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THINK

POLICY BRIEF

INTEGRATED NEXUS POLICIES FOR SUSTAINABLE AND RESILIENT ENERGY, WATER, AND FOOD SYSTEMS

Task Force 10

SUSTAINABLE ENERGY, WATER, AND FOOD SYSTEMS

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موجز السياسة

سياسات الترابط المتكاملة لنُظم الطاقة والمياه والغذاء المستدامة والمرنة

فريق العمل العاشر

نُظم الطاقة المستدامة والمياه والغذاء

المؤلفون

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ABSTRACT

Population growth, climate change, and resource depletion put food and water security and energy supply at risk. Sustainable and resilient water, food, and energy systems are crucial to meet Sustainable Development Goals (SDGs) and increase resilience to global health crises such as the COVID-19 pandemic. This policy brief describes the challenges and presents proposals regarding synergies in the land, water, and energy nexus to maximize net environmental, health, and social benefits. First, this brief focuses on water desalination, where the nexus approach helps to balance the full cost, including externalities, of desalinated water, and its socio-economic benefits. Second, this policy brief highlights nutrition-sensitive food policies that improve health and contribute to the preservation of natural resources. Finally, this brief presents challenges and opportunities for developing renewable energy.

أدى النمو السكاني والتغير المناخي واستنزاف الموارد إلى تهديد الأمن الغذائي والمائي وموارد الطاقة. تعد أنظمة المياه والغذاء والطاقة المستدامة والمرنة أنظمة جوهرية لتحقيق أهداف التنمية المستدامة وزيادة المرونة تجاه الأزمات الصحية العالمية كجائحة كوفيد-١٩. يعرض موجز السياسة هذا التحديات، ويقدم حلولاً مُقترحة بشأن أوجه التآزر في رابطة الأرض والمياه والطاقة بهدف تحقيق أقصى فائدة على المستوى البيئي والصحي والاجتماعي على النحو التالي: أولًا- يركز هذا الملخص على تحلية المياه، حيث يساعد النهج الترابطي على موازنة التكلفة الكاملة، بما في ذلك العوامل الخارجية للمياه المُحلاة وفوائدها الاجتماعية-الاقتصادية. ثانيًا- يسلط ملخّص السياسة هذا الضوء على سياسات الغذاء الحساسة للتغذية التي تحسّن الصحة وتساهم في الحفاظ على الموارد الطبيعية. وأخيرًا، يعرض هذا الملخّص تحديات وفرصًا لتطوير الطاقة المتجددة.

CHALLENGE

Megatrends, such as population growth, urbanization, and climate change, put pressure on land, water, and energy resources. An integrated forward-looking approach to "Food Water Energy Security for 9.7 billion people," as described by the United Nations for 2050 (United Nations 2019), can guide the vision, strategy, and actions for sustainable development, built on partnerships within, among, and beyond G20 countries.

Upgrades to food, water, and energy infrastructure are capital-intensive and require long-term planning. Coordinated planning across infrastructure is critical for leveraging resources and optimizing outcomes (OECD 2017; Ringler et al. 2018). This analysis considers interdependencies within the "land-water-energy nexus" elements (see Figure 1). More generally, managing the nexus is necessary to attain the United Nation's Sustainable Development Goals (SDGs; Fader et al. 2018). Additionally, better access to energy, water, and food, can improve individual and collective responses to new global threats such as the COVID-19 pandemic.

The land-water-energy nexus has a local dimension because it is grounded in local needs and the resources available locally. As nations seek to solve these local challenges, sharing lessons learned and best practices in an international forum will be highly valuable. This brief presents proposals in areas where the G20, as a leadership group and global forum, can support the effective sharing of information, analyses, and best practices for addressing land-water-energy challenges.

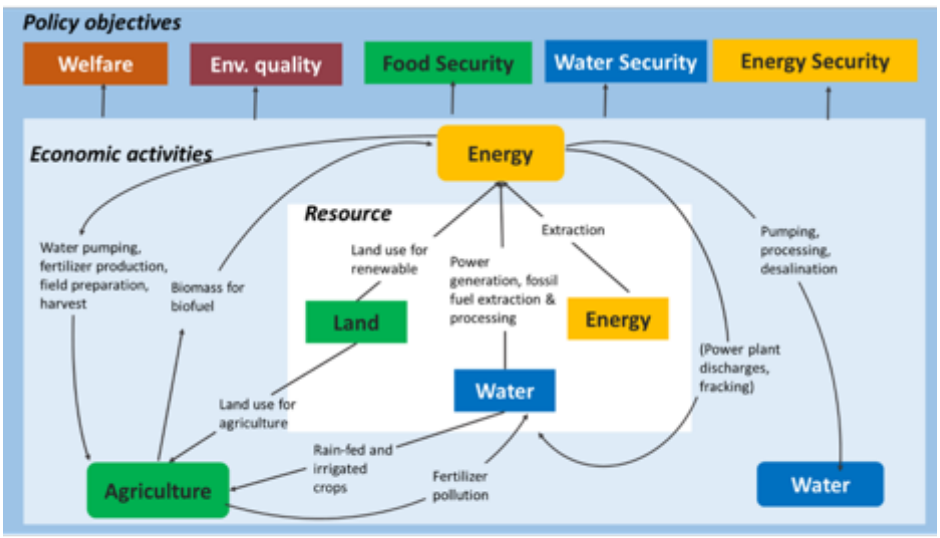

Figure 1: **Main linkages within the land, water, and energy nexus.**
Source: **based on OECD (2017).**

Challenge 1: Balancing the social costs and benefits of water desalination.

Water supply in many regions will increasingly rely on desalination technologies, which are costly and energy-intensive. The G20 workstream "Energy end-use data and energy efficiency metrics" created under the Chinese Presidency in 2016 (G20 2016) improved the exchange of knowledge on energy efficiency. However, specific work is required on energy efficiency for water desalination. The data gap is large in this area, and efficiency assessments do not take into account local resources. Desalination technologies powered by renewable energy are, in many regions, the least-cost option (IEA, ETSAP, and IRENA 2013). However, there is a lack of comprehensive assessments of the positive and negative externalities of water desalination. Standardized assessments of the full-costs of water provision and the benefits for society could help to design incentives for investing in technology options that minimize the cost of the system, ensure water security, and limit the environmental impacts.

Challenge 2: Designing agricultural policy that includes both the nutritious content of food and resource preservation.

For a given region, crops that preserve water and reduce land-use may not simultaneously be sufficiently nutritious. In several regions of the world, existing food and crop pricing mechanisms are oriented to meet calorific needs but may result in the sub-optimal use of land resources and wasteful water and energy consumption. Agricultural policies may unconsciously neglect land, water, energy, or nutritional value even as they meet caloric needs.

Challenge 3: Deploying renewable energy without compromising food or water sustainability.

Renewable energy deployment is a key element of approaches for climate change mitigation and for achieving the SDGs related to affordable and clean energy and other development goals. However, the land and water use of renewable energy varies significantly across technologies such as solar, wind, biofuels, and hydropower (Fritsche et al. 2017). Without co-consideration, renewable energy deployment may not optimize the achievement of other SDGs on clean water, food, and sustainable agriculture, and land management. Additionally, although multiple approaches exist for developing renewable energy while promoting wise land and water use and agricultural productivity, it can be challenging for countries to identify which approach would be most successful in addressing their unique challenges.

PROPOSALS

Key proposal 1: Create a G20 workflow on energy and desalination to support knowledge sharing, policy dialogue, best practices, and cross-border cooperation

Collect data and develop metrics for the full cost and benefits of water desalination

In water-scarce regions, "a synergistic approach involving desalination, water management, consumption reduction, and water reuse is needed to efficiently confront the water challenge" (Mezher et al. 2011). It is crucial to develop models and approaches that account for the full cost of desalinated water provision and its full economic and social benefits, but this requires significant amounts of data. Traditionally, water planning has focused primarily on technical costs and has not taken into account the costs of externalities caused by the industry itself (e.g., the pollution at the plant level), implied emissions from power generation, and, more generally, by all the effects on the environment caused by desalination (e.g., the release of brine and toxic substances). Several national assessment studies have estimated that the external cost of water provision for different plant configurations may range between 37 percent and 114 percent of the production cost (Saleh, Mohamed, and Mezher 2019).

Assessments of the full costs and benefits require multidisciplinary analyses with a global reach and rely on inputs from a variety of institutions. These requirements could be addressed through a workflow to evaluate the full cost of water desalination. UN agencies, other international organizations (such as IEA and IRENA), and development banks could host the workflow and mobilize experts, NGOs, and local communities for bottom-up assessments. Elements of the workflow could include:

- Collect and provide data: Construct a public inventory of energy consumption and GHG emissions related to water desalination. This database would ideally fit into existing mainstream energy balances and GHG inventories, for example, the extended energy balances of the IEA (2020) and the EDGAR database (Crippa et al. 2019).

- Create benchmarks: Based on technical characteristics and domestic circumstances, benchmark the production costs of desalination technologies under specific and diverse environmental, financial, and operations conditions.

- Quantify impacts: Assess the flows of GHG emissions, pollutants, and releases of by-products to the environment that are directly or indirectly imputable to desalination.

- Provide methods: Propose a common method for assigning monetary values to the impacts of desalination. The cost of each unit of GHG can be based on a common global carbon price benchmark reflecting the marginal damage costs at the global level. The air pollution costs need to take into account the economic cost of health damages through a value of statistical life or other metrics. Brine and toxic waste cost will require alternative metrics, such as the impact on fisheries, tourism, or ecosystem services.

- Estimate potential improvements: Evaluate the potential of each desalination technology for future improvements. Nano and membrane technologies and digitalization can improve efficiency in the operations and maintenance of desalination plants. Technologies can see their costs decrease in the future because of, for instance, learning effects. Future technology cost reductions are a positive externality that can be discounted from the current full provision cost.

- Assess secondary impacts of desalination: Assess key socio-economic benefits of water provision. These benefits include the marginal productivity of water, and also the positive health and welfare impacts of improved access to water.

Support best practices, policy dialogue, and cross-border cooperation

Comprehensive knowledge sharing and collaboration programs on advanced desalination may encourage deployment of sustainable desalination technologies. Best practices that can be documented and shared include research and the demonstration of advanced technologies, stringent emission and discharge standards, contract incentives for new clean desalination plants, and decommissioning of aging desalination facilities. Economic approaches can include pricing emissions in power generation and water supply and time of use water pricing. These may help to reduce the peak of electricity and water demand and limit the backup capacity investment required.

Countries may also consider how cross-border cooperation could unlock the potential of integrated transnational water and energy management. Cooperation can address the challenges surrounding transboundary surfaces and groundwater. Moreover, it supports locating the desalination facilities where the conditions are most favorable and where the environmental impacts can be mitigated (for example, the impacts of water intake or brine discharges). Additionally, cross-border power grid connections can help deliver energy from low-cost production areas to desalination plants and increase the resilience of energy and water supply, taking into consideration the security concerns for each country.

Key proposal 2: Extend the objectives of national agriculture regulations to include nutritious food while ensuring land and water sustainability

Agricultural programs in most developing countries remain largely focused on meeting basic calorific needs with a limited number of crops, especially cereals. However, malnutrition and the numerous related public health issues call for nutrition-sensitive food policies (FAO and WHO 2018). The COVID-19 crisis has underlined how crucial nutrition is to reducing the effects of co-morbid medical conditions (Rajgopal et al. 2002) and improving resilience to health crises (Hill, Mantzoros, and Sowers 2020).

Crop diversification can be an important tool for enabling nutrition requirements by providing a variety of cereals, vegetables, fruits, and pulses. In addition to public health, there are numerous co-benefits of shifting food systems toward more diverse and nutrient-rich crops. Some highly-nutritious crop species also preserve soil quality and are adapted to marginal lands. These crops may also require less water and generate a stable revenue for rural communities. Among cereal grains, millet is an example of a nutrient-rich crop with sustainability co-benefits. The share of millet in the cereal basket is currently very low in the G20. An analysis for 2018 based on the FAOSTAT for G20 countries placed production of millet under 1.4 percent of the combined production of millet, paddy, and wheat. Notably, the majority of the G20 millet production is in India. Outside of G20 countries, millet is a significant constituent of the food basket of many low income countries (LICs). Initiatives that encourage millet production can provide a more nutritious cereal basket, reduce groundwater extraction, and help increase sustainability. Another advantage of millet is that its production systems have a relatively better reach in the far-flung and degraded areas, and these efforts can promote the localization of cereal production while helping small and marginal farmers.

Moreover, millet has a low glycemic index and high fiber and mineral content, making it more useful for people who have diabetic conditions, which is a comorbidity factor of COVID-19 (Hill, Mantzoros, and Sowers 2020). While millet is an illustrative example, there are many examples of agricultural best practices that support multiple co-benefits. To address nutrition and sustainability deficiencies in agricultural policies, this brief suggests the following best practices:

Consider agricultural policies that jointly promote the diversification of the food basket, health, and sustainability. The food basket should consider the nutritive values and related attributes of minerals and micronutrients, as well as characteristics, such as the low glycemic index of crops. Crops that can be grown in degraded soils, can reduce erosion, and bind atmospheric nitrogen should be favored. Agricultural policies should also recognize the contributions and incentivize crops that provide them.

Consider holistic water, agriculture, and energy policies that focus on vulnerable sections of the SDGs. Water, agriculture, and energy necessitate an intertwined approach to achieving the SDGs and mitigate the adverse impacts of climate change. The lower deciles of the population, including small and marginal farmers, agricultural laborers, and other people living in poverty are more prone to the adverse effects. They deserve a more equitable share in quality water, food, nutrition, and energy security, in line with the SDGs, especially as globally vulnerable populations have been hit hard by COVID-19. The G20 Agriculture Ministers in their Virtual meeting on April 21, 2020, stressed, "We will work together to help ensure that sufficient, safe, affordable, and nutritious food continues to be available and accessible to all people, including the poorest, the most vulnerable, and displaced people in a timely, safe, and organized manner, consistent with national requirements."

Governments and development banks may benefit from supporting investments that enable the emergence of efficient value chains for nutrient-rich non-staple items that preserve natural resources. There is, for example, a need to invest in production technologies as well as in storage and transportation facilities for fruit and vegetables. Moreover, governments, technology companies, and research institutions can assist rural communities in enhancing their productivity and increasing their socio-economic empowerment by encouraging the use of new technologies, reforming agricultural research and extension, and providing adequate funds. There is a need to ensure that the dissemination of research outcomes extends to the rural community. Jurisdictions may consider policies that strengthen on-farm management of water and energy use and the use of more efficient delivery mechanisms, such as drip irrigation, sprinkler systems, and solar pumps that could enhance productivity while reducing environmental impact. Mechanisms for improved access to agrofinance services for farmers and linking them to e-marketing for their products can also assist rural communities.

For the social and economic empowerment of rural communities, the agriculture supply, and value chains can be strengthened to support rural communities, a primary focus in several global fora, including the G20. In addition to generating additional income for over 1.2 billion people in mostly rural and agricultural households, supply chain strengthening can also be effective in minimizing food waste and loss, as well as reducing water and energy use. Further, it would result in inclusive development to enhance the voices of rural communities in development and related decision making. This brief therefore proposes that countries re-examine policies around agricultural supply chains.

Thus, the amount spent on better nutrition, efficient value chains, and the higher productivity of rural communities is an "investment" and not an "expenditure." It pays itself back many times over and can ceteris paribus increase the resilience to fight against pandemics such as COVID-19.

Key proposal 3: Consider a cohesive nexus approach when developing renewable energy projects

Studies have indicated that renewable and other clean energy can be implemented in ways that result in positive net benefits for the water and food SDGs (Fader et al. 2018). Each country's energy mix will depend on its natural resources and development programs, and therefore, the specific actions will vary. However, the maximum benefits across this nexus can be achieved only if countries have a strong energy-water-food framework supported by cohesive data and a coherent policy. The following generalized steps represent a high-level approach that countries could explore to enable sustainable clean energy:

- Develop and Share Spatial Resource Knowledge: Identify key regions that have significant value in terms of agriculture, water, and energy production. Also, consider the material resources for the energy supply chain, such as metals, minerals, and biomass.

- Identify Technology Options: Identify renewable energy technologies that could potentially be deployed in the region with synergistic effects. This consideration requires an understanding of the location-specific industry and resources. Potential technologies, including solar photovoltaics, distributed wind turbines, or run-of-the-river hydropower, need to be carefully considered and modeled in the context of local water and land conservation.

- Consider Economic Drivers: Design economic incentives that can be given to key actors in local industries for the identified regions that simultaneously incentivize low-cost renewables that also benefit land and water use. For example, an auction process to competitively procure new power generation can be paired with policies to encourage scaling renewable adoption (e.g., net metering) and preserve designated agricultural zones and water resources.

• Consider Communications and Information Sharing: This brief recommends publicizing the programs and incentives through community outreach programs. Many policy schemes have resulted in low uptake unless local governments and the community are engaged. To leverage successes and enable nexus projects, it is important to encourage information sharing between experts in energy, water, and food systems as well as between countries through scientific fora and collaborative programs.

Combining these steps results in a more robust development framework than if energy, water, and food resources are considered and developed in isolation. Figure 2 illustrates the geospatial data visualization of the existing transmission infrastructure, generation, and land-use. Data such as these can assist decision-makers in determining the best outcome for all SDGs simultaneously and balancing conflicting goals.

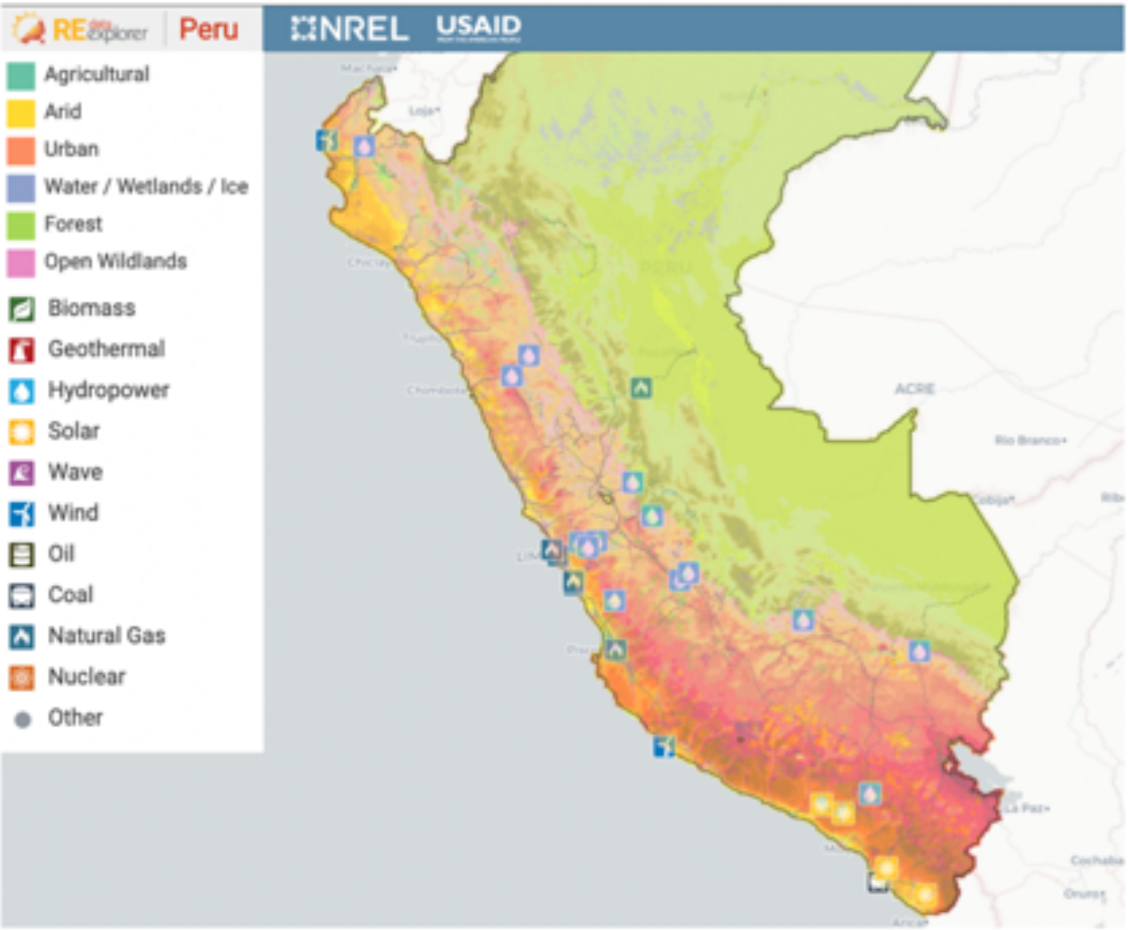

Figure 2. **Electrical Generating Units, Transmission Infrastructure, and Land-Use Data Overlaid on Peru (RED-E Peru n.d.)**

The following are examples of programs that have incorporated integrated approaches to energy-water-food systems:

Consider Agroforestry: In Latin America, several programs to promote agroforestry and reduce deforestation have been implemented (Elvers 2015). Trees planted around crops and farmsteads reduce energy consumption and water use, generate an agricultural energy product to be sold, and sequester carbon. In Guatemala, farmers were compensated if they practiced agroforestry rather than deforesting (UNDP 2020a, 2020b). This agroforestry included using plant species that could thrive under the existing forest canopy.

Consider Energy-Agriculture Co-location: Several examples exist where renewable power generation and various forms of agriculture are co-located, including wind power and livestock, floating solar and fish farms, and solar photovoltaics and vegetables/bee-keeping (agrivoltaics, see Figure 3; Barron-Gafford et al. 2019; Macknick 2019). In all cases, the farmer benefits from payments for the energy generated similar to land leases in oil and gas or through co-ownership, and there are often improvements in crop growth (Bolinger and Seel 2015; Mills 2018; Ravi et al. 2016). Indoor agriculture, or vertical farming, further extends this paradigm by allowing for increased synergy between RE availability and agriculture. Countries may benefit from the promotion of co-location of energy and agriculture and agroforestry.

Examine Bioenergy: Biofuels can offer local sources of liquid fuels with the potential to be carbon neutral. To that end, examining the cost and benefits of incentives such as grants, loans, income tax credits, subsidies, and requirements to blend renewable fuels with gasoline and diesel (US EPA 2010) can inform policy decisions. However, the food price crisis that occurred between 2007 and 2008 increased the awareness of the potential negative effects on food security of policies that incentivize the use of crops for bioenergy (Maggio et al. 2018). By considering incentives in the broader context of the nexus, carefully designed financial programs can encourage biofuel growth without damaging agriculture production and sustainability, such as through the use of agricultural waste to create cellulosic ethanol and waste oils for biodiesel.

Figure 3. **Crops growing under solar PV arrays in a test plot at the University of Massachusetts (Photo by Dennis Schroeder/NREL).**

The guidelines outlined in this document share some high-level consideration for holistically viewing land-energy-and water in support of sustainable growth and SDGs. Leaders can review these steps and then apply their country-level expertise to innovate in ways that are most successful for their situations.

These programs require research, planning, and local coordination to be implemented effectively. The high-level approach outlined in this document, informed by lessons learned from actual program experience, can be applied to evaluate natural resources and plan their development in conjunction with local leaders for synergistic growth of all SDGs. This brief provides a starting point that country leaders and members of the G20 can use to develop better guidance, best practices, and resources. Countries can then apply these alongside their country-level expertise to innovate the proposals in ways that are successful for their specific situations.

Disclaimer

This policy brief was developed and written by the authors and has undergone a peer review process. The views and opinions expressed in this policy brief are those of the authors and do not necessarily reflect the official policy or position of the authors' organizations or the T20 Secretariat.

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