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The Water-Energy-Food Nexus in the Arab Region

Nexus Capacity Development Needs

Summary

Reliable water, energy, and food supplies are strongly linked and interdependent in the Arab region. This interdependency is expected to intensify in the future due to many internal and external driving forces the most important of which are population growth, changing consumption patterns, and the impacts of climate change. As such, management of these vital primary resources needs to be carefully designed including such that securing one of these primary resources does not compromise the other resources. In order to achieve reliable water, energy and food supplies at a national and global scale, multi-stakeholder platforms are needed in order to develop and explore science-policy-society linkages and opportunities to share knowledge and employ it to meet the targets for both the Sustainable Development Goals and the Paris Climate Change obligations. Understanding these complex linkages and translating this into solutions requires increased nexus system thinking and problem solving competence. These platforms can only be created by building capacity at different levels, including institutional, academic (knowledge) and outreach. Many Arab countries have competent professionals in the fields of water, energy, and food/agriculture, and there is no need for new staff for the WEF nexus. What is needed is an inter-sectoral capacity building and cooperation among these professionals. Moreover, many decision support tools are available to provide guidance on science-based policies; each of these tools has different data requirements and applicability. The choice of the tools used is dependent on the local conditions and it can provide projected solutions or a portfolio of solutions for a more integrated resource management. Furthermore, decision support tools are highly valuable in promoting cross sector communication and trade-offs, thus it is critical to create these competencies at an individual as well as institutional levels.

Recommendations

Policy makers in the Arab region should mainstream and support the WEF nexus system thinking and build the capacity for integrated approaches for natural resource management through the following measures:

- Assemble a multi-stakeholder working group from the water, energy and food sectors across the public and private sectors to help guide the management of these three vital sectors.
- Develop specific institutional and individual capacity building programs across the three sectors. A main focus of these programs must be creating competence in dialogue and conflict resolution, data management and analysis and an understanding of the WEF nexus at a technical as well as policy levels.
- Determine the right tools and data sets for scale specific conditions (local, national, regional) and goals.
- Apply outcomes from holistic nexus tools and comprehensive data sets to guide the management of water, energy and food resources. Use this data as well to bring stakeholders into negotiation dialogues and find trade-offs.
- Create training programs across the various sectors to build capacity on the analytics as well as the negotiation aspects of the implementation of nexus solutions at different levels.

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The Triple Nexus of Water, Energy, and Food

Looking at the water-energy linkages, the water system is an energy user mainly through electricity consumption for pumping fresh water, drainage and water table management, desalination, water treatment, and water distribution in farms and cities. Energy in return is a major water consumer. Water is needed for energy generation, cooling, resource extraction and refining, transportation, and bioenergy production. The dependency of one system on the other is largely defined by the choice of technology used in energy–water demanding activities.
The energy–food nexus relates mainly to energy use within the food supply chain. Depending on the extent of mechanization, agricultural production consumes energy directly in the form of fuels for land preparation and tillage, crop and pasture management, and transportation or electricity supply, and indirectly through the use of energy-intensive inputs, such as fertilizers and pesticides, or energy for manufacturing agricultural machinery. Energy is also needed during processing, distribution, storage, retail and preparation of food products. This makes food security particularly sensitive to the quality and price of energy inputs: in some countries, the price of oil has a rather direct effect on the price of food.

Among the most widely covered and quantified elements of the nexus is the relationship between water and food systems. Today, the water–food nexus is symbolic of vulnerabilities on two fronts: changing patterns of water supply that are influencing the reliability of water-intensive sectors including agriculture,

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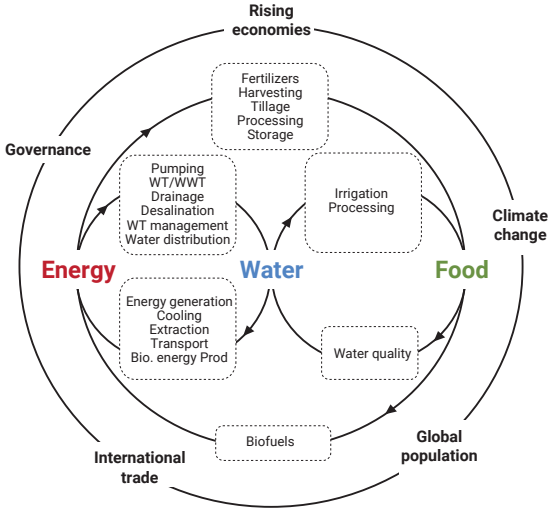
and the growing competition for limited water resources in meeting the projected increase in food demand.

The ability to face the current and anticipated global challenges and mandates of SDGs and the Paris Climate Change agreement will be governed by the ability of better understanding the interconnectedness and tradeoffs between these systems. According to the Global Risk 2011 report presented by the World Economic Forum, the water–food–energy nexus is a global risk that fundamentally threatens human, social, and political security.

A Conceptual framework of the nexus with the existent linkages between water, energy, and food and the factors affecting the nexus



As most global projections indicate, the demand for freshwater, energy and food will increase significantly over the next decades under the pressure of population growth and mobility, economic development, international trade, urbanization, diversifying diets, cultural and technological changes, and climate change. By 2050, 60% more food will need to be produced; energy consumption is expected to increase 50% by 2035. As demand increases, so the competition does for resources among sectors; the food sector (mainly agriculture) accounts for 70% of total global freshwater withdrawals. At the same time, the food production and supply chain consumes about 30% of total energy consumed globally.

The Bonn conference on Sustainability in the Water-Energy-Food Nexus (2011) created momentum as an institutional platform, and called for the great need of expanding financial, institutional, technical and intellectual resources for nexus research and applications (Sustainability in the WEF Nexus Conference, 2014). Moreover, The GIZ has worked closely with governments of the Arab region in the promotion of educational reforms, in the environmental and infrastructure sectors, food safety, and groundwater resources in the desert to name a few. Egypt is one of the GIZ priority partners; during the political transition, a team of experts has played an important role in capacity building and networking management. Other examples of this program have tackled pressing issues such as water demand for Syrian refugees, decentralization of wastewater management, solar cooling for industry and several projects related to climate change in the region.

In order to achieve water, energy and food security objectives at the national and regional scale in the Arab region, multi-stakeholder platforms are needed in order to develop and explore science-policy-society linkages and opportunities to share knowledge. These platforms can only be created by building capacity at different levels, including institutional, academic (knowledge) and outreach, and by creating synergies and building a strong capacity for negotiation between stakeholders. The competition for resources as well as the establishment of financial responsibilities when managing resources as a nexus can be challenging; even more complex when these resources are viewed as a matter of national security as well as an issue of creating more stable societies and providing basic human needs.

Who Owns the Nexus?

Some argue that managing the nexus at the local or national level does not require a major institutional restructuring, but rather appropriate changes to protocols, procedures and processes that improve interactions among the relevant governance entities. Others, on the contrary, affirm that lack of co-ordination among institutions (silo decision making) could be a key cause of the nexus pressures that are being experienced today **(Policy Brief 3)**. The reality is that neither the state nor the markets have been uniformly successful in solving common pool resource problems. At the individual level, in the Arab region there are a group of world class professionals in the areas of water, energy, and food/agriculture that are a vital local resource. Therefore, there is no need for new workforce to implement the WEF nexus, but rather a need for inter-sectoral capacity building, organizational learning, and cooperation for each of these sectors.

Capacity Development in the WEF Nexus

The science behind the interlinkages between water, energy and food in ecosystems and societies is still not fully understood. Furthermore, the external pressures into the WEF Nexus such as climate change, population growth, political unrest and specific local conditions, among others call for an impending need to create capacity building programs and knowledge management systems at all levels involved. However, it should be noted that capacity development is a long-term and continuous strategic process where individual, institutional and policy environment go hand in hand.

Who's Capacity Matters?

Capacity building and development in the WEF nexus approach need to be made at different levels, including institutional, academic (knowledge) and outreach. Specifically these are:

- Institutions in the public sector (e.g. legislators, politicians, utilities, municipalities, etc.) and private sector (utilities, supply chain, agricultural and industrial sector, etc.)
- Educational establishments (research and technical training). Academic institutions are required to develop curricula and invest in research geared towards a WEF nexus system thinking and approach at a technical as well as policy levels.
- Outreach (civil society and foreign aid agencies). Creating outreach programs for increasing awareness and knowledge dissemination is of great aid in the implementation of the WEF Nexus; client ownership in capacity building is a must to move towards greater impact.

Building Capacity at the Institutional and Policy Levels

Adopting a nexus approach has a major role in generating the dialogue for tradeoffs and moving towards cooperation and away from conflict among sectors. There is no possible scenario where societies will be able to achieve all of its needs of vital resources in all sectors; there are no win-win scenarios, and therefore compromises and tradeoffs are needed. Capacity development for decision makers at this level should be focused on the following main areas:

a. Conflict resolution and communication skills across disciplines and sectors. Additionally, at the regional level, there is a need to build capacity in negotiators where there is a deep understanding of transboundary issues, international conventions, dialogue and trust building as well as legal aspects.
b. Establishing a network of leading experts in the region. The challenges are too large and too complex to be tackled in an isolated manner. Particularly in the Arab region where brain drain is a chronic phenomenon, there is a need to create 'institutional memory' to ensure the sustainability and permanence of the capacity created.
c. Providing decision making tools that visually present to national and sectoral planners the imports/exports, consumption, production, emissions, demand projections and scenarios, in a simple holistic way as a precursor for creating the right environment for negotiations and institutional learning.
d. Provide an appropriate legal framework and regulations that will encourage an effective nexus governance. Legislators must be informed and build capacity for promoting institution al reforms, laws, regulatory standards and enforcement mechanisms in favor of the implementation of nexus policies and strategies.
e. Work with parlamentarians/legislators towards the decentralization of water and energy institutions in the region in order to create a more participatory environment. The involvement of civil society in decentralized institutions create better accountability and compliance.

Summary of WEF nexus tools (modified after IRENA, 2015)

Tool	Main Inputs Required	Outputs/Answered Questions					
		Energy	Water	Food	GHGs	Economic	Land
Climate, Landuse, Energy, and Water (CLEW) (Alfstad, 2013)	• Extensive data requirements • Technical and economic parameters of power plants, farming machinery, water supply chain, desalination terminals, irrigation technologies, fertilizer production, etc.	• Energy balance, including power generation and refining • Energy for food • Foreign (virtual) energy	• Water balance • Water supply and desalination • Water pumping • Water for food Water for energy (hydropower, power plant cooling, biofuel crops)	• Irrigation technology • Use of fertilizers • Use of farming machinery	• Local and foreign (virtual) • Cumulative emissions	• Selected economic indicators	• Biofuel crops • Types of land according to context
The Water, Energy, Food Nexus Tool 2.0 (Mohtar and Daher, 2013)	• Data and local characteristics of food, water and energy systems • Local production of food, water and energy (per type) • Context-specific policy inputs	• Implications of food production on energy trade • Energy for water (pumping, treatment, desalination) • Energy for food (tillage, fertiliser production, distribution, harvest)	• Implications of food production on local and virtual water	• Levels of local production of different types of food	• Implications of food production • on emissions (local and virtual)	• Costs of food production	• Land for food
MARKAL/TIMES (Loulou et al. 2005)	• Extensive data requirements • Techno-economic details of energy technologies • Characterization of the reference energy system	• Energy planning with high technological detail Energy balances • Effectiveness of • energy policy	• Water use in energy sector		• Emissions from energy sector	• Total discounted costs of energy sector, including its water supply	
WEAP-LEAP (SEI, 2013)	• Extensive data requirement • Techno-economic details of energy technologies	• Detailed analysis of energy demand, transformations and stocks • Energy balances	• Watershed hydrology and water planning • Physical and geographic simulation of water demands and supplies • Groundwater, water quality And conservation, reservoirs and hydropower		• Emissions from energy sector	• Includes a financial module	
FAO's nexus assessment methodology (FAO, 2014)	• Indicators that are already available • Key classifications of the country under study to place it under country typologies	• Specific to each type of intervention, but a large choice (e.g., energy consumption and production)	• Specific to each type of intervention, but a large choice (e.g., water pumped, water for energy, etc.)	• Specific to each type of intervention, but a large choice (e.g., yields, harvested food, etc.)		• Specific to each type of intervention, but a large choice (e.g., costs, incomes, jobs, etc.)	• Specific to each type of intervention, but a large choice (e.g., areas needed, cultivated land, etc.)
WBCSD Nexus Tool (WBCSD, 2014)	• Characterization of the energy sector • GIS maps and information • Characterization of water for food and for energy • Information on labor force and availability of machinery	• Energy for water • Energy for food (for irrigation, fertilizer production or machinery)	• Water for energy (for power generation or fuel production) • Water for food (e.g., green water, blue water)	• Food production			• Land use
MuSIASEM –The Flow-Fund Model (FAO, 2013)	• Extensive data requirements • Socio-economic indicators, including work force evolution • Availability of land Climate change impacts • Characterization of all flows	• Energy flows in society (of fossil fuels and electricity)	• Water flows in society (e.g., for drinking, domestic use, irrigation, industrial processes, etc.)	• Food flows in society	• Implications of all flows on emissions	• Costs and value added	• Land use
Diagnostic, Financial, and Institutional Tool for Investment in Water for Agriculture (Salman, 2013)	• Full data sets needed to characterize local irrigation and hydropower projects	• Impact of hydropower projects in improving local livelihoods • Access to electricity	• Water management Water for agriculture • and energy (hydropower) Water management •	• Food security • Agricultural production	• Impact of irrigation and hydropower on emissions	• Contribution of agriculture to GDP and income generation • Investment needs • Impact of irrigation projects in improving local livelihoods	• Cultivated land and crop yields

Nexus Decision Making Tools

In order to achieve the goal of integrated policy-making, decision-makers must be equipped with both qualitative and quantitative frameworks to both understand the challenges and then to effectively implement the appropriate policies to address those challenges. The development of such tools support policy dialogues across sectors and inform policy makers the extent to which a certain policy affects the different sectors.

Decision support tools are available to provide guidance on science-based policies. The choice of the tools used is dependent on the local conditions and it can provide projected solutions or a portfolio of solutions for a more integrated resource management comparing the business as usual vs. Nexus approach scenarios. Furthermore, decision support tools are highly valuable in promoting cross sectoral communication and trade-offs, thus it is critical to create these

competencies at an individual as well as institutional levels.

Several nexus tools are available and have different analytical approaches, depending on the inputs required, the outputs provided and the analytical characteristics. In many cases, the basic simple tools that have a limited scope have proved to be very useful in bridging the gap between a silo approach and a more comprehensive nexus assessment.

From all decision support tools available, it proves helpful to choose the ones that meet these three important criteria: (1) address at least two of the three elements of the nexus; (2) allow policy analysis at a national (and local) levels; and (3) have an open access for end-users. Currently, there are eight relevant tools that are mostly valuable in the nexus implementation: WEAP/LEAP, LEAP, Markal/Times, CLEWs, WEF Nexus Tool 2.0, the Global Calculator tool, MuSIASEM, and FAO tool.

These decision support tools are an example of how these models can inform policy making by quantifying the extent to which a policy for one sector affects other sectors. There is no 'one-size-fits-all' tool; therefore, there is an importance of identifying the critical question in order to prescribe the proper tool. Different tools answer different questions at different scales and require different sets of data. The choice of tool will also depend on the resources and time available.

The water and energy footprint of different technologies implemented in resource management are available and included in many of the nexus tools described above. However, it has to be noted that specific data for each site and sector is needed to obtain relevant answers. For example, in the case of groundwater use, it is not enough to define only the amount of water to be pumped; the depth from which water is extracted as well as its quality (treatment needs) are important to establish an integrated water management with a water-energy nexus lens.

Also, it is important that tools provide information to encourage diversification in the national and regional portfolios for the nexus (for example, nutrition security in the food sector and renewable energy). In addition, the decision making tools need to create some indicators to measure the impacts of a policy implemented, where costs, benefits and impacts can be evaluated.

Data is usually available in individual sectors or for specific stakeholders but it is not compiled. These valuable knowledge resources can only be compiled if all sectors are in synergy.

The WEF Nexus Course and Executive Masters at Texas A&M University

The Water-Energy-Food Nexus Group at Texas A&M University established a graduate course program on the "The WEF Nexus: Towards Sustainable Resource Management". The program was introduced in a joint appointment between the College of Engineering and College of Agriculture; students enrolled in Masters and PhD programs from a wide variety of backgrounds such as civil engineering, agriculture and biological engineering, economics, and political science study the principles of the WEF nexus and their impact on national and international securities. Given in the form of a module, the course explores spatial variability of resources, localizing water and food reliable supplies, as well as covers a quantitative nexus framework and environmental policy as well. This learning experience has facilitated understanding on how engineering and analytics interface with economics, policy and supply chain at local and global scales. The course relies on multimedia resources and includes lectures/discussions with internationally renowned experts via interactive web-based discussions.

Source: The WEF Nexus Research Group at TAMU; http://wefnexus.tamu.edu/courses-at-tamu/

Building Capacity at the Knowledge Level

The academic training provides a platform to generate a multidisciplinary discussion that will bridge the knowledge gaps and aid in understanding the interlinkages between water, energy and food and external factors.

Moreover, creating an inter-phase between formal academic knowledge to provide training to the public and private sectors is of utmost importance; for example, technical instruction in industry, professional engineering practice, or through mandatory trainings for public sector employees.

At this level, capacity development should focus basically on the following areas:

a. Establishing programs at local universities for training professionals at an academic level as well as creating short-term capacity development programs for targeted institutions and decision makers (for example, on the use of nexus tools).
b. Technical staff should learn about operational efficiencies of water and energy use.
c. Training programs should include also dialogue and conflict resolution, data management and analysis and an understanding of the WEF nexus at a technical as well as policy levels.

Building Capacity in Outreach

It is important to build programs or entities to facilitate and promote collaboration among public, private, academic sectors and NGOs; these programs must target specifically increasing awareness, knowledge dissemination, policy dialogues, and information sharing networks. This can be in the form of extension programs from universities to producers (e.g. farmers, utility companies) and industries, for example.

Civil society is the source of demand for resources, which takes shape based on population size, social breakdown, preferences and needs. Approaching the water-energy-food nexus from a people-centered framework is central to create common goals in the region as well as achieving sustainable development in the region. Also, when civil society is actively involved in the governance of the nexus, it has an important role in being the engine for accountability moving from a passive criticism role into a more proactive participatory one.

Capacity Development Financing

To develop and build the capacity in all these sectors, the financial responsibility of the nexus implementation (who will pay the cost?) is a critical aspect; it is imperative to find a suitable model of governance of the nexus and the mechanisms of regulation and oversight that will work for each specific region or country.

Conclusion

In order to achieve water, energy and food security objectives at a national and regional levels in the Arab region, a WEF nexus approach to resource management needs to be implemented. Multi-stakeholder platforms are needed in order to develop and explore science-policy-society linkages and opportunities to share knowledge, including public sector (legislators, politicians, utilities, among others), private sector (utilities, supply chain, agricultural and industrial sector, etc.), civil society and foreign aid agencies. To build capacity in all these sectors, academic institutions are required to develop curricula, experimental pilot projects, and invest in research geared towards a WEF nexus approach at a technical as well as policy levels. Legislators have a central role in facilitating institutional reforms, laws and enforcement mechanisms that will create better collaborative platforms. The establishment of a network of leading experts in the region is encouraged to create more synergy in the technical knowledge as well as in transboundary issues, international conventions and legal and institutional aspects. The use of decision support tools provides highly valuable information to look for trade-offs and evaluate the impact of the business-as-usual vs. WEF Nexus approach for specific
scenarios of water, energy or food security. Finally, the involvement of civil society in the nexus governance can be an important asset in generating better dialogues and bringing legitimacy and accountability to governing institutions; creating outreach programs for increasing awareness and knowledge dissemination is of great aid in the implementation of the WEF Nexus; client ownership in capacity building is a must to move towards greater impact.

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