renewable energy, the total installed power capacity amounts for around 350 megawatts (MW), including hydropower sources, energy from landfill in Naameh and solar PV.

There are also challenges related to the capacity to generate electricity and distribute it. For example, in 2009, average demand stood at 2,100 MW, while the available capacity was 1500 MW. This caused severe shortages that consumers met using private diesel generators. Since summer 2021 electricity generation from Electricity of Lebanon (EDL) is less than 4 hours a day threating the continuousness of different sectors: agriculture, industry, health, education, food safety… Thus, there is a gap between energy demand and supply that the state provider of electricity struggles to meet. Moreover, there is also inequality of access to electricity, particularly for rural communities and most agricultural far ms are not connected to the grid.

The utilization of pumps to lift water from wells and rivers, combined with the high cost of fuel, is leading to high costs of irrigation water to farmers. Problem exacerbated with the economic crises when price of diesel has increased around 55 times between 2019 and November 2022, after the cessation of fuel subsidies by the central bank of Lebanon and the drastic increase of oil price worldwide. In 2021, farmers were faced to a sharp shortage of diesel supply in the Lebanese market they were struggling to find diesel to operate their pumps and sometimes forced to buy fuel from the black market sold in USD at extremely overrated exaggerated prices. In this context, decentralized generation of renewable energy through solar technology would improve energy security for irrigation, the equality of access to energy for rural communities practising agriculture, and also improve environmental sustainability by reducing reliance on fossil fuels.

Although now, fuel is available, it often remains out of reach. The agricultural operations do not appear to have suffered significantly as mechanization from the increase in the energy price since it is often substituted by labor. However, price of transportation of agricultural goods increased drastically leading to a huge increase in the price of fruits and vegetables. Another impact of the increase in energy price is on the refrigerated transportation and storage which are highly critical for product quality, marketing and human health. Cold storages across the country are already lower in number and space than the actual needs and only part of them were able to operate in 2021, leading to a large proportion of production left without cold storage. At the same, price of cold storage increased to a higher level than the price of the agricultural goods, leading to the facts that many farmers left their crops unharvested this

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year. All these challenges facing the energy sector in Lebanon, are threating a variety of sectors at different levels, which need an immediate intervention.

Regulatory and institutional framework is one of the most important barriers to the development of the energy sector in Lebanon. The Lebanese electricity sector can be characterized as a monopoly managed by Electricity of Lebanon (EDL). Law 462/2002 is still not implemented. This law unbundles Lebanon's power sector, and opens the market for electricity with independent power producers (IPPs). On another had, recently in May 2022, the Lebanese government issued 11 licenses to companies to produce 15 megawatts (MW) of solar power each. In parallel, electricity tariffication from the Electricity of Lebanon will be following a new schedule of tariffication starting November 2022, those can be described as first steps in the reform of the energy sector in Lebanon. Such decisions will increase the appetite towards shifting to renewables and promote innovation in the sector. At the same time Bioenergy has also to the Lebanese government's attention for its potential to generate low-energy output from sludge of small or medium wastewater treatment plants (WWTP). A study by CEDRO, 2013 reflected that the generation of biogas can be achieved in two wastewater plants in Lebanon (Sour and Tripoli). The system is still non-operational in both facilities. Although this technology it seen as a pilot study for Lebanon, it exhibits potential to increase energy production and decrease greenhouse emissions. The increase in energy production will permit the WWTPs to be self-sufficient in terms of electricity and even produce excess to power the surrounding villages (UNDP, 2015)

Highlighting challenges facing Water- Energy-Food sectors, trying to achieve security in one of these sectors independently without addressing the trade-offs with other sectors will compromise their sustainability and security. Where the need to replace the existing conventional silos policy and decision-making approach, when addressing the management of these three sectors, through nexus thinking. The complex linkages between these critical domains require an integrated approach at planning and management levels to ensure water and food security, and sustainable agriculture and energy production. The need of innovation to overcome these challenges seems crucial.

Cleantech within the WEF nexus

Clean technology, or cleantech, is an expanding market referring to products, services and technologies that reduce negative environmental impacts through improving energy efficiency, the sustainable use of resources or environmental protection activities. It uses innovative technologies with the eventual goal to reduce negative impact on the environment and create eco-friendly technology. Cleantech includes different sectors: renewable energy generation, energy storage, energy efficiency, transportation, air and environment, clean industry, water and agriculture. Examples of cleantech applications in the WEF Nexus include waste management, water treatment, and the use of renewable energies. Globally the highest investments in cleantech sector in 2022 were toward energy storage, electrical vehicles, hydrogen solutions and carbon capture. This reflects the commitment of countries to achieve net zero emissions by 2050. According to World Bank "SMEs in developing countries can generate significant growth and create jobs by seizing a potential $1.6 trillion market opportunity in clean technology". Accordingly, cleantech are considered as an important economic opportunity in developing countries. Cleantech jobs have advantage on jobs in other sectors being on average more skilled, safer, and better paid. Since cleantech uses less resources and pollutes less, it is considered as a potential to drive employment, innovation and economic growth. According to "Investing news network" the global cleantech sector is expected to be worth as much as US$3.3 trillion in 2022 (https://investingnews.com/daily/tech-investing/cleantech-investing/what-is-cleantech/, 2022).

In Lebanon, environmental pressures related to climate change, growing population and urbanization leading to an increase demand on the resources, Water-Energy and Food, in addition to the economic crisis limiting the access to finance and largely affecting infrastructure and capacity of the related institutions to provide sustainably and efficiently water, energy and food, all these challenges seem to turn into opportunities for the SMEs and cleantech entrepreneurs to invest in innovation in order to ensure sustainable access to resources and ensure food security. In fact, these environmental pressures faced by the country, need an optimal management plan mainly for water, energy, wastewater and agriculture sectors. According to the fourth biennial report on climate change in Lebanon, energy sector is the highest contributor to GHGs emissions with around 82% of the total emissions, followed by the industrial sector 10%, waste and waste water 5% and finally agriculture with 3% (MoE/UNDP/GEF, 2021). In another hand, Lebanon being characterized by the availability of important natural resources (wind, solar and water) innovations in the cleantech sector can help the country to preserve its natural resources, as well as benefit from them through renewable energy systems.

Opportunities and challenges in the cleantech business in Lebanon

Lebanon is characterized by high qualified labor force, ranking 18th worldwide for the quality of its higher educational system. At the same time in 2015 it was ranked 8th in the MENA region for its ICT capabilities and skills, which will help to empower the innovation and technology in the cleantech sector in Lebanon. On another hand, workforce compared to other regions (US, Europe and GCC) is cost competitive being cheaper than the other mentioned regions. At the same time, scientific research in the field of environmental technologies and agriculture is flourishing in the country at public and private sectors however financing R&D in Lebanon is still minor compared to Global and MENA fundings. Lebanon is also characterized by fiscal incentives, having one of the lowest tax rates globally. Before the financial crises that occurred in 2019 many financial opportunities were available among which the BDL circular 331 released late 2013 injecting nearly $400 million into the entrepreneurial sector to build a Lebanese knowledge economy. Lebanon is considered as one of the oldest startup and venture capital ecosystems in the region. Even with the tremendous changes that occurred in Lebanon during the last few years due political protest, falling economy and COVID-19, accelerators and investors, are still interested to invest and provide their support to the startup community. The leading investors in the startup business in Lebanon are: Berytech, Speed accelerator, Flat6Labs Beirut and MEVP ((Choudhary, 2020).

Examples of opportunities trying to grow up in the cleantech sector from a nexus approach would be the biomass heating, consisting on transforming forestry and agriculture residues into high quality sustainable heating fuel which can be used for different needs. The competitive advantage of this technology is that there will be no shortage of raw material, as agricultural wastes are produced along with crops and require no extra land or efforts (Kaur, 2021). The end-produced bioenergy can be used for heating the animals inside the farm during the cold seasons, reducing the cost of energy and contributing to the protection of the environment and limiting the GHGs emissions. Such interventions are already promoted in Lebanon as pilot projects, like in the CEDRO project in 2016, when two 3MW briquetting plants were established in Bkassine in the South and Andket in Aakkar. Benefits from such projects can go beyond reducing the energy cost to creating job opportunities, forestry management and fire reduction, agricultural activity advancement through reduction of pollution and pests created by plants residues ploughed or left over in soil from a year to another, and consequently reducing the use of pesticides and improving the quality of the end product. Such interventions shall be upscaled to a level of entrepreneurship and cleantech industry in the country. The limiting factor in this technology will be the cost of investment making it difficult to realize at individual level, and needs the support of local partner such as municipality, adding to it the large volume of residues needed to make the project profitable. In such cases, collaborating with municipalities will be the added value of the project, who will be responsible of collecting the forest residues and consequently creating jobs, at the same time the municipality will be engaging several local farmers, collecting the agricultural residues in one centralized bioenergy producing plant. CEDRO through its 2022 bioenergy project is promoting this technology by subsidizing the farmers for the onsite production and reuse of bioenergy.

Many development agencies and institutions are promoting and subsidizing the reuse of solar energy in agriculture mainly for irrigation.

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Such technology can provide access to cost-effective and environmentally sustainable supply of energy, reducing the cost of the food products and ensuring the sustainability of the agriculture sector, however such technology if not adequately managed and regulated, it can bear the risk of fostering unsustainable water use, since low energy cost may lead to over abstraction of groundwater and low field application, where the need to set a clear regulatory framework for the reuse of renewable energy in agriculture mainly in irrigation. Some startup companies are innovating in the Water-Energy and Food nexus. An example is the Green Studios, that created the Switch Card, allowing to plant all types of plants including high shrubs, trees and vegetables in the hottest climates due to a fibrous skin layer that allows complete temperature insulation. The fibrous skin adapts to changing conditions via sensors linked to smart controllers, in order to keep the plants in good health. This technology contributes in saving both energy and water and opening the opportunity to grow in previously considered unfavorable regions for agriculture production (IDAL, CLEAN TECH SECTOR in Lebanon Factbook, 2018). Other example is Lifelab which is a custom hydroponic system with plans to create a 3,000 m2 hydroponic farm in southern Lebanon. Lifelab's hydroponic system can be operated through programmable logic controllers (PLCs), which provide a high degree of automation and the ability to manage the system remotely.

Although, having all these opportunities for cleantech and startups in Lebanon, the surveys and workshops for the water and energy sectors made by AUB-IFI of SMEs, identified many barriers for these latter to develop. For most of the start-ups involved in the workshops that were organized, the financial side was not a major issue at the beginning of their venture. But after October 2019, the situation changed drastically due to the financial and political instability that ensued and the collapse of the Lebanese Lira. Another concern was the corporate environment and the attitude of governmental institutions towards startups.

The corporate environment in Lebanon is very bureaucratic. Corruption was also mentioned by many of the participating firms as being an obstacle. Finally, most participating firms indicated that the move from a startup to an SME would have been near impossible were it not for the support of incubators such as Berytech.

A survey involving 110 firms, indicated that the most prominent obstacles faced by SMEs are the political/economic and security situation (combining for 26%) along with the government's regulations, SME protection policies, and bureaucracy (combining for 27%). Further, the survey that was conducted by AUB-IFI of SMEs in the water sector identified key challenges that were prioritized as follow:

1. Absence governmental policies stimulating and encouraging innovation and cleantech incentives
2. Lack of technical capabilities and facilities for research and development
3. Lack of financial resources for innovation
4. Lengthy bureaucratic procedures for approvals of new technologies
5. Limited networking between SMEs and academia
6. Absence of a clear and proper classification/ ranking criteria for SMEs
7. Lack of trained personnel in the water sector

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For the last decade, it has been progressively recognized that co-benefits can be achieved through an integrated approach to addressing security issues related to water, energy and food, and a nexus approach is an effective way to manage the interdependences between the resources. In Lebanon, as in other MENA countries, the water-energy-food nexus approach is widely accepted. However, implementation is still limited due to many challenges related to the enabling environment. (WALEED KHALIL AL-ZUBARI, 2020)

In this paper we highlighted many challenges facing each sector alone, but at the same time it was obvious to which extent they were interconnected, where the need to create the appropriate environment to find innovation solutions in an integrated WEF nexus approach.

A favorable business environment can facilitate the emergence of high-quality companies that are open to growth and becoming more conductive to the rise of innovation in the cleantech sector, and increase the demand of this technology among the public at a local and international level.

Creating favourable environment for Innovation in the Cleantech Water-Energy-Food

The existing nexus tools highlight a limited number of models and frameworks that address all WEF together for a nexus approach and those models are not extending beyond WEF when designed to include different sectors such as political, social and economic in order to reach a full nexus thinking and address the complexity of it being a multi-sectoral resource approach. One important feature toward more integrated modeling includes data sharing and incorporation of spatial and temporal drivers and generate effective policy recommendation (Mabrey, 2018). Improving data sharing across the three sectors and on different levels is a critical step towards improving integrated nexus modeling.

Innovation systems are complex and rest on four pillars: financing, knowledge management, marketing, and socio-political support.

Innovating relies also on good governance involving a wide range of stakeholders: governments, researchers, investors, entrepreneurs, and civil society they all participate in generating ideas for new or improved technologies and in financing them.

Clean technology SMEs face daunting challenges. Government can help cleantech SMEs facing their challenges by creating targeted policy incentives.

The Global Cleantech Innovation Index determined inputs to innovation and divided them into two main categories (UNIDO, 2017):

- General Innovation drivers:
  - General innovation inputs
  - entrepreneurial culture
- Cleantech specific Innovation drivers:
  - Government policies
  - Public R&D spending
  - Access to private finance
  - Infrastructure for renewables
  - Cleantech industry organization

Global Cleantech Innovation Index, highlighted the important role of the government in promoting cleantech and thus at different levels: policies, R&D, infrastructure and financing. Accordingly, in Lebanon government shall set overall national objectives and priorities adapted to the local environment that can help in creating the enabling environment for the cleantech technologies.

Institutional and Policy level: When promoting cleantech environment, it is also important to have a strong integrated framework for Water-Energy-Food context to translate nexus ideas into steps for the government to apprise policies. In Lebanon, the sectoral planning and management of water and energy falls under one single ministry, which is the Ministry of Energy and Water (MoEW) while the Ministry of Agriculture (MoA) is identified as the key ministry mandated with the planning and management of the agriculture sector. The state actors show integrated system according to their mandates however, the existing institutional interlinkages within and between ministries are not usually taken in advantage and this due to several barriers of which; the complicated bureaucratic procedures and the high number of vacancies in the various ministries causing a great loss in efficiency in addition to the lack of common methodologies and visions for setting the strategies (Farajalla N., 2016). However, comparing the strategy of the water sector set by the MoEW in 2010 and the updated one if 2020 we can notice

a great progress toward a more comprehensive vision and a greater overlap with other sectors. In this new strategy not only supply for irrigation were considered but also the present and future demands were calculated. Another step toward a more integrated management of the water and food sectors was mentioned in the strategy talking about the "Organization of the irrigation sector under the Water Establishments and coordination with Ministry of Agriculture to develop and optimize sources of water for agricultural lands in order to decrease the need for private wells for irrigation" purposes. (MoEW, Updated National Water Sector Strategy (2020-2035), 2020) Electricity policy paper dealt mainly with supply without detailing the needs of different sectors among which agriculture and food sectors. However, a good progress is to be mentioned in the updated Energy paper of 2019 where the target of the green and sustainable power being 30% by 2030 compared to 12% in the previous paper (MoEW, Updated Policy Paper for the Electricity Sector, 2019). The recent agriculture strategy, showed an improvement from its initial strategy to include a pillar on cross sector integration planning and responding to climate change. However, these strategies lacked coordination and were set apart from a clear common vision about agriculture, irrigation and energy needs and future plans from the two key ministries.

One innovation in developing policies to increase the use of sustainable energy for the agri-food chain is the "energy-smart food systems" which improve access to modern energy services, rely more on low-carbon energy systems and use energy more efficiently. These systems take advantage of the fact that agri-food chain is not only a consumer of energy but also a producer of energy. Energy from the value chain can be in the form of bioenergy that uses crop and livestock residues for instance, while energy for the agri-food chain includes the use of renewable energy technologies like solar PV to increase cold storage, and processing infrastructure and to promote irrigation. If such systems are included within the policy of the government, this will create a good opportunity for the startup companies in the cleantech sector to innovate.

Both water sector strategy and strategy of the agriculture sector prioritized the reuse of treated waste water in irrigation. The reuse of treated wastewater was one of the main nonconventional resources that the NWSS 2010 has assessed and set to increase to 50% in 2020. However, only Ablah WWTP in Bekaa was equipped with a reuse system for the irrigation of 20ha of grapes that replaced irrigation from individual wells. Reusing wastewater for irrigation helps achieve water efficiency and conservation, reduces the need for pumping from private wells, saving on energy and decreasing the cost of crops. One of the main constraints in implementing the WWTPs is the high operation cost. To enhance the transition towards both renewable energy and non-conventional water, it is recommended to undertake the following measures and actions:

- Reform the subsidy and tax system to promote more sustainable production and consumption patterns across sectors, make the polluter-pays principle operational, and take into account equity considerations (Barde., 1994). Accordingly, the application of an adequate tariff that is socially and economically appropriate has to be adopted

Public R&D spending: An R&D effort is necessary not only to develop new technologies but also to make existing ones more affordable. Innovation has to be a major part of the climate solution (across energy, food and water) and while we can be deploying more technologies, we also need to be investing more. A scarcity of funding, facilit ies, and human capital for startups to perform R&D can prevent entrepreneurs from inventing, prototyping and testing cleantech ideas that can

turn into high impact companies. This in turn prevents launching and ultimately scaling cleantech startup solutions in Lebanon. Where the need to increase the public spending on R&E for the development of the cleantech sector.

Access to finance: Environmental innovations or cleantech include new technologies that are able to compete on price and performance, while reducing environmental impact. That's why attention shall be given to create opportunities of finance for the ecofriendly initiatives. Accordingly, strategies to finance cleantech need to be comprehensive addressing any barrier that may arise at any stage of the cleantech company. Large and high capital scale for many cleantech projects compared to early-stage-high-growth rate areas such information and communication technology complicate efforts to obtain financing and scaling up the project from demonstration to commercial level (UN, 2011). An increasing share of global venture (VC) capital is targeting the development of clean technologies as investors seek to take advantage of a growing demand for green technologies. Accordingly Lebanese government, should play a leading role in terms of encouraging VC and investors to allocate more of their capital into the cleantech sector through setting clear overall national objectives and priorities. By stimulating investments in cleantech sector, this will increase job creation and attract investors' attention.

Enabling infrastructure: Infrastructure plays an important role in SMEs' competitiveness and development (OECD, 2004), (UN-ESCAP, 2011), (ILO, 2019). Enhancing transportation, telecommunication, energy, water and sanitation can provide SMEs with accessibility to local, regional and global markets (ILO, 2019) The quality of the infrastructure smooths the production of services and goods and can lead to an improved competitive business environment. Information and communication technologies (ICT) are considered a fundamental element for the sustainability of enterprises (ILO, 2019). Its affordability and accessibility provide a better competitive and innovative environment for SMEs.

Entrepreneurial culture: Entrepreneurs contribute significantly to the enhancement of the GDP in several countries and are considered as the main engine for global economic development. SMEs are the engine of economic growth and judged as key to development. Local production and innovation opportunities should always be grasped whenever possible (ILO, 2019). Government policies should help and support entrepreneurs, which entails developing their technical skills, given that entrepreneurs are vital and essential for the economy. Policy measures should include entrepreneurship training and education, youth entrepreneurial programs, new business incubation and women entrepreneurship development. External funding plays a significant role in developing the entrepreneurial culture in needed areas (UN-ESCAP, 2011).

To fulfill and enhance an entrepreneurial culture, human capabilities should be developed through high-quality systems of education, training and lifelong learning (ILO, 2019; (IMF, 2019); OECD, 2004). The lack of a well-educated and skilled labor force is one of the most significant challenges faced by developing countries (OECD, 2004).

The press and media also play a vital part in recognizing, stimulating and promoting the success of local entrepreneurs. The positive media coverage of success stories from (tech) entrepreneurs has the ability to inspire a new weave of forward-thinking entrepreneurs. These programs can have a positive effect on social norms and values associated with entrepreneurship. At last, positive media coverage can be complementary to policy initiatives aiming to stimulate entrepreneurship.

WEF Nexus

Participatory approach and stakeholder engagement: create a participatory approach and include all stakeholders in the policy making, designing and implementation of cleantech would leverage the sector to a competitive level. The project identified many ways of stakeholder engagement such as increase the participation of SMEs in governmental decisions through a dialogue between SMEs and non-SMEs. Create partnerships with universities to design, study and test innovative material and solutions for the cleantech industry. Collaborate with the Ministry of Industry (MoI) and Ministry of Finance (MoF) in the development of an SME Master Plan to develop the Enabling Environment. Coordinate with MoF and Banque du Liban (BDL) to introduce tools to improve the enabling environment mainly at fiscal level the role of the Ministry of Finance is inevitable, especially in setting and implementing alternative financial schemes to fund innovation for SMEs in the Cleantech sectors, as well as in issues related to tax incentives, issuance of permits, and prioritizing the donors' community grants. This is complemented by the role IDAL and Kafalat should be playing as well in this regard.

Participants in both water and energy workshops identified several steps that need to be implemented to improve the cleantech sector. Establish clear classification criteria for SMEs in green technology sector to enhance credibility and ensure good quality services, especially when it comes to ToRs/Calls launched by public institutions. Identify areas for business improvement through dedicated training and certification programs for SMEs. Ex: TASMU Innovation Lab in Doha, Qatar that enhances business research, development and innovation through events, training and certificates. Find practical solutions and shortcuts to simplify governmental/institutional bureaucratic delays that hinder the implementation of any decision/decree. Issuance of Exclusive Permits on some primary equipment such as: the issuance of decisions/ decrees or "licenses for import" by the Ministry of Industry on some specific equipment used in the cleantech sector.

Way Forward

Lebanon's current economic and politic crises has led to a number of factors leading to food insecurity throughout the country. Adding to this, our natural resources quality and quantity are threatened being affected by climate change and unsustainable exploitation. Moreover, Lebanese economy in all its sectors relies mainly on imported sources of energy, which are closely related to the global market. Within this challenging environment, considering an integrated nexus approach regarding Water, Energy, and Food sector will help in sustainably manage our resources and promote our food security. Cleantech are innovative drivers in protecting the environment and promoting the economy. SME's that can invest in cleantech technologies are facing daunting challenges, where the need for the creation of an enabling environment that would allow SMEs to better and more constructively engage in the cleantech sector. The various meetings conducted within the water and energy projects have helped in identifying indicated key pillars for such a move are.

Leveraging public procurement is a measure that would generally stimulate demand in the cleantech sector, mitigation measures for the bureaucratic process at all levels can help reducing barriers that are still hindering SMEs from moving forward in their innovative approach.

Changes in relative prices can increase the attraction of new clean technologies where the need for a good cooperation between the Ministry of Finance and the Central Bank in promoting tax incentives, tax breaks, exemptions, VAT, tariff restructure.

Regulatory measures may also be required to overcome market failures and to generate demand for environmentally friendly technologies.

Improvement in the cooperation and coordination between line ministries in water, energy and food as well with other involved institutions will help in building more integrated and comprehensive strategies that pay attention to both supply and demand-side measures. Other examples of coordination would be between Ministries of Industry and Finance in the creation of an SME Master Plan.

Investment in infrastructure is necessary to break path dependency that blocks innovation. The quality of the infrastructure smooths the production of services and goods and can lead to an improved competitive business environment.

The development a set of criteria to qualify and certify SMEs. Such an undertaking would ensure the quality of service that would be delivered by SMEs in the cleantech sector and improve accountability. Partnership with universities to design, study and test innovative material and solutions for the cleantech industry is also a boosting step. This would also require the qualification and certification of laboratories (within and outside universities) that will be involved in the water, energy and food sectors.

Moreover, certification schemes are also a crucial topic that SMEs consider to be an important subject to be assessed. Certifications allow SMEs to boost technical credibility by acquiring relevant know-how and skills from accredited international institutions, thus, tapping into consumer demand for clean technologies, tools and products. Once certified, SMEs accredited gain credibility to local and international market, which increases their income and encourages the business.

WEF Nexus

Collaboration, in particular at regional and international levels, is essential for the development of clean technologies. Such collaboration facilitates the exchange of policy experiences, the pooling of resources and the achievement of scale effects

Predictability and stability of policies and regulations are essential to ensure the growing engagement of the private sector in financing and developing clean technologies and to attract fresh grants and funds.

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