

**Review paper**

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## **THE WATER- ENERGY-FOOD SECURITY NEXUS IN THE MEDITERRANEAN: CHALLENGES AND OPPORTUNITIES**

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### **Abstract**

The water-energy-food security nexus is now receiving consensus and attention of both political and technical experts. Indeed, the World Water Day 2014 was mainly on this topic. Although, some of the biggest challenges the world is facing hinge on the growing scarcity and allocation of resources vital to sustaining life-water energy and food. Food, water and energy security are finally being recognized as the most important national and international security issues. Understanding the complex relationship between water, energy and food systems has become critically important to the development of a sustainable and secure future for all nations and regions. This was clearly highlighted at the Bonn 2011 nexus conference held in the preparation for the United Nations (UN) Rio +20 Conference which brought to light the need to address sustainability issues in the closely related sectors of water, energy and food security. In this regards, the question to be raised concerning water-energy-food nexus is where are we now? This will bring us to several crucial questions which technically and politically are wide bargaining and serious discussion including the following: (i) Nexus thinking has been around for a while now, but is it really joined up enough yet? (ii) Do we have enough data points to catalyze action? (iii) How are organizations tackling interconnected resources challenges and what are the concrete examples of scenario planning collaboration or programmes in place? (iv) Could the move towards valuing natural capital help accelerate nexus thinking and policy making?

In this paper evidence will be given that if the food, water and energy connection remain unaddressed, global food security will not be achieved increasing poverty and environmental degradation.

**Key words:** *Water-Energy-food nexus, Security, Sustainable development, Mediterranean*

### **Introduction**

Global trends such as population growth and rising economic prosperity are expected to increase demand for energy, food and water which will compromise the sustainable use of national resources. Besides positive effects, this pressure on resources could finally result in shortage which may put water, energy and food security for the people at risk, hamper economic development, lead to social and geopolitical tensions and cause lasting irreparable environmental damage.

Bonn (2011) conference considers that achieving water energy and food security and consequently reducing hunger and eradication poverty, is a central future challenge that is possible even under difficult and challenging global economic conditions. This has opened up a global debate on the importance of the nexus on water, energy and food security and the need for interlinked thinking and action fields for sustainable development including the following three dimensions (Hoff, 2011):

- The social dimension- accelerating access, integrating the bottom of the pyramid.
- The economic dimension- creating more with less
- The ecological dimension- investing to sustain ecosystem services.

By the year 2050 with the expected global population 9.2 billion demands for water, energy and food will increase exponentially. Therefore projections of a 70% increase in agricultural demand by 2050 and energy demand of 40% by 2030, water needs to satisfy agriculture and energy production is projected to be the double of what is available now. In the meantime, the world is reaching, and in some cases had already exceeded the sustainable limit of resource availability and is at risk. The global demand and supply assessments predict significant shortfalls in water and food in future. Those are the nexus challenge. The raised question do we have the integrated solutions to satisfy the tremendous future demands of water, food and energy. This cannot be easily done without having the appropriate enabling conditions which needs major work towards finding the solutions to the existing problems mainly related to weak governance systems, limited awareness, and distortions from perverse subsidies and unsustainable investments. Those factors and others related to the non efficient use and mismanagement of the resources can exacerbate a set of unintended consequences and contradictory outcomes. The current situation shows the need to build on more innovative solutions to achieve water, energy and food security.

### **The nexus**

- Water-energy-food nexus

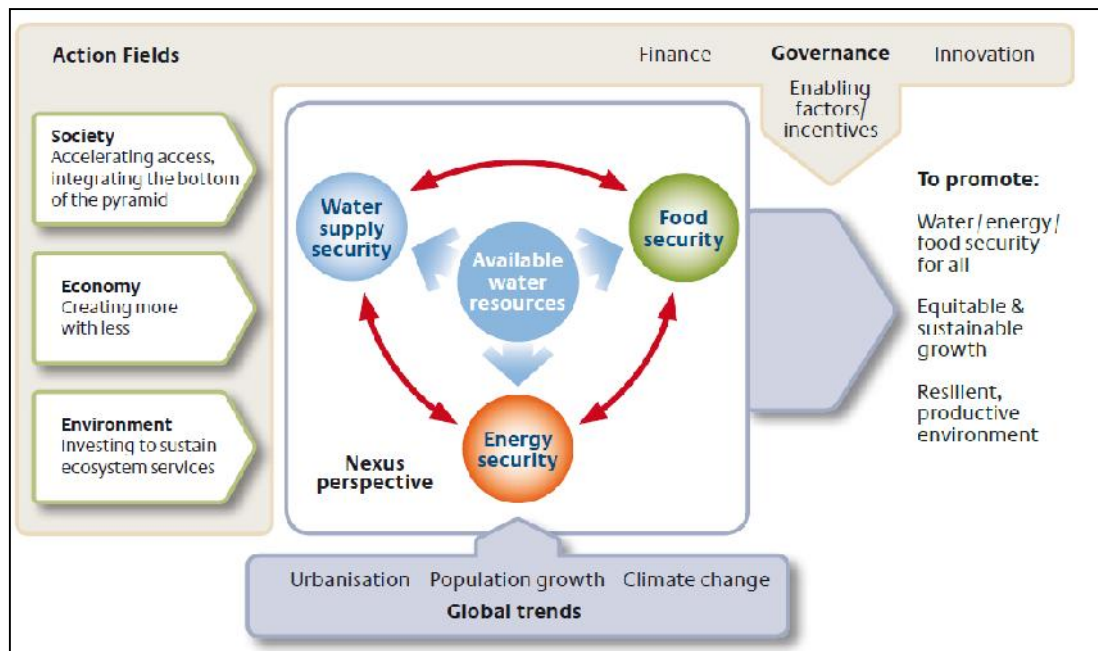
The nexus has emerged as a key concept to describe the complex and interrelated of our global resource systems, on which we depend to achieve different, often competing development goals. In practical terms, it presents a conceptual approach to better understand the interactions between the natural environment 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 (McCornick *et al.*, 2008; OECD, 2011).

It is important to note that there are different conceptualizations of the nexus that vary in their scope, objectives and understanding of divers. Several concepts, frameworks and methodologies have looked at the inter-linkages between water, energy and food (Mohtar and Daher, 2012; ADB, 2013; Bizikova *et al.*, 2013; UN-ESCAP, 2013).

The case of nexus thinking has been around for a while now, but is it really joined up enough yet? Do we have enough data points to catalyze action? How are organizations talking recommended resource challenges and what are the concrete examples of scenario planning, collaboration, or programmes in place? Could the move towards valuing natural capital help accelerate nexus thinking and policy making?

- Nexus approach

It 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 natural environment to humans. Improved water, energy and food security on a global level can be achieved through a nexus approach- an approach that integrates management and governance across sectors and scales. It highlights the interdependence of water, energy and food security and the natural resources that underpin that security-water, soil and land (figure 1).



**Figure 1:** The water, energy and food security nexus ( *Source: Bonn, 2011*)

A nexus approach can support the transition to a green economy which aims among other things, at resource use efficiency and greater policy coherence. Indeed, the green economy itself is the nexus approach par excellence. To succeed a green economy must go beyond sectorial solutions and actively address the water, energy and food security in line with human rights-based approaches.

Given the increasing interconnectedness across sectors and in space and time, a reduction of negative economic, social and environmental externalities can increase overall resource use efficiency, provide additional benefits and secure the human rights to water and food. Conventional policy and decision making therefore needs to give way to an approach that reduces trade-offs and builds synergies across sectors- a nexus approach. Business as usual is no longer an option. Based on better understanding of independence of water, energy and climate policy, this new approach identifies naturally beneficial responses and provides an informed and transparent framework for determining trade-offs and synergies that meet demand without compromising sustainability. The following guiding principles are central to the nexus approach:

- Investing to sustain ecosystem services
- Creating more with less
- Accelerating access, integrating the poorest

The nexus approach will also allow decision-makers to develop appropriate policies, strategies and investments, to explore and exploit synergies, and to identify and mitigate trade-offs among the development goals related to water, energy and food security. Furthermore, through a nexus approach as it integrates management and governance across sectors and scales improved water, energy and food security can be achieved. A nexus approach can also support the transition to green economy which aims among other things, at resource use efficiency and greater policy coherence. In addition it can also help to avoid “sunk costs” i.e investments that lock development into non sustainable pathways. Active participation and among government agencies, the private sector and civil society is critical for avoiding unintended adverse consequences. A true nexus approach can only be achieved

through close collaboration of all actors from all sectors (Hellegers *et al.*, 2008; Karlberg and Hoff, 2013; Stein, 2013).

### **Why do we need nexus approach?**

- Accelerating development

Development has rapidly accelerated over the half past century, but the benefits of development and progress on water, energy and food security (e.g. per capita calorie production has increased from 2280 to 2800 kcal/per day) have been unequally distributed between and within countries. A range of pressures from global and regional changes, such as population growth, economic development and changing lifestyles, are growing simultaneously and sometimes amplifying each other. In most developing countries, there is a rapidly expanding affluent middle class which is nearly tripled in size particularly in developing Asia between 1990 and 2005 (The-Economist, 2011). The consumption pattern diets and resource use of this class are quickly approaching those of developed countries (FAO, 2013). In the meantime there must be additional resources available to meet the food and energy needs of the poorest.

- Urbanization

Continuing urbanization, often driven by deteriorating rural living conditions and a quest for a better life. City dwellers now account for 50% of the total global population which is projected to reach 70% by 2050 (UNDP, 2011). There are currently one billion slums dwellers (UN-HABITAT, 2003) projected to increase to two billion by 2030 who are especially food insecure and disconnected from water and energy services. This is the reason behind having a nexus approach for cities. However, such nexus approach should include integrated planning of infrastructure for water, wastewater and energy. In the meantime cities have to build synergies with their hinterlands and water sheds, by providing markets for agricultural production, by recycling waste products into and out of cities through cascading water uses and by promoting nexus approaches through peri-urban agriculture and landscaping.

- Climate change

Climate change is mostly driven by energy use and changes in land use. Climatic variability adds further pressures such as accelerating drying of dry lands, reducing glacier water storage, as well as having more frequent and intense extreme events such as droughts or floods and less reliable water supplies and agricultural productivity. At the same time change mitigation places new demands and water and land resources and biodiversity. Climate adaptation measures such as intensified irrigation or additional water desalination are often energy intensive. Thus climate policies can impact on water, energy and food security and adaptation action can in fact be maladapted if not well aligned in a nexus approach and implemented by appropriately interlinked institutions (IPCC, 2007; Smith and Barchiesi, 2009; FAO, 2011; IPCC, 2011).

- Degradation of the resource base

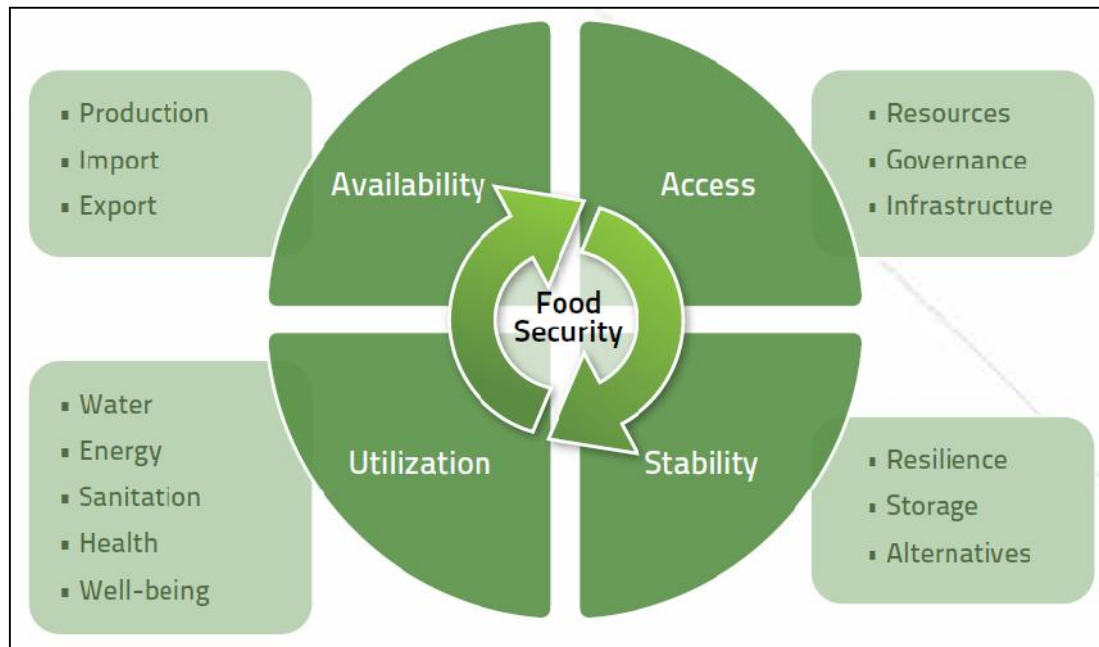
Growing demand and non-sustainable management have increased human's ecological footprint and caused degradation of the natural resource base in many regions including severe modification of ecosystems. This has resulted in a notable reduction in the land primary productivity primarily for food production (MA, 2005; Haberl *et al.*, 2007; Ellis, 2011). Desertification and soil degradation have reduced water and land productivity, water and carbon storage biodiversity and a wide range of ecosystem services. Regarding the water while it is a renewable resource, pollution and over use can still have long lasting impacts such as degraded and depleted aquifers and loss of aquatic ecosystems and wet lands.

### **Water energy and food security**

Food water and energy are finally being recognized as most important national and international security issues. However, we are long away from achieving water energy and food security for the entire world’s people. Water energy and food security have so far been mainly constrained by unequal access, but mainly is now also approaching limits of global resource availability.

Food security refers to both physical and economical access to food and food supplies. The current food crisis in most developing arid and semi arid countries cannot be understood unless located in the broader nexus that encompasses food, water and energy.

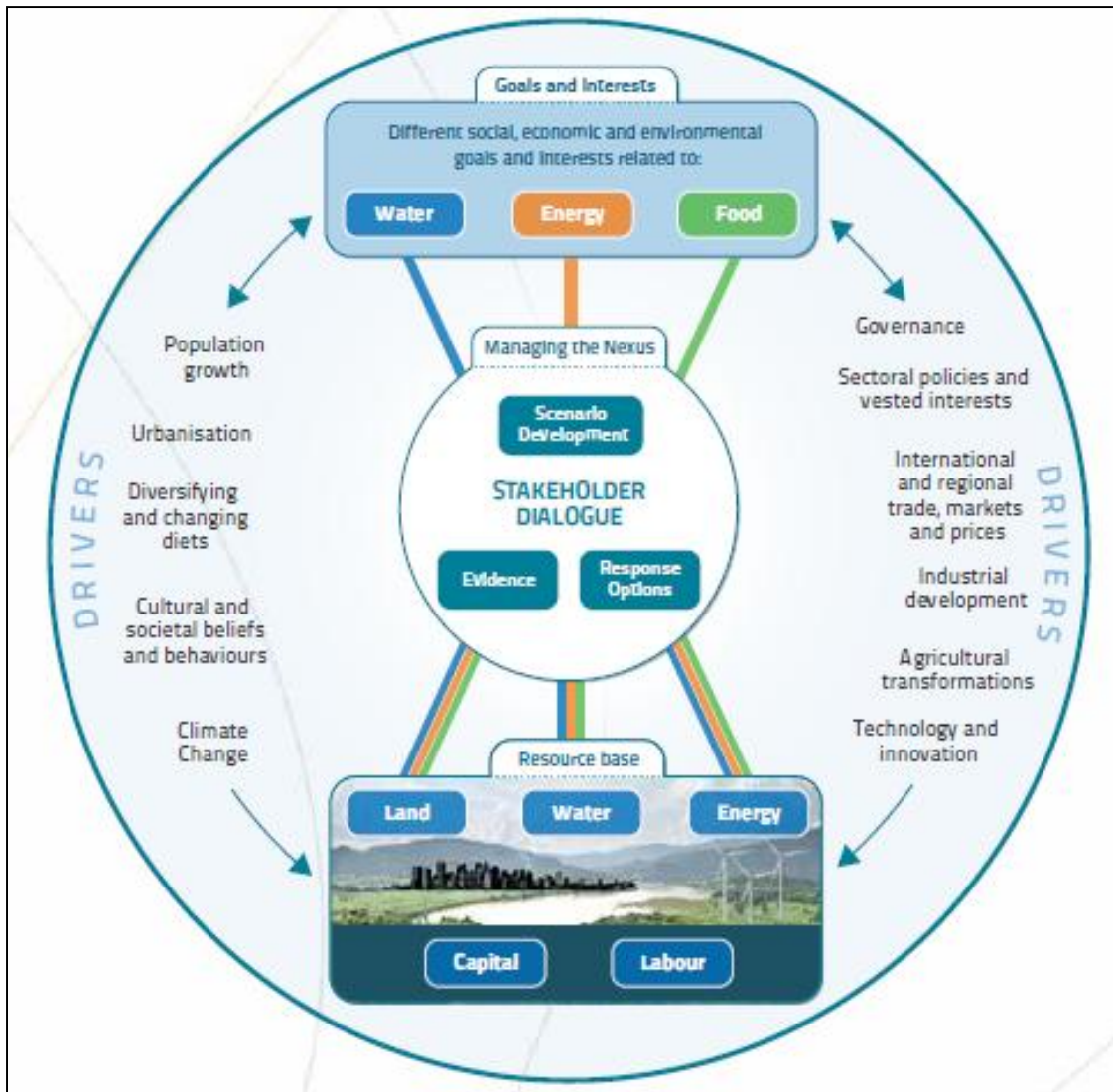
According to FAO (1996), as illustrated in figure 2, the concept of food security has four components, namely food availability, access, stability of supply and utilization. They reflect different social, cultural, political aspects as well as biophysical and socio economic conditions (Clark et al, 2013). Food security is determined by FAO as “availability and access to sufficient, safe and nutritious food to meet the dietary and food preferences for an active and healthy life. Adequate food has also been defined as a human right.



**Figure 2:** The components of Food Security (Source: Clark et al, 2013)

Food security alone does not ensure economic social and environmental sustainability. There is need to a nexus approach as it 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 resource and other key drivers. Water security, energy security and food security are inextricably linked and these linkages have always been present.

Interactions take place within the context of globally relevant drivers, such as demographic change, urbanization, industrial development, agricultural modernization, 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 social beliefs and behaviors (Figure 3) (FAO, 2014)



**Figure 3:** The FAO approach to the Water-Energy-Food Nexus (Source: FAO, 2014)

Indeed water, energy and food sectors are connected in important ways and each sector has its potential to either help or harm the other two. Interrelationships between water food energy and environment are both facing challenges and opportunities (McCornick *et al.*, 2008). Water security, food security and energy security are chronic impediments to economic growth and social stability. Food security in particular can be threatened by water and energy shortages. The availability of water for agriculture directly determines the availability of food. Higher energy prices increase the price of agricultural inputs and reduce the availability of land and water for food production due to competition from expanded biofuel production. This dampens food demand as a result of higher food prices.

### The nexus perspective

A nexus perspective increases the understanding of the interdependencies across water, energy, food and other policies such as climate and biodiversity. The nexus perspective thus helps to move beyond silos and ivory towers that preclude interdisciplinary solutions, these increasing opportunities for mutually beneficial responses and enhancing the potential for the cooperation between and among all sectors. Everyone in all disciplines need to think and act from the perspective of being interlinked in order to realize the full impact of both direct and indirect synergies that can result in this context, it is to be emphasized that the opportunities



provided by the nexus perspective and consequent social, environmental and economic benefits to be realized, implementation requires the right policies, incentives and encouragement, and institutions and leaders that are up to the task as well as frame works that encourage empowerment, research, information and education. Capacity development programme should be well developed and tailored to meet the know-how required for the implementation of the various nexus approach steps (UN-WWDR, 2014).

### **The nexus opportunity areas**

The areas of energy water and food policy have numerous interwoven concerns ranging from ensuring access to services, to environmental impacts to price volatility. These issues manifest in very different ways in each of the three spheres but often the impacts are closely related. Identifying these interrelationships a priori is of great importance to help target synergies and avoid potential tensions. The fact that environmental issues are normally the ‘cohesive’ principle from which the three areas are considered jointly, the enormous inequalities arising from a lack of access suggest that economical and security related issues may be stronger motivators of change.

They support sustainable growth and achievement of water energy and food security by cutting across interlinked decision spaces and identifying win-win solutions. Such nexus opportunity areas are:

- Increase policy coherence by ensuring that synergies and trade-offs among water, energy and food are identified both in design and implementation policies, plans and investments.
- Create more with less by increasing productivity establishing mechanisms to identify the optimal allocation of scarce resource for productive process and sustainable intensifying the use of land and water to achieve equitable social, economic and environmentally sound development.
- Accelerate access by progressively realizing in a more coordinated way- the human rights obligations related to water, sanitation, energy and food to reap the resulting health, productivity and development benefits.
- Value natural infrastructure by investing to secure, improve and restore the considerable multi-functional value of biodiversity and ecosystems to provide food and energy, conserve water, sustain livelihoods.
- End waste and minimize losses by reducing waste and losses along supply chains to capture significant economic and environmental gains within and across sectors and reduce demands on water, land and energy.

Here, it should be quite clear that for each of the nexus opportunity areas there is a set of policy recommendation that provide the basis to build momentum for a more coherent approach, develop enabling policy frameworks, provide economic incentives and establish market instruments; re-orient regulatory, planning and institutional set up; stimulate good governance; and build capacity.

### **Opportunities to improve water energy and food security**

A nexus approach can support a transition to sustainability, by reducing trade-offs and generating additional benefits that outweigh the transition costs associated with stronger integration across sectors.

A number of opportunities can be outlined in the followings:

- Increased productivity resources. Sustainable and inclusive intensification and decoupling of economic development from resource use both fundamental to a green economy can be achieved through technological innovation, recycling wastage. The nexus focus is on system efficiency rather than on the productivity of isolated sectors.
- Stimulating development through economic incentives. Innovation to improve resource use efficiency requires investments and reduction in economic distortions. Economic instruments for stimulating investments included for example pricing of resource and ecosystem services, water markets and tradable rights and payments for ecosystem services. A nexus approach can also help to avoid sunk costs, i.e. investments that lock development into non-sustainable pathways.
- Governance, institutions and policy coherence. Regulation and collective action can help to guide investments and innovation to minimize negative externalities and share benefits equitably enabling conditions for horizontal and vertical policy coherence include institutional capacity building political will, change agents and awareness raising. Additional opportunities can be realized if the nexus is addressed coherently across all scales through multi-level governance.

### **Concluding remarks and recommendations**

Some of the biggest challenges the world is facing things on the growing scarcity and allocation of resource vital to sustainable life water energy and food. To make enough food to support a growing population we need more water and energy. Producing energy requires water to cool power plants and produce biofuel, while making water accessible and clean for human consumption demands energy. According to UN estimates by 2030 we will need 30% more water, 45 more energy and 50% more food.

For most countries around the world there is a need for a new nexus oriented approach to address sustainable parameters of growth and impeding resource constraints promote security of access to basic services. It is an approach that better understands the interlinkages between water, energy and food sectors as well as the influence of trade, investments and climate policies. A nexus that helps to identify mutually beneficial responses and provides an informed and transparent frame work for determining trade-offs to meet demand without compromising sustainability and exceeding environmental tipping points as well as bringing economic benefits through more efficient use and management of the resources, productivity gains and reduced waste.

Central to a human rights approach is the achievement of water, energy and food security for the poorest of the poor. Many programmes and activities have been made to contribute to this objective including the millennium development goals complemented by a drive towards renewable energy sources, adoption the concept of integrated water resources management and moves taken towards more sustainable and efficient agricultural practices. Great efforts and much work is also being done by governments, communities, private agencies to achieve more productive resource efficient equitable and sustainable outcomes. However, in spite of this significant progress security of water, energy and food supplies are still remaining far from being achieved work on what is being termed the water-food-energy nexus is starting, but, much still needs to be learned and accomplished on increasing efficiency, reducing trade-offs and building synergies across sectors.

To achieve water energy and food nexus goals there is need for a coordinated harmonized nexus knowledge-base and database indicators and metrics that cover all relevant spatial and temporal scales and planning horizons. Full life cycle analysis across the nexus is also needed.



Such an improved nexus understanding could underpin new decision and policy making in a green economy framework.

Despite the strong, food, water and energy linkages practitioners and policy maker continue to approach developing programme and policies in the ‘silos’ of their respective ministers. To maximize food, energy and water security, mechanisms must be created to raise the policy makers’ awareness of these issues and promote greater collaboration among ministers as well as communities, civil societies and the private sector in policy design and implementation. Research too needs to address the linkages across these sectors, and provide the evidence of the strategies, investment and policy action needed to consider all three sectors. If the food, water and energy connections remain unaddressed, global food security will not be achieved, increasing poverty and environmental degradation.

The increased demand of energy worldwide will reflect directly and indirectly on water-dependent systems. Rising fuel cost and increasing concerns over the effects of climate change are reinvigorating policy makers’ interest in renewable energy sources such as hydropower and bioenergy- both from biofuels as well as biomass. Development of any of these sources has the potential to generate positive economic and environmental benefits, yet, at the same time they can cause negative food and equity impacts. This obviously entails major trade-offs between, the food, energy and environmental goals of water and energy development, allocation and management. Increasingly complex energy-agriculture relationships require in-depth understanding of water and energy trade-offs. Choosing biofuels for energy production should require a careful balancing of priorities, since water that has been used to grow feedstock for biofuels could also have been used to grow food.

For water, energy and food security nexus the resource limitations in all sectors require a shift towards resource use efficiency, demand management and more sustainable consumption patterns. Without such changes current development trajectories threaten to drive social-ecological systems at all scales towards critical thresholds. Crossing critical thresholds at any scale could result in possibly irreversible system.

To avoid such negative impacts new approaches are needed; institutions need to be flexible, adaptive and enabled to cooperate with institutions representing other sectors and in some cases new institutions may be required (UNECE, 2014). Stronger institutions that are better interlinked are a key to a nexus approach and may be more important than additional institutions.

### **Manuscript analysis (raised items for oral discussion)**

Deep analysis of this manuscript and others cited in this paper could be conclusively highlighting the following:

- Many governments have separate agencies to oversee water, energy and food production, and they set policies and plans for each sector separately. The same is true of research on these issues; expertise on energy, water and use is clustered in separate groups, with limited interaction.
- Nexus analyses need to go beyond human systems, and look at resources within ecosystems. Impacts on ecosystems, in turn, affect human livelihoods and wellbeing by eroding vital ecosystem service. Experiences gained and lessons learned indicate that an ecosystem-based approach can find ways to avoid negative impacts and actually strengthen ecosystems and the services they provide.

- Along with cross-sectoral interactions, nexus analysis need to examine how systems interact across scales, and the role of factors such as political and social structures, governance and trade.
- If nexus research is to make an impact on policy and practice, it must connect with stakeholders and their terms. To operationalize the nexus, it is needed to understand conditions on the ground including the perspectives of different institutions and stakeholders groups, at all relevant scales. In this regard, participatory processes are thus crucial and are playing an important essential role. Participatory processes can also help ensure that vulnerable stakeholders have the information and access they need to advocate for themselves, and can foster dialogue across sectors and scales.

Many nexus problems have win-win solutions, but some do not. For many places there is great potential for efficiency improvement and waste reduction and thereby producing more food with fewer resources. For example, nexus analysis of proposed sustainable development goals targets, found numerous synergies and potential win-win. However, this could not be the same in some cases especially when resources are very scarce, a nexus analysis may not find win-win option, but just difficult trade-offs (Weitz *et al.*, 2014).

Nexus approach implementation, an outlook on the future, clearly identify that there is several pathways needed including: building scientific knowledge, well tested methodologies, transparent well designed integrated models. Equally, there is need to expand nexus perspectives focusing more on integrating socio-economic and bio-physical perspectives, and looking across scales, from the local to the global.

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