Scientific challenges posted by the water-energy-food nexus in the Mediterranean

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The EU strategy for international cooperation in research and innovation (European Commission, 2014), targets an early identification of cooperation initiatives at an appropriate scale and scope, as well as initiatives to develop a post-2015 agenda including Sustainable Development Goals. Regarding the EU-Mediterranean Partners Countries cooperation agenda, several initiatives are being promoted to this end, notably those regarding the challenges of securing affordable food, managing scarce water resources and promoting the use of renewable energies. These actions are included in the INCo.Net Project MEDSPRING and the ERA.Net MED, both coordinated by CIHEAM-Bari, which also include an intellectual support to the setting of a permanent instrument of Euro-Mediterranean cooperation in research and innovation based in Article 185 of the Treaties, the PRIMA initiative which is at this moment under impact evaluation.

The water-Energy-Food NEXUS describes the complex and inter-related nature of our global resources systems. It is about balancing different resource user goals and interests, while maintaining the integrity of ecosystems (FAO, 2011). The NEXUS approach is a scientific, technical and political question. The scientific approach to the NEXUS is yet an open question about how an integrated approach to the challenges identified within the NEXUS could be addressed from a heuristic scientific point of view. FAO has identified three working areas as part of a broader process of stakeholder dialogue addressing the NEXUS: a) Data and analysis; b) Scenario development; c) Response options. These are complemented by a continuous process of stakeholder dialogues.

Facts and Social and Economic Challenges

About one billion people live in the EU and in the neighboring countries. Of this total roughly half live in the EU-27; slightly less than 30% live in the countries of the South and East Mediterranean (SEMCs), including Turkey.

Some 40 per cent of the population in the Southern Mediterranean area lives in rural areas, and the population of the SEMCs will increase by some 25 % to 370 million in the next 20 years; in the EU-27, the population will increase only very slowly, by less than 2% over the entire period. In the EU-27, the population in the age group from 15 to 64 will fall by 6.5%, from about 330 million in 2010 to 310 in 2030. This decline contrasts with an increase in the comparable age group in the SEMCs by more than 31%; the total in this cohort will increase from 195 million to 250 million over the period. A consequence is that about 55 million more people will be looking for work (European Commission, 2011).

Much of the Mediterranean basin is arid and as the climate changes it becomes still drier; water resources are scarce and reducing. Rates of water use in the SEMCs often exceed the capabilities of the natural water resources, and it is worsened by the difficulties to monitor individual withdrawals of underground waters (FAO, 2015). The 'water exploitation index' measures this stress. If the index is below 25 %, water exploitation is negligible, and above 75 % water resources are overexploited. Countries such as Libya, Israel, Egypt, Jordan and Malta have a Water Exploitation Index (WEI) (Fig. of 2003) of 100%, Tunisia has an WEI of 60%, Algeria of 55% and Morocco of 45%. From a total World water withdrawal of 3752 Km^3, Northern Africa extracts 202 Km^3 and the Middle East 276 Km^3, where only 5 and 7 % are used by the industry. The regional fresh water availability is respectively 0.1% and 1.1% of the total world resources.

The rapid increase in population and in urbanization over the past 40 years has stimulated high growth in demand for energy, water and food. Much of the net growth in the global population by 2050, estimated in 9 to 10 billion people, will occur in cities of developing countries, so reinforcing the urban demand for these resources (FAO and WWF, 2015). Water and energy are closely linked: water use for energy generation represented 15 percent of world water withdrawals in 2010, and can compete with food production (FAO 2015).

Renewable energy and especially solar energy has great potential to improve security and new industrial development as the region has impressive resources of renewable energy. The German aerospace Centre (DLR) has estimated that, by using less than 0.3 % of the entire desert area of the MENA region, enough electricity and desalinated seawater can be produced to meet their own growing demands along with 100 GW of export to Europe by 2050.

However, the high subsidized prices of energy in the MENA countries, the cumbersome burocratic barriers to investments in this sector, and the lack of public perception of the long term benefits of RE could represent, paradoxically, a threat to the water and food production and prices (BETTER Project, 2014).

Recent studies have shown that more than half of the food calories consumed in the SEMC region is imported and would increase to 64% over the next two decades (World Bank, 2009**)**. An older study in the mid-1990s showed that the food imports of the region were equivalent to 83 billion m3 of virtual water, or about 12% of the region's annual renewable water resources. Food security has long been a political concern in the Mediterranean region.

Originally the cause of the anxiety was not so much availability as declining self-sufficiency. More recently, the concern has widened; it is now a matter of access for populations to foodstuffs and inevitably it is the poor who suffer. In the SEMC countries, with the exception of Turkey, supplies are provided to a large extent through trade and even in some cases through food aid. The North African countries (from Morocco to Egypt) absorbed in 2007- 2008 almost 20 % of world wheat imports, whereas they account for only 2 % of the world population. Farming output cannot keep pace with the needs of a rapidly growing population, so that the deficits in the South and East are growing (Al-Zubari, 2014**)**. Globally, rain-fed agriculture is the primary source of food production. In many regions, there is still an important yield gap, and potential to improve yields and water productivities without irrigation. Rainwater harvesting, as well as supplemental irrigation, can also substantially improve rain-fed agriculture (FAO, 2015).

In the Middle East, the roles of the branches of government in setting national priorities and addressing them are not clearly drawn. Soft security, such as security of water, energy, and food, is probably more important to a country's development than hard security, which emphasizes the military and defense. Science-based policies will be needed to meet the challenges of developing water, energy, and food security, simply because they are likely to promote development that is both effective and efficient. While research will be needed to potentially shape future policies, it is important to ensure that initially, policy development makes full use of existing science (Vaux and Dooley, 2014).

The NEXUS Scientific challenges

A survey of the literature dealing with the Water-Energy-Food NEXUS allow us to identify some unsolved key questions that could make part of a EU-MPC common research agenda to engage the scientific and innovation communities.

The recent paper of the FAO High Level Panel of Experts (FAO, 2015) makes concrete recommendations to the scientific community about the scientific challenges of the Food Security and Nutrition (FSN), particularly in developing countries, asking for methodological and institutional innovations for the participatory co-construction, co-validation and dissemination of knowledge appropriate for risk prone, diverse and complex environments, such as arid and semi-arid regions, wetlands, deltas, and mountains.

Moreover, investments in research and innovation for water and FSN, with due attention to neglected areas, must increase. The following key areas should be addressed: impacts of climate change on run off, aquifer recharge, water quality and plant water use, and means to address them; incentive instruments and pricing structures for energy and water to reduce water waste or over-utilization; monitoring and evaluation of the water-related impacts, at different geo-spatial and temporal scales, of large-scale land acquisitions and foreign direct investments impacting water availability, access, quality and stability of supply, as well as on policies, interventions and institutional innovation to regulate their negative effects on FSN; establish and manage open data systems to provide evidence for decision making and monitoring; facilitate knowledge exchange on best practices for the management and governance of water systems for FSN.

There is no blueprint for overcoming institutional disconnection and power imbalances between sectors and different sectoral goals, policies and strategies in regard to water, energy and food in terms of resource use efficiency and productivity, planned investments, reforms, and large-scale infrastructures (FAO, 2014). There are serious gaps in science communication strategies.

Other significant issues have also been identified from other papers and Conferences dealing with the challenging and, may be, contradictory demands of the NEXUS Water-Energy-Food sectors. This issue should be addressed by considering that the interactions between water, energy and food systems should incorporate full life-cycle assessments in terms of the mutual interaction between the three components of the full nexus. Moreover, resources policies and regulations are frequently based in social and economic demands and not in the scientific evidence or warnings related to their use and the natural or man-induced impacts.

The current state of pressures on natural and human resources systems, and the expected demands, trends and drivers on resources are not well understood (FAO, 2014; Hoff, 2011). Climate change is deeply embedded within the water and soils cycles and food production, but there are not yet reliable models of such impact (Al-Zubari, 2014), or the impact of solar activity on the local climate change effects. Diffuse soil and aquifers non-point source contamination by traditional (fertilizers, insecticides, etc.) and new contaminants and its impact on water availability is not well studied, while in some places this contamination is more important than point source pollution, easier to control.

The increasing urban and industrial water consumption should be coupled with plans to recover nitrogen and phosphorous from the waste water, to be used as nutrients in agriculture (Wichelns, 2015). More data are needed on sustainably available water resources, in particular on safe aquifer yields and for so-called 'economically water scarce' regions. Water accounting and water balances between water availability and water consumptions and losses are needed (Hoff, 2011). Observations from satellite or in-situ are 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 and provide arguments for adaptive management of resources based in the new evidences (FAO, 2014). There are scarce data on consumptive water use in the energy sector, compared to withdrawal data. Existing data are scattered and not consistently traced throughout the full lifecycle ('from the well to the wheel'). The water use intensity of the several varieties of energy production systems must be assessed (Halstead, Kober and van der Zwann, 2014)

Water productivity in agriculture is mostly calculated per kilogram of product, sometimes also per kilocalorie, but rarely takes into account the nutritional content of food products. Energy productivity in water availability and agriculture requires further research; there is conflicting evidence about the positive or negative energy balance of different biofuels. There is a lack of consistent and agreed quality standards upon water and energy for different crops and production systems, which would promote wastewater reuse and hence increase water and energy use efficiency. Uniformly applicable 'water footprint' or water cycle accounting systems are not yet available to allow comparison of water use efficiency for different forms of energy or food production. Irrigates agriculture accounts for some 20% of the cultivated area worldwide, while it generates about 40% of crop productions (FAO and WWC, 2015). Currently, about 0.25 to 1.5 million hectares of irrigated land are estimated to be lost annually because of salinization due to bad irrigation practices. Globally 34 million hectares are now impacted by salinity representing 11 percent of the total irrigation equipped area (FAO, 2015).

The Meeting organized by INCO.Net Project MEDSPRING (MEDSPRING Project, 2015) gathering several dozens of EU-Financed projects dealing with one or more components of the NEXUS, was a good opportunity to assess from the ground the perception of the scientific community of the challenges faced by the NEXUS. The main agreed conclusions was, perhaps, the perception that the research environment on the challenges posted by the NEXUS (and in general in any other challenge) must be handle incorporating externalities such as communication, measures to guarantee exploitation of possible results, provisions to perform short and long term technological impact assessment, as well as political and social impacts.

Other conclusions were the need for the aggregation of knowledge processes around the challenges. Moreover, actions based in Projects dimensions are not enough to guarantee sustainability of the effort; a clear engagement of Institutions and funding agencies around the challenges is needed. A common wish was to explore means to present the results of the effort of the scientific community to the society, and reach the political level of decision on funding and continuity in actions. It was acknowledged the need to be present in the forums where the concerns are exposed, and be closer to the end users of the research effort, notably consumers and young generations. Good quality data sharing is a must if common North-South problems are to be jointly addresses.

Conclusion

There is a general agreement within the scientific community about the need to create a permanent instrument to frame the EU-MPC cooperation in research and innovation. The NEXUS approach is a challenge, where the difficulties and benefits of such cooperation can be tested and communicated to the general public and the decision makers. However, this target must be addressed in a holistic way and adapting the scientific environment.

There are several open questions that hinder an efficient use of the scientific effort and provoke a slow pace of knowledge transfer from the scientific and technical communities between themselves and to political, administrative and industrial and agricultural producers and users of water, energy and food: Which is the degree of coordination between policies and regulations? How can the challenges of the NEXUS be presented to the large public? Where are the public benefits of this approach? Where are the industrial benefits of this approach?

There is no yet a harmonized 'nexus database' or analytical framework that could be used for monitoring or trade-off analyses between the three components. Hence the effects of increasing energy or water scarcity on food and water or energy security, as well as potential synergies between land, water and energy management, are not well understood. Questions include to what extent can higher availability of one resource sustainably reduce scarcity of another, and how might this work at different spatial scales? There is a lack of policy coherence (Al-Zubari, 2014). We need to listen other`s opinions, as warnings use to be listened too late…

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