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Tools for the **Water-Energy Nexus**

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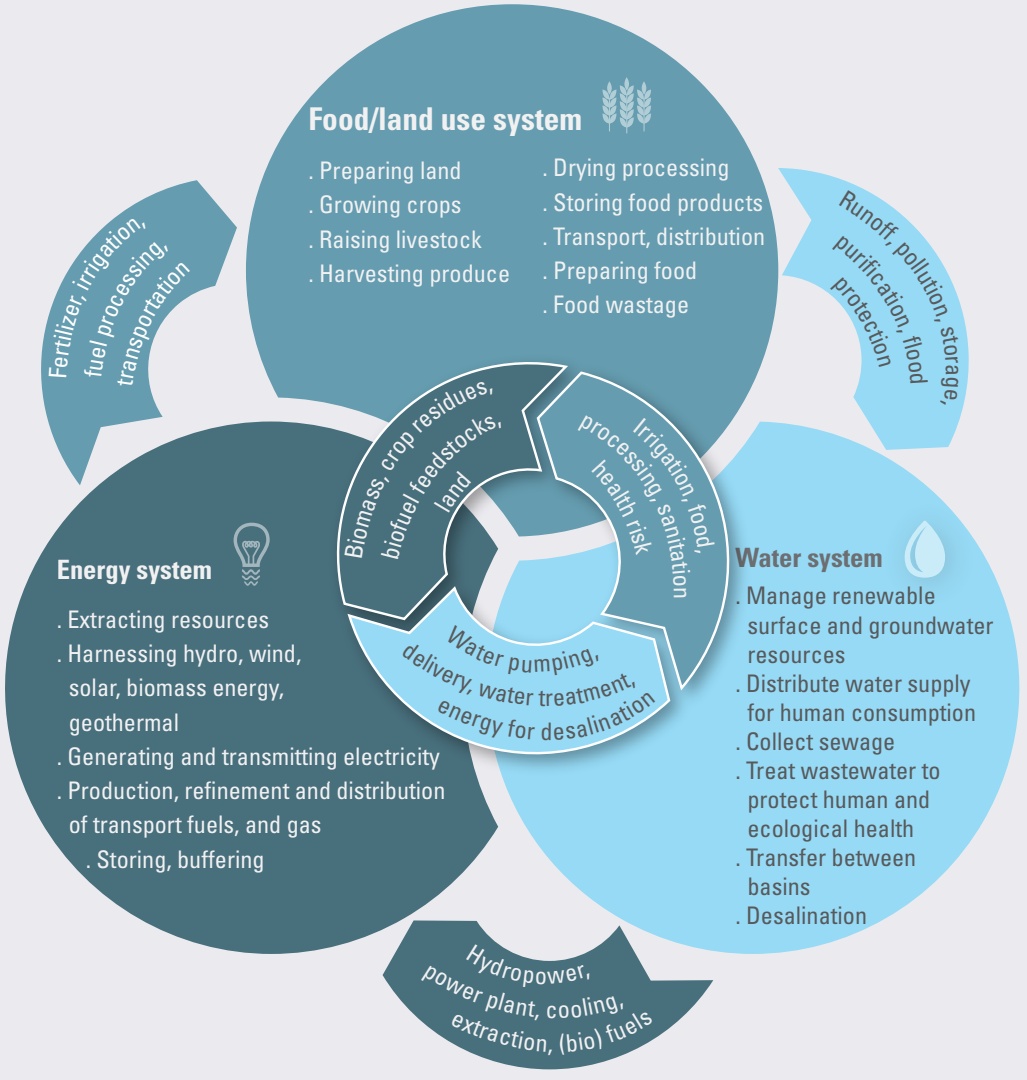
Tools for the **Water-Energy Nexus**

The Nexus Approach

The United Nations Sustainable Development Goals (SDGs) are interlinked to, and benefit from, increased synergies in their deployment. Energy is critical for assuring quality of life and underpins the attainment of the 2030 Agenda for Sustainable Development (2030 Agenda). Achieving the SDGs will require coordination between sectors, coherent policies and integrated planning. The image below describes the different SDGs, alongside the institutional frameworks related to the nexus dimensions.

The nexus approach provides an opportunity to strengthen actions aimed at achieving the SDGs. First, it contributes specifically to setting complementary goals and targets that can be achieved hand-in- hand, as it helps identify interactions between goals and across sectors. Second, by bringing stakeholders together, the approach promotes the creation of partnerships and collaboration across sectors and countries that are essential to achieving the 2030 Agenda. Third, the nexus approach can be used as a framework for solutions that arise based on examination of plans for countries and entities. The water-energy-food nexus integrates the security, accessibility and affordability of essential resources and underpins the sustainable management of resources within the 2030 Agenda framework.

Figure 1. **Water-Energy-Food nexus and efficiency**



Source: United Nations Economic and Social Commission for Western Asia (ESCWA). *Developing the Capacity of ESCWA Member Countries to Address the Water and Energy Nexus for Achieving Sustainable Development Goals-Regional Policy Toolkit*, 2016.

01

The Role of Renewable Energy within the Nexus Approach

Renewable energy plays a crucial role in the agricultural and water sectors, provided that trade-offs and synergies in the water-food-energy-ecosystem nexus are appropriately addressed.

➔ The 17 SDGs include economic, social, and environmental dimensions of sustainability, with progress of each SDG relying on the progress of the other goals;

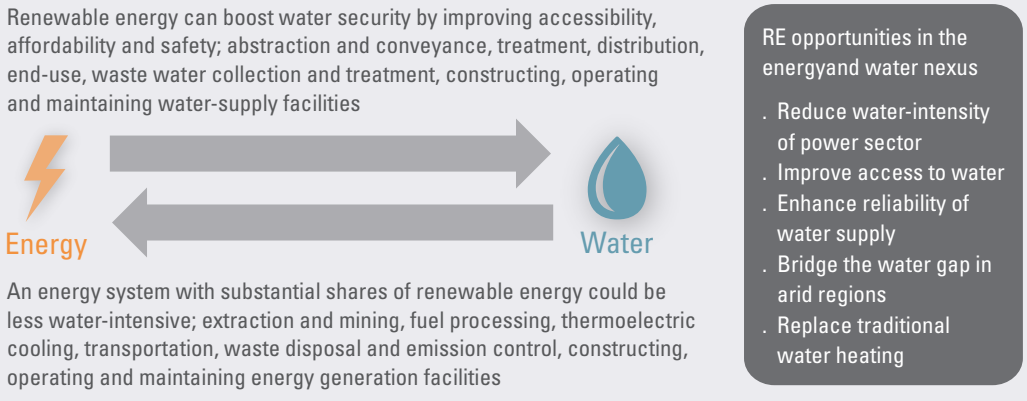
➔ All SDGs form a network connected by linkages that are both positive and negative:

- Positive: synergies that reinforce each other's progress;
- Negative: trade-offs that hamper each other's progress.

➔ Renewable energy technologies can be used to improve water access and increase food production. However, their deployment can also be a limiting factor that highlights the importance of inter-sectoral impacts and sustainable priorities.

The role of renewable energy as a means to achieve several SDGs at the same time is very promising. In particular, there are many ways in which it can strengthen the water-energy nexus, as shown in the image below.

Figure 2. **Renewable Energy opportunities and various elements in the water, energy and food nexus**



Source: ESCWA. *Water-Energy Nexus Operational Toolkit: Renewable Energy Module*, 2017.

Renewable energy will increasingly drive the transformation of the energy sector

- The global energy demand is predicted to double by 2050, with the energy sector undergoing major transformations.
- The role of renewable energy is important for this transition, particularly that the cost of producing electrical power through solar photovoltaic (PV) and wind technologies will decrease with the increase of newly discovered technologies.
- With the growth of renewable energy markets, policymakers are helping facilitate investments through appropriate regulations.
- The main challenge is to maximize the impact of renewable energy as a catalyst for development.

Renewable energy can help improve water security by providing the power needed, through water-related techniques, such as water distribution and wastewater treatment. Regarding energy security, renewable energy can also boost water security by providing energy sources that are less water intensive, and by strengthening accessibility, affordability and safety. Such systems can fulfil energy requirements along the water supply chain. For example, solar-based pumping solutions offer a cost-effective alternative to diesel generators and on-grid electricity supply. However, proper incentives and regulations are required to avoid water over-abstraction due to lower energy operating costs.

Renewable energy technologies can stimulate the food sector through economic opportunities and reduced losses, while improving productivity by bridging modern energy deficit with the supply chain. It can also provide energy on-site or be integrated through large-scale installations into existing energy supply chains.

Adding renewable energy capacity across the Arab region, in the form of wind and solar power, will also affect land use. Increasing demand for land may have negative effects on the agriculture sector and food supply, with consequences for food prices. In order to avoid such a scenario, a holistic water-energy-food nexus approach, based on sustainable resources management, needs to be adopted. The objective would be to promote, coordinate and integrate planning and sustainable management of interlinked resources across sectors.

Integrated management of natural resources, such as energy, food and water, would improve efficiencies, reduce environmental footprints and eliminate waste. The distributed nature of many renewable energy technologies allows them to offer integrated solutions that strengthen security across all three sectors. With such an integrated approach, renewable energy technology can provide energy services while using resources in a sustainable manner.

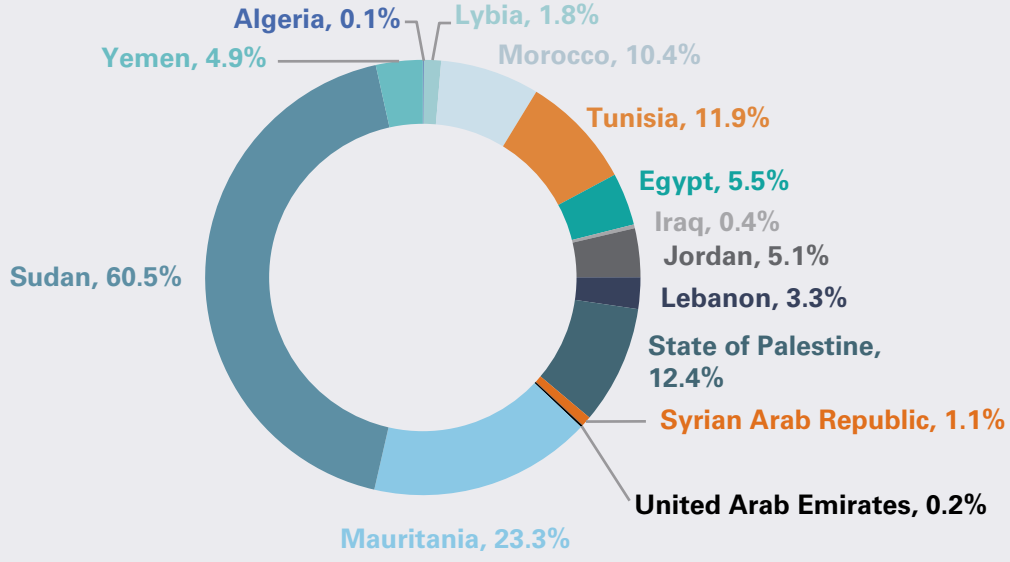
The energy-water-food nexus approach aims to support more sustainable renewable energy deployment by building synergies, increasing efficiency, reducing trade-offs and improving governance among the sectors.

02

Renewable Energy Potential in the Arab Region

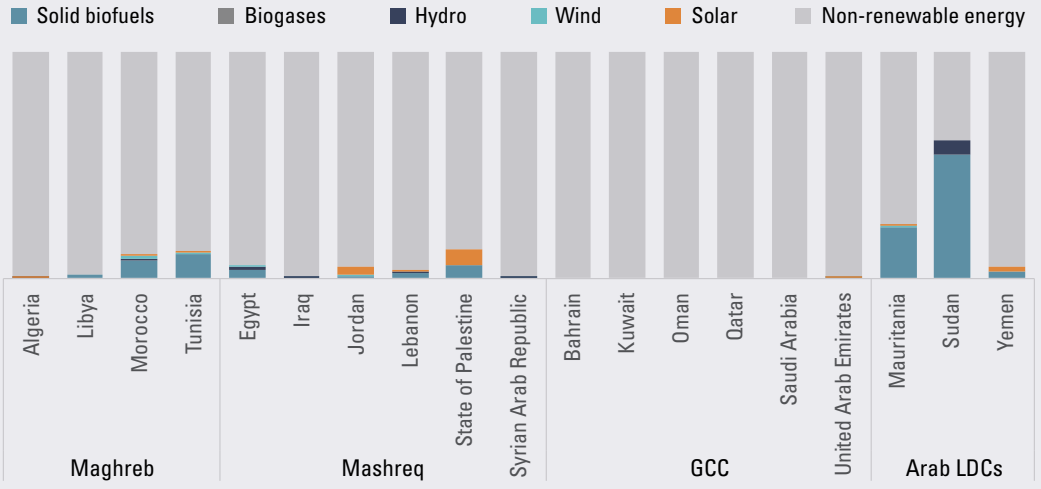
The share of renewable energy has been plateauing at around 10.2 per cent of the Arab region's total final energy consumption since 2010, following a long-term trend of decline. Renewable energy again declined by 11 per cent between 2014 and 2017, due primarily to declining consumption shares in the State of Palestine, the Sudan, the Syrian Arab Republic and Tunisia. This trajectory, which is contrary to the world trend, but similar to consumption patterns in South and East Asia, largely reflects the move away from (mostly traditional) solid biofuels towards higher quality fuel and electricity. As of 2017, renewable energy accounted for around 10.8 per cent of the Arab region's energy mix, the lowest share in any of the world's regions. Just a handful of countries account for virtually all of the region's renewable energy consumption, leaving substantial scope for further uptake, given the region's plentiful renewable energy resources. The figure below presents the total consumption in share of renewable energy as a per cent per country for the year 2017.

Figure 3. **Renewable energy consumption in the Arab region by country, 2017**



Source: International Renewable Energy Agency (IRENA). *Tracking SDG7: The Energy Progress Report.* 2019.

Figure 4. **Share of renewable energy in Arab countries' energy mix, 2017**



Source: IRENA. *Tracking SDG7: The Energy Progress Report.* 2019.

Solar energy is the next largest renewable energy source in the Arab region, accounting for some 3 per cent of the region's total renewable energy consumption. It is also the fastest growing renewable energy source in power generation, according to International Renewable Energy Agency (IRENA) data. Solar resources are generally excellent throughout the region, though deployment has so far fallen short of the technology's region-wide potential.

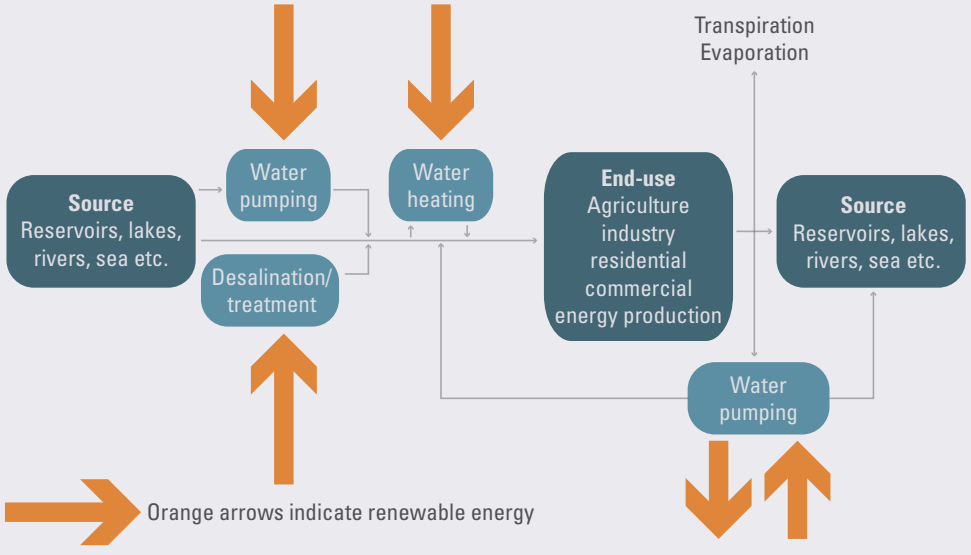
Four countries – Jordan, the State of Palestine, Tunisia and Yemen – account for over three quarters of the entire Arab region's solar power consumption. The most recent advent of solar power in the Arab region reflects much increased policy focus on promoting alternative energy, combined with the rapidly falling cost of solar power – both in the on- and off-grid value segments. The fast adoption of solar power in Lebanon, the State of Palestine and Yemen also highlights the vast potential of stand-alone solar systems, in addition to larger scale utility-size projects, to contribute significantly to energy provision. This includes the increasing importance of off-grid solar power as a long-term solution for rural populations otherwise cut off from main-grid electricity access, as well as the flexible use of rooftop solar systems in countries with unstable grid-based supply, including countries in conflict.

03

The Nexus between Renewable Energy and the Water Supply Chain

Figure 5 below shows where renewable energy inputs may be used in the water supply chain.

Figure 5. **Renewable energy across the water supply chain**

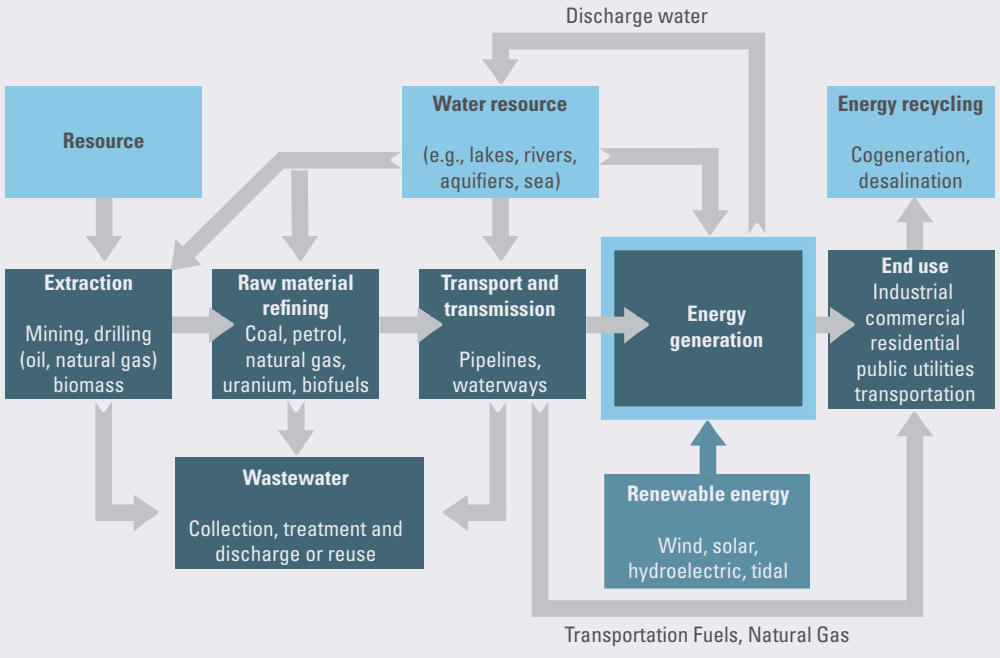


Source: ESCWA. *Water-Energy Nexus Operational Toolkit: Renewable Energy Module*, 2017.

Similarly, figure 6 shows the complete energy production process and the different ways and points in which water is involved in this process. Both figures show where renewable energy can be used.

An important aspect of the water and energy nexus that is crucial for the Arab region is the way water is used in the production of electricity, and how such processes can be made less water resource intensive. When renewable energy options are used for electricity generation, the process by which electricity is generated varies significantly according to the technology being employed. Consequently, the amount of water being used also differs according to the type of renewable energy used.

Figure 6. **Flowchart of embedded water in energy**



Source: ESCWA. *Water-Energy Nexus Operational Toolkit: Renewable Energy Module.* 2017.

04

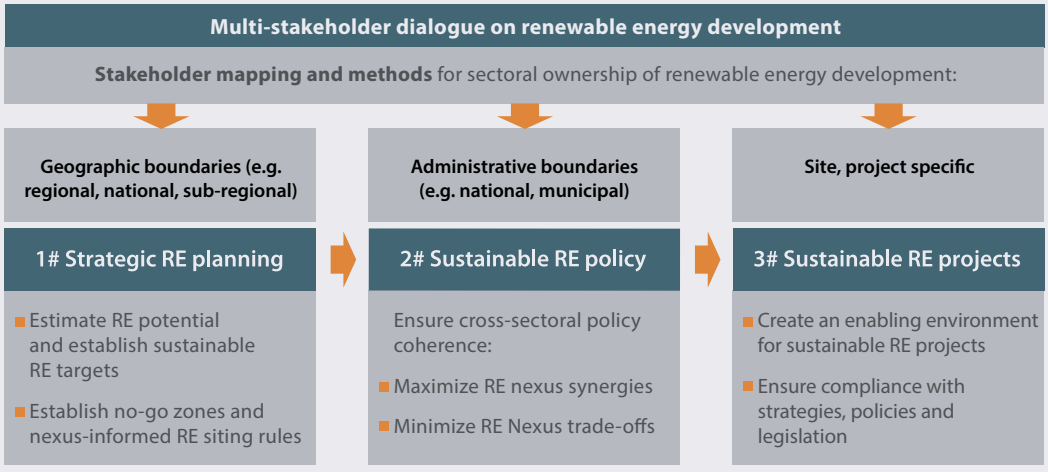
Renewable Energy Deployment in Planning within the Nexus Framework

The objective of the water-energy-food nexus is to promote coordination, integrated planning and sustainable management of interlinked resources across different sectors in order to speed up the achievement of the 2030 Agenda for Sustainable Development.

➔ Strategic planning should not be limited to assessing the potential of different renewable energy technologies; it should also consider other sectors' policies:

- Renewable energy sustainability deployment begins with resource assessment, spatial planning and target

Figure 7. **Multi-stakeholder dialogue and the three tracks of sustainable renewable energy development: Planning, policy and project**



Source: United Nations Economic Commission for Europe (UNECE). *Towards sustainable renewable energy investment and deployment: Trade-offs and opportunities with water resources and the environment*, March 2020.

setting. These activities should incorporate geographic technologies, cross-sectoral aspects and nexus priorities into the strategic planning process.

➔ Renewable energy policies can be vetted to effectively tackle inter-sectoral synergies and trade-offs, as suggested through the Sustainability Assessment Matrix (UNECE, 2020):

- Policymakers should ensure that inter-sectoral linkages are adequately reflected in renewable energy policies, as well as in water, agriculture, and environment-related policies, in order to support sustainability;
- Synergies should be supported and trade-offs should be assessed, discussed, mitigated and compensated.

➔ Policymakers should actively engage with private sector actors to ensure they are developing sustainable projects:

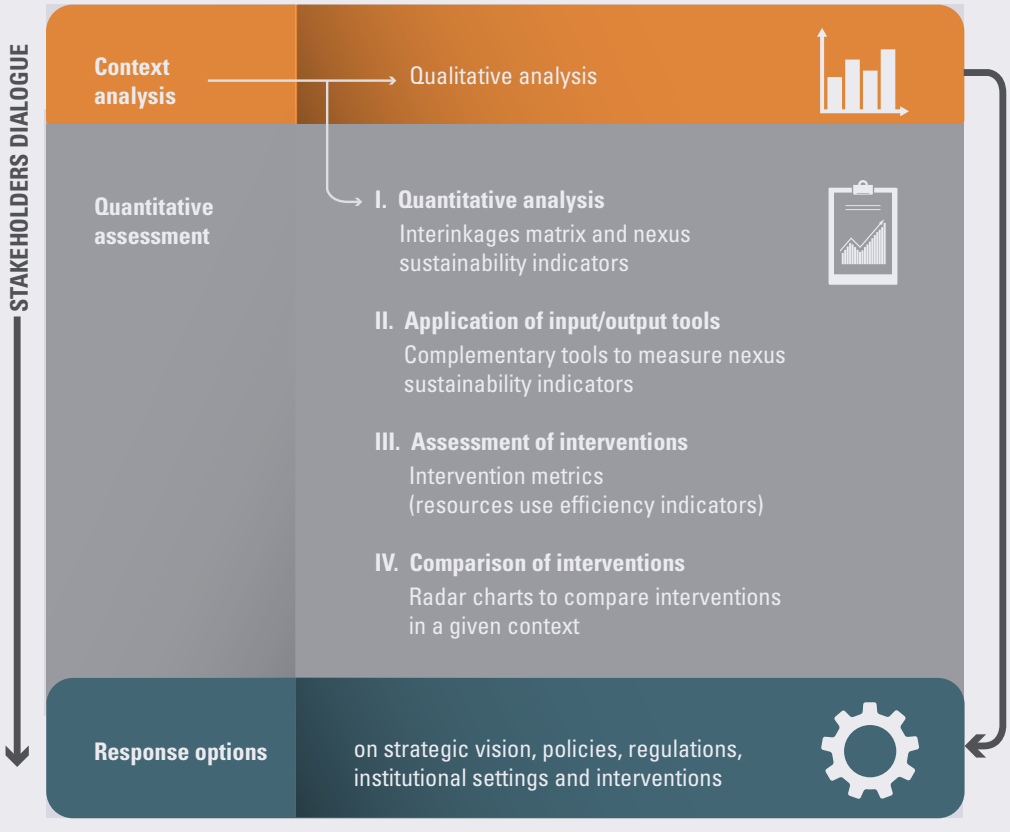
- Such private sector actors include project owners, developers, equipment manufacturers, engineering, procurement and construction contractors, as well as bankers and financers;
- This could be achieved by creating an enabling environment that facilitates compliance with the relevant standards;
- Energy projects should also ensure value beyond energy generation, and that they are in line with the

government's social, economic, and environmental priorities and regulations.

Planning and decision-making that consider the impact of water and energy strategies on other sectors require substantial qualitative and quantitative insight. Adopting a nexus approach to sector management involves analyzing cross-sectoral interactions and using different decision support tools and methodologies, depending on the purpose of the analysis, access to data and availability of technical capacity. Outcomes inform policymaking by quantifying the extent to which a policy affects sectors.

Analytical tools can be either qualitative or quantitative. Qualitative tools are useful in preliminary analysis of the water-energy

Figure 8. **Components of nexus assessment**



Source: ESCWA. *Developing the Capacity of ESCWA Member Countries to Address the Water and Energy Nexus for Achieving Sustainable Development Goals-Regional Policy Toolkit*, 2016.

nexus, where stakeholders are looking at a scenario in resource management, such as geographical area, stakeholders involved and regions/communities potentially affected. Quantitative tools build on the data produced by a qualitative analysis and generate indicators that assess the impact on sustainability, resource management and efficiency, resource gaps and the needs of a specific scenario indicated above.

A comprehensive nexus tool accepts inputs from the three sectors and provides information on basic resource requirements (e.g. total land needed), complemented with "quality" data (e.g. types of land) and other particulars related to scale, distribution/equity or governance, among others. In some cases, the outputs of one analysis could be inputs to a more comprehensive one.

05

Dialogue for Nexus Cooperation

Although the benefits of a coherent water-energy nexus are apparent, the political, socioeconomic and security realities faced by the Arab countries often complicate the implementation of nexus solutions. Knowing how to negotiate these obstacles with appropriate tactics and strategies can help policymakers overcome zero-sum perspectives and increase the chances of unified nexus policies.

Three areas identified as useful spaces for negotiations include within sectors (intra-sectoral), between sectors (inter-sectoral), and among nexus policies of the Arab countries (transboundary nexus relationships). Negotiation within the water-energy nexus is a matter of balancing the competing inputs and uses of water and energy resources to achieve mutually acceptable and sustainable management policies. A primary way is by developing common standards, particularly around data. It is useful to establish standards prior to entering negotiations, which can help build an environment that generates trust.

Due to the interdependence of water and energy sectors, understanding the trade-offs and synergies that can be made

between them is a good starting point to achieve a consensus. One way to evaluate nexus trade-offs and synergies is by involving the private sector. While private sector investment in the energy sector can produce options to negotiate with the water sector, the idea of water as a flexible resource can provide options to negotiate with the energy sector. Water is still perceived as a fixed resource that remains static or decreases in quantity. However, the nexus shows that water can be "created" by improving efficiency through policies, technologies and alterations in consumer behaviour. Negotiations are important for the success of the water-energy nexus, and should continue to be considered integral to the policymakers' toolkit.

A common way to encourage cooperation is to agree on common values, such as the importance of human rights to water, food and development for achieving the SDGs. Policy incentives (typically economic) are also highly effective in encouraging cooperation. Further incitements include awareness-raising, public participation and institution building, each of which should be encouraged in the Arab region.

➔ A multi-stakeholder dialogue should involve policymakers from relevant sectors and key actors from civil society, industry and investment groups:

- The main areas where policy needs to be coherent with renewable energy are:
  - ✲ Water
  - ✲ Agro-forestry
  - ✲ Environment
- Cross-sectional areas:
  - ✲ Climate change
  - ✲ Health
  - ✲ Employment
  - ✲ Tourism
  - ✲ Rural development
- Multi-stakeholder dialogue should also include:
  - ✲ Civil society organizations
  - ✲ Renewable energy industry representatives
  - ✲ Bankers and financers

➔ Transboundary cooperation and coordination are needed to exploit regional synergies and to ensure the sustainability of renewable energy deployment:

- The main advantages of renewable energy cooperation

across national borders is the opportunity to exploit resource complementarities and pursue common objectives and interests;

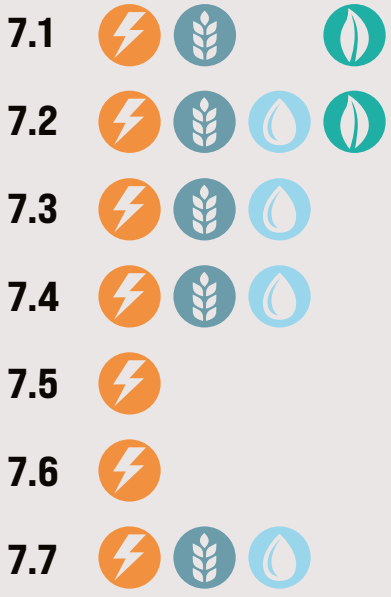
- Since renewable energy projects can have transboundary impacts, effective cooperation is critical to preventing conflicts and ensuring appropriate coordination.

Renewable energy opportunities to power groundwater use and treatment in the North Western Sahara Aquifer System

An assessment of the water-food-energy-ecosystems nexus in the North Western Sahara Aquifer Systems (NWSAS), shared by Algeria, Libya and Tunisia, was carried out as a participatory transboundary process from 2017 to 2019, involving two regional workshops and national consultations. The dialogue, supported by a multi-disciplinary analysis, provided for a joint identification of inter-sectoral issues and a broad range of solutions. One of North Africa's largest groundwater reserves, extending over a million square kilometres, NWSAS is under pressure from increasing water abstractions driven by socio-economic development, technological progress in well-drilling and the low efficiency of irrigation in a highly arid climate. Among the identified challenges are those related to energy security and energy developments, particularly renewable energy and its potential to help transform water management and agriculture. The proposed packages of solutions and synergetic, coordinated multi-sector actions (see the example below), implemented at different levels, can effectively contribute to a sustainable future for the NWSAS.

An integrated model was used to evaluate the competitiveness of off-grid solar pumping to supply future demands of the agricultural sector (irrigation and desalination), considering different costs of fuels and levels of subsidies. The results suggest that making PV technology more affordable is an effective way to promote solar energy, even more than reducing subsidies. However, the results also show that without planning, solar energy has the potential to seriously aggravate groundwater depletion.

Example of a package of nexus solutions, "Multi-purpose renewable energy and small-scale solar irrigation", and the corresponding actions:



7.1	Affordable solar energy in irrigation and rural development plans, reduced used of fuel
7.2	Technical, legal and economical measures to limit the exploitation of groundwater
7.3	Solar energy solutions aggregating energy demands and distributing costs across uses
7.4	Development and diversification of renewable energy
7.5	Restructuring fossil subsidies to facilitate transition to renewable energy
7.6	Transboundary sharing of information and experience about renewable energy
7.7	Capacities and awareness about renewables and the efficient use of energy and water

The nexus assessment of the NWSAS was carried out under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes, in close cooperation with the Global Water Partnership Mediterranean and the Sahara and Sahel Observatory, and was funded by the Swedish International Development Cooperation Agency.

Source: UNECE. *Reconciling resource uses: Assessment of the water-food-energy-ecosystems nexus in the North Western Sahara Aquifer System, Part A - "Nexus Challenges and Solutions"*, 2020b.

Recommendations

Despite the Arab region being heterogeneous in climate and socioeconomic and political governance structures, there are similarities and a common platform that can benefit from regional cooperation around nexus data and tools. The following key messages are drawn:

1. There is no one-size-fits-all model for the production, consumption and governance of natural resources. Climate, geography, socioeconomic scenarios, transboundary issues, refugees, conflict, tribal governance and other political models have wide-ranging implications in the Arab region, with no magic approach to an integrated and sustainable management of resources. The water-energy-food nexus must be needs-oriented and context-sensitive. Cooperation around the knowledge, platform and process of implementing nexus solutions can create a win-win situation for the entire region.

2. Human rights and access to water, energy and food resources should be the foundation for producing and managing these primary resources. This will create regional cooperation and set common goals to achieve economic growth and development.

3. A people-centred approach grounded in the SDGs and defining the global and regional agendas will enable needs to be mapped and create cooperation.

4. There are clear interdependencies among the SDGs on poverty, health, economic growth, education, social justice, water, energy and food security. They are part of a continuum, and managing them creates a nexus which must be dealt with holistically, using tools and data to achieve the goals.

5. Capacity of local structures and institutions must be built by creating indicators and local accountability mechanisms to bring global SDGs to a local scale. They must be synergized with existing programmes so they can start "speaking the same language".

6. The water-food-energy nexus governance can be implemented in existing institutional programmes that are country- and region-specific. However, they must be reformed, with the capacity for a holistic approach built at all levels, inclusively and transparently. Such reform must focus on better coordination among all sectors and levels of governance. Capacity-building must include technical, social, negotiation and conflict-resolution skills.

7. The public sector should be viewed as a major stakeholder in nexus implementation. Accountability and transparency mechanisms that allow proactive society involvement, rather than passive-critical interventions, must be encouraged.

8. Strategies that allow Arab countries to implement national and international commitments on economic and sustainable development must be developed. This includes, for example, sustainable energy for all, reliable trade regimes, sustainable consumption and production protocols.

9. It is important to consider different types of governance for primary resources management, including decentralization. This can be achieved by better coherence among separate water and agricultural authorities, and by promoting cooperatives or associations that pursue resource efficiency and pricing in the water and energy sectors.

10. Decision support tools/systems (DSS) for nexus management and interlinkages allow decision makers to look at scenarios in an objective and quantitative way. Policymakers can then allocate primary resources and make better technology choices for a specific water and energy portfolio. These analytical models also help to

create platforms for trade-off discussions, negotiations and financing.

11. Decisions affecting the energy sector need to consider water resources to avoid strains in the water sector. This can be achieved by integrating energy and water policy planning. Water availability in each region should be a factor in determining the choice of technology for power production and cooling system configuration.

12. Energy costs in water utilities can rise to 55 per cent of total operating costs. Relying on one energy source to supply water nationally can represent a huge risk to the water, energy and food sectors. Energy requirements and the carbon footprint of water technologies, such as desalination and treatment, should be considered when planning policies in the water sector.

13. Poor infrastructure and technology choices, and deficient institutional support for water and energy supply, hinder human well-being and economic development. There is a huge potential for growth at both local and regional levels when linked systems for water use, energy and food production are advanced in a coordinated, holistic way.

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