The Water-Energy-Food Nexus at FAO

Concept Note

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The Food and Agriculture Organization
of the United Nations (FAO)

May 2014

1. The Water-Energy-Food Nexus: Understanding and managing the complex interactions between water, energy and food

Water, energy and food are essential for human well-being and sustainable development. Global projections indicate that 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, urbanisation, diversifying diets, cultural and technological changes, and climate change (Hoff 2011). Agriculture accounts for 70 percent of total global freshwater withdrawals, making it the largest user of water. Water is used for agriculture production, forestry and fishery, along the entire agri-food supply chain, and it is used to produce, transport and use all forms of energy (FAO 2011a). At the same time, the food production and supply chain consumes about 30 percent of total global energy (FAO 2011a). Energy is required to produce, transport and distribute food as well as to extract, pump, lift, collect, transport and treat water. Cities, industry and other users, too, claim increasingly more water, energy and land resources, and at the same time, face problems of environmental degradation and in some cases, resource scarcity.

This situation is expected to be exacerbated in the near future as 60 percent more food will be required to be produced in order to feed the world in 2050. Global energy consumption is projected to grow up to 50 percent by 2035 (IEA 2010). Total global water withdrawals for irrigation are projected to increase by 10 percent by 2050 (FAO 2011a).

As demand grows, there is increasing competition over natural resources between the water, energy, agriculture, fisheries, livestock, forestry, mining, transport and other sectors with unpredictable impacts for livelihoods and the environment (FAO 2011b). For instance, large-scale water infrastructure projects may have synergetic impacts, producing hydro-power and providing water storage for irrigation and urban uses, but these might come at the expense of downstream ecosystems and food systems and with social implications, such as resettlements. Similarly, growing bioenergy crops in an irrigated agriculture scheme may help improve energy supply, but may also result in increased competition for land and water resources and in risks to food production. There are clear interlinkages between water, food and energy that may result in synergies and trade-offs between different sectors or interest groups.

In this context, the Water-Energy-Food Nexus has emerged as a key concept to describe the complex and interrelated nature of our global resource systems, on which we depend to achieve different, often competing development goals. In practical terms, it presents a conceptual approach to better understand the interactions between the natural environment and human activities, and to work towards a more coherent approach to natural resources management vis-à-vis our social, economic and environmental goals. This can help us to identify and manage trade-offs and to build synergies through our response options, allowing for more integrated and cost-effective planning, decision-making, implementing, monitoring and evaluating.

Water-Energy-Food Nexus trade-offs in the Red River Basin in Vietnam

A series of reservoirs in the upstream reaches of the Red River in northern Vietnam regulate flows and supply much of the electricity needed for Vietnam's modernization and industrialization strategies. The same system is the sole water source for domestic uses and irrigation of almost 750 000 ha of rice-based farming in the Red River delta, which is critical to social stability and food security in Vietnam. Most of the irrigation systems in the delta use pumps, with electricity supplied by the reservoirs, to distribute water to the fields and other users within the irrigation systems.

As water becomes scarce, and competition is growing between the energy and agricultural sectors, there is still a lack of reliable data and information to guide water allocation choices, and the absence of cross-sectoral consultation mechanisms prevents the development of concerted efforts to address this problem. Decisions on water release and allocation remain mostly ad-hoc rather than having an integrated, long-term strategy.

Nexus interactions are complex and dynamic, and cannot be looked at in isolation from one another. Importantly, they exist within a wider context of transformational processes – or drivers of change – that need to be taken into account. It is important to note that there are different conceptualizations of the Nexus that vary in their scope, objectives and understanding of drivers. Several concepts, frameworks and methodologies have looked at the interlinkages between water, energy and food (Mohtar and Daher 2012; Bizikova *et al.* 2013; ADB 2013; UN-ESCAP 2013), but also land and soil (ERD 2012; Hoff *et al.* 2013), minerals (Andrews-Speed *et al.* 2012), and ecosystems (UNECE 2014; ICIMOD 2012).

2. What is the added-value of a Nexus approach?

a. A cross-sectoral and dynamic perspective

A Nexus approach helps us to better understand the complex and dynamic relationship between water, energy and food, so that we can manage our limited resources sustainably, taking into account different economic, social and environmental goals. A Nexus perspective forces us to think of the impacts a decision in one sector can have not only on that sector, but on multiple sectors and drivers. Based on this, we can identify trade-offs and synergies and we can design, appraise and prioritize response options and interventions.

A cross-sectoral perspective on groundwater pumping

The Green Revolution and introduction of groundwater pumps, for example, have transformed irrigated economies and now underpin the food security of countries, such as China, India and Pakistan. However, groundwater pumping has accelerated the depletion of water resources and aquifers. Food production has become increasingly vulnerable to energy prices, often resulting in the farmers' dependency on energy subsidies. At the same time, farmers are left with little choice but to pump water, as services by public irrigation agencies are often poor and increasingly prioritize energy production. The solution commonly advocated is to revise tariff and metering systems and to improve pumps' technical efficiency. Looking at the problem from a Nexus perspective can help us to understand the wider implications for water, energy and food, and broaden the scope of interventions to include water demand management, investment frameworks for public funding for improved surface irrigation, groundwater management, irrigation technologies, agricultural practices, as well as food procurement and trade policies (e.g. Swain and Charnoz 2012). These interventions are likely to have an impact on the drivers and pressures that have led to overpumping in the first place.

Any intervention can have diverse and multiple impacts greater than the sum of individual initiatives. Often decisions on how to intervene are made without cross-sectoral coordination, targeting sector-specific optima and, thereby, resulting in risks and uncertainties across sectors and scales. Interventions are likely to impact on drivers, such as the structure of the population, the state of natural resources or financial flows. This can substantially alter the initial conditions confronting decision-makers and their ability to achieve sectoral goals. In order to ensure the optimal management of trade-offs and maximization of overall benefits, interventions need to be reflective and take into account the dynamic nature of complex systems.

b. Is the concept of the Water-Energy-Food Nexus just "some old wine in new bottles" or does it bring something new to the table?

A recurring criticism of the Water-Energy-Food Nexus is that it adds relatively little to already existing integrated approaches to resources management, such as the integrated landscape approach (FAO 2012c) or integrated water resources management (IWRM).

For instance, the conceptual framework articulated as Integrated Water Resource Management (IWRM) arguably pursues the integrated and coordinated management of water and land as a means of balancing resource protection, while meeting social and ecological needs and promoting economic development. However, by explicitly focusing on water, we risk prioritizing water-related goals over others, thereby counteracting the initial idea of a cross-sectoral perspective and response options that go beyond traditional sectoral approaches. The Water-Energy-Food Nexus considers equally all three dimensions and complements already existing, internationally recognized approaches.

3. The Water-Energy-Food Nexus at FAO

a. Framing the Water-Energy-Food Nexus within the broader sustainability debate

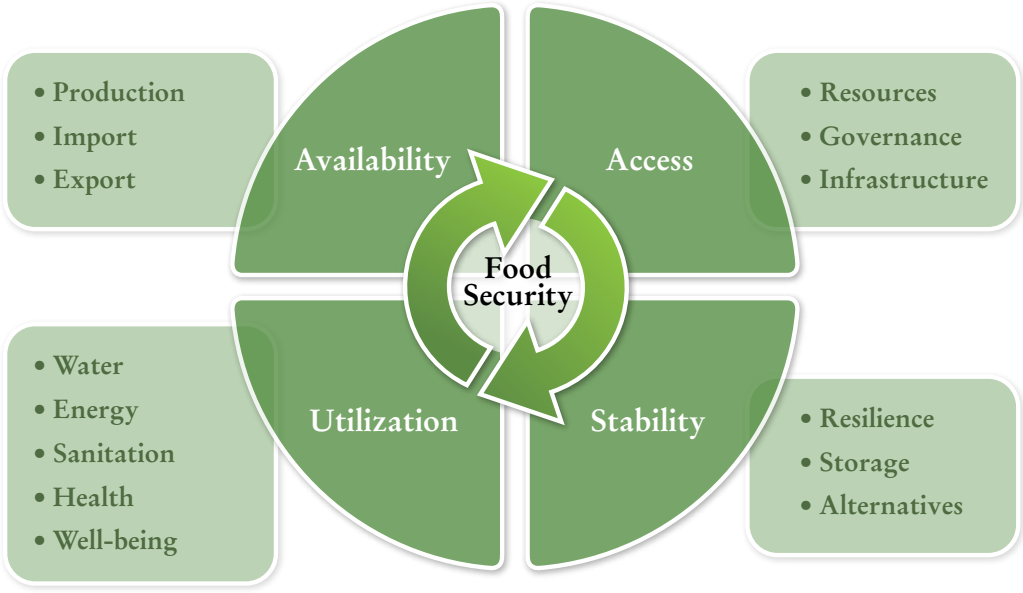
The Water-Energy-Food Nexus can be framed within the broader sustainability debate and as part of FAO's vision of sustainable food and agriculture to achieve its mandate of eradicating hunger, reducing poverty, and sustainably managing and using natural resources and ecosystems (FAO 2013b).

> *Agriculture must meet the needs of present and future generations for its products and services, while ensuring profitability, environmental health, and social and economic equity (FAO 2013b, 11).*

A Nexus approach complements this vision as it highlights the trade-offs and synergies in trying to achieve these goals.

The FAO mandate of achieving food security serves as entry-point for FAO work on the Nexus. FAO defines food security as the state in which "all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active, healthy life" (FAO 1996). As illustrated in Figure 1, the concept of food security has four components, namely food availability, access, stability of supply, and utilisation. They reflect different social, cultural, political aspects as well as biophysical and socio-economic conditions (Clark *et al*. 2013).

Figure 1: The Components of Food Security



Source: Clark *et al.* "NAF-SAR Workflow Working Draft" FAO and University of Southampton

Food security alone does not ensure economic social and environmental sustainability. Underlying FAO's Nexus approach is a holistic vision of sustainability that tries to balance different development goals by managing trade-offs and exploring opportunities for

synergies in light of growing demand for resources and other key drivers. It recognizes the incremental value of the natural environment to humans.

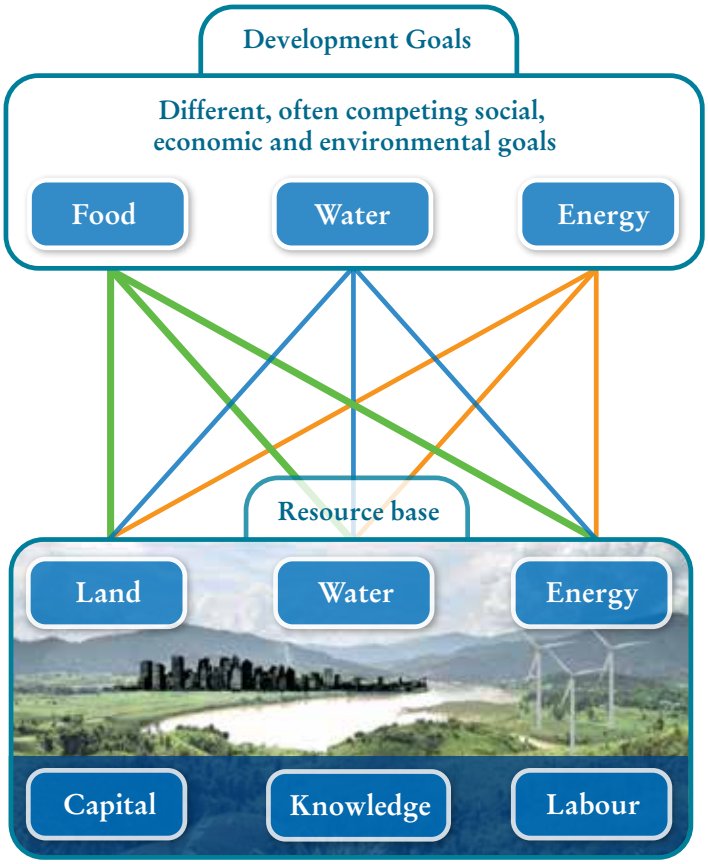
b. A Nexus approach for whom?

The Water-Energy-Food Nexus can be framed within the broader sustainability debate and as part of FAO's vision of sustainable food and agriculture to achieve its mandate of eradicating hunger, reducing poverty, and sustainably managing and using natural resources and ecosystems (FAO 2013b).

A Nexus approach provides an opportunity for decision-makers to engage with each other to better understand and manage the interactions between water, energy and food. This involves a whole range of stakeholders from local to national governments, regional and basin organizations, development banks and agencies, international organizations, research institutes and universities, NGOs, civil society and the private sector. Furthermore, it encourages intra-organizational collaboration between different technical divisions.

c. The Water-Energy-Food Nexus at FAO explained

Figure 2: **Nexus interactions between the resource base and the users**

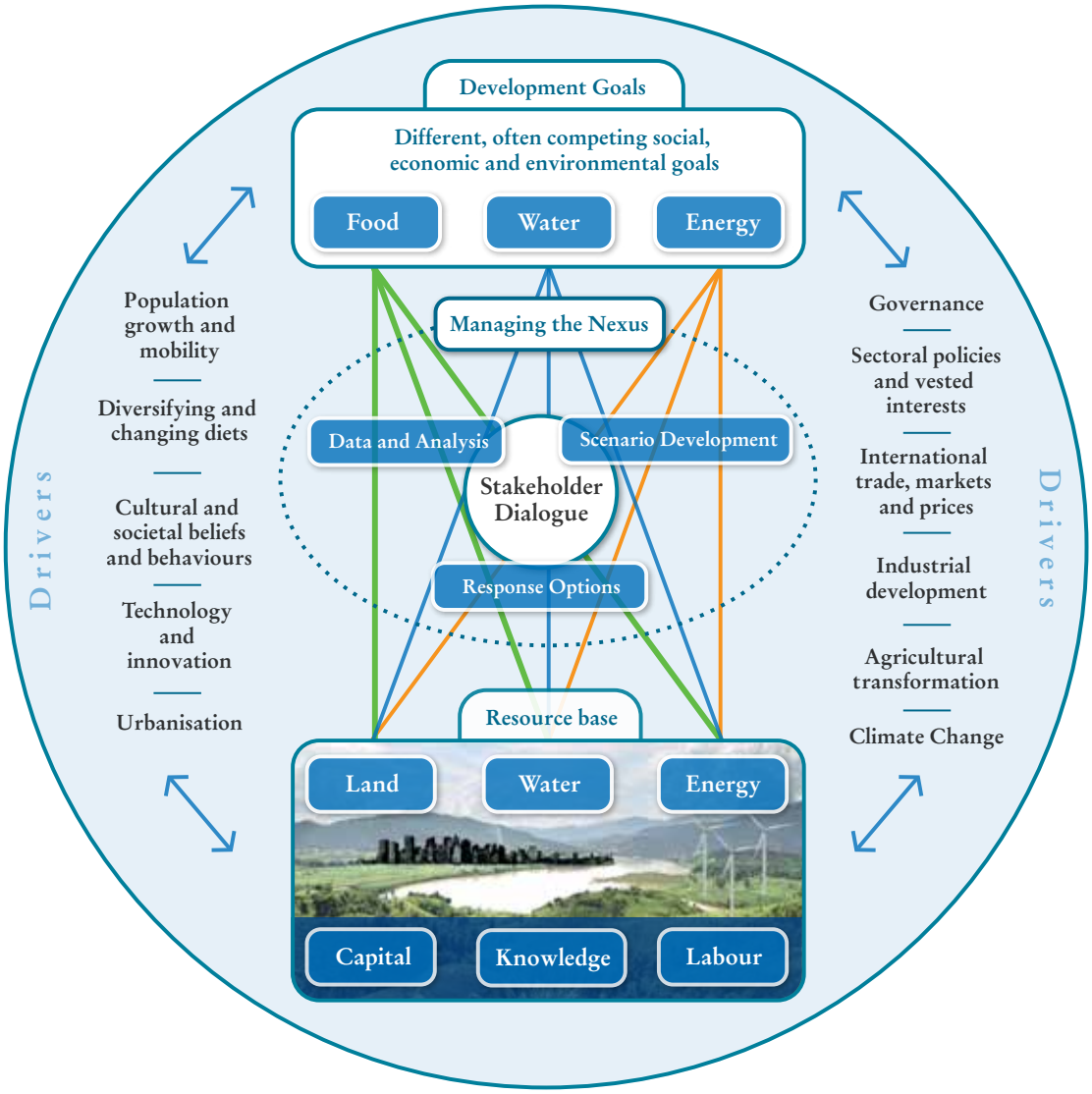


The Water-Energy-Food Nexus approach of FAO explicitly addresses complex interactions and feedback between human and natural systems. The resource base refers to both biophys-

ical and socio-economic resources, on which we depend to achieve social, environmental and economic goals pertaining to water, energy and food (as illustrated in Figure 2). Nexus interactions are about how we use and manage resource systems, describing interdependencies (depending on each other), constraints (imposing conditions or a trade-off) and synergies (reinforcing or having shared benefits) (Weitz *et al*. 2014).

Interactions take place within the context of globally relevant drivers, such as demographic change, urbanisation, industrial development, agricultural modernisation, international and regional trade, markets and prices, technological advancements, diversification of diets, and climate change as well as more site-specific drivers, like governance structures and processes, vested interests, cultural and societal beliefs and behaviours (Figure 3).

Figure 3: **The FAO approach to the Water-Energy-Food Nexus**



4. Working Areas of the Water-Energy-Food Nexus

Two conditions are needed in order to manage human-environment systems effectively and sustainably: a) the capacity to identify, assess and analyse Nexus interactions and the implications that any change – a policy decision, a large-scale investment or a change in agricultural practice – may have beyond the intended objective and scale, and b) developing and prioritizing response options.

FAO has identified three working areas as part of a broader process of stakeholder dialogue. The working areas should not be understood as a linear set of steps to follow, but rather as dynamic and complementary components of an overall approach to managing and using our natural resources sustainably. They are a) data and analysis; b) scenario development; c) response options. These are complemented by a continuous process of stakeholder dialogues.

a. Data and Analysis

In order to assess and analyze Nexus interactions, we need accurate, pertinent and timely data. At the same time, we need to be realistic about the availability of data, linking to existing and planned observing systems around the world and supporting the development of new systems, tools and services (NaF-SAR Workflow 2013). This will help to fill data gaps and to provide key data to decision-makers.

Earth observations and Water-Energy-Food Nexus

Satellite observations, combined with in-situ data, provide a unique source of consistent information about the natural environment, on which we rely to produce water, energy and food. Such observations are necessary to begin understanding the complex feed-back processes between the natural environment and human activities. They also provide resource managers with the information they need to assess the current state of the environment, weigh the requirements of different uses by multiple stakeholders, and manage the natural resources and ecosystems in a sustainable manner.

FAO can draw on and continue to build up various existing programmes and databases, using a wide range of data from Earth Observations to statistics and indicator-based assessment tools. This data can then feed into the assessment and analysis of the Water-Energy-Food Nexus, providing 1) an overview of the current state of natural resources and their uses, and 2) an outlook on key Nexus issues, making explicit the current baseline scenario as well as possible future scenarios, trends and goals. Any such analysis can help to inform decision-makers on how to respond to these issues, taking into account the diverse and multiple impacts these responses may have across sectors and over time.

Data and Analysis: Ongoing Nexus-relevant activities at FAO

- FAO-CIRAD Observatory for World Agricultures (OAM)
- FAO-IIASA Global Agro-Ecological Zones (GAEZ)
- NaF-SAR Workflow and LRMIS+
- Global Soil Information System
- FAOSTAT and AQUASTAT
- World Agriculture Watch (WAW)
- Global Monitoring for Food Security Geo-Network
- MASSCOTE reports on irrigation scheme and regions
- BEFS Operational Level Food Security Assessment Tool

b. Scenario Development

The cross-sectoral nature of the Water-Energy-Food Nexus indicates a need to create a shared understanding of the interrelations between water, energy and food as well as the underlying drivers. This can best be done through scenarios. Scenarios are used to describe a set of multiple, equally plausible future developments in an inherently uncertain world. They represent plausible evolutions from the current situation, depending on how major driving forces develop and interact, and help assessing the implications of specific policy decisions.

The development of scenarios poses a methodological challenge, which can be addressed using systematic approaches that strengthen cross-sectoral perspectives and highlight links between sectors. These can be quantitative tools, models and accounting frameworks, such as WEAP/ LEAP (SEI 2012) or MuSIASEM (FAO 2013c), and qualitative approaches, such as the participatory and forward-looking scenario-thinking approach (FAO 2012d), agent-based social simulation and structured expert panels (Smajgl and Ward 2013). When used in a complementary manner, the resulting scenarios can inform decision-makers to anticipate, plan and manage transitions successfully (e.g. demographic changes, climate change, economic development, etc.) and re-think their policies and strategies in an uncertain world together.

c. Response Options

The third working area refers to a) the planning and implementation of new policies, regulations and incentives (such as subsidies, promotion of appropriate business models, institutional mechanisms, financial instruments and funds/finance facilities, legislation, policy instruments and support mechanisms), capacity development and training, and technical interventions; and b) the process of evaluating and revising already existing policies and strategies.

Ideally, the response options are being developed on the basis of the other working areas on data, evidence-based analysis, scenario development and stakeholder dialogues, allowing for better understanding of multi-sectoral interactions as diverse and interdependent. In so doing, the Water-Energy-Food Nexus helps us to avoid some of the negative implications of poor sectoral coordination, institutional fragmentation, and inadequate capacity, and contributes to a better understanding of sectoral interests and political sensitivities related to policy decisions.

d. Stakeholder Dialogue

The stakeholder dialogue is a continuous process that brings together the different working areas through a participatory process of engaging with all relevant stakeholders and experts. The dialogues have to be designed for a specific context – regional, national, local or basin level – and problem, e.g. to evaluate a national policy on water, energy and food systems.

Why do we need stakeholder dialogues?

- To engage and bring together actors from different sectors and levels of governance
- To develop a shared understanding of the national, regional and international context in which future interventions will be embedded and to ensure that these interventions are aligned with national needs and priorities
- To directly link to ongoing and emerging decision-making processes
- To create momentum to move from assessment outcomes to action, instilling a sense of ownership, leadership and mutual accountability

Strong emphasis is placed on inviting stakeholders from a broad range of sectors and interest groups, including economy and finance, as well as from different levels of governance, like mayors of medium/ large-sized cities, farmer rights' organisations, irrigation agencies, energy utilities, national government representatives, and the private sector (e.g. hydropower company, mining industry).

The overall objective of stakeholder dialogues is to build a shared understanding of:

1. Current state of natural resources and ecosystems;
2. Expected trends and drivers of resource uses and management;
3. Goals and interests of different sectors/user groups in regard to water, energy and food;
4. Key interactions of water, energy and food systems, including trade-offs and shared of different resource uses and ecosystem management;
5. Opportunities for linking to ongoing decision-making processes.

The dialogue process can complement and reaffirm data, analysis and scenarios, and it can contribute to informed decision-making in regard to water, energy and food. FAO can take a strong role in initiating these processes, engaging with stakeholders and linking to ongoing work all around the world.

Stakeholder dialogues: Linking to global political processes

FAO is co-leading in the Sustainable Energy for All (SE4ALL) High Impact Opportunity on the Water-Energy-Food Nexus. SE4ALL is an initiative launched by the UN-Secretary in 2011 to promote energy efficiency, increase the use and production of renewable energy and increase access to modern energy services in rural areas (FAO 2012a).

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