Sustainability in the Water-Energy Nexus **Open Access**

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Agriculture, biofuels and watersheds in the water-energy-food nexus: governance challenges at local and global scales

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Abstract: Agricultural land use in watersheds for food and biofuels production presents several challenges within the Water-Energy-Food (WEF) nexus at the local and global scales. Firstly, high global energy prices may lead to increasing demand for bio-energy crops, thereby intensifying the competition for arable land and water with food crops. There may be potential net welfare benefits from bio-energy development in terms of poverty reduction, higher agricultural household incomes, and lower greenhouse gas emissions. However, so far, there has been little quantitative research evaluating and communicating the nexus synergies and trade-offs. Another challenge is that differentiation of gender roles in the nexus trade-offs and synergies is mostly overlooked. This results in marginalisation of mostly the female gender in land use decisions. Therefore, there is a need for quantitative evidence-based research and incentive frameworks for governing the nexus to ensure the continuity and progress in global and local food supply and bio-energy development, while maintaining the sustainability of the watershed ecological services.

Keywords: agriculture, biofuels, watersheds, water-energy-food nexus

Introduction

This paper brings into focus the governance challenges faced in the water-energy-food nexus at global and local scales with regards to agriculture, biofuels and watersheds. The challenges emanate from the complex interactions in the nexus, which at the same time present opportunities for new thinking and approaches on the sustainability of social-ecological systems at global and local scales. Agricultural land use in watersheds for meeting food and energy security is one example of a social-ecological system, whose inherent synergies and trade-offs are best explained by the nexus-thinking approach in order to maintain stability of the system.

The world is faced with the challenge of feeding a growing human population. As such watersheds provide important ecological services including water capture, storage and release to support agricultural production and other socio-economic activities. However, unsustainable agricultural practices tend to degrade watersheds through deforestation, erosion and pollution. These processes result in loss of biodiversity, degradation in water quality and quantity, and soil fertility. The renewed interest in bio-energy development may lead to increasing demand for bio-energy crops and cultivated land, thereby intensifying the competition for land and water with food crops. This will then result in increased magnitudes of the negative effects of agriculture unless actions are taken to mitigate them. Therefore, there is need for a pragmatic evidence-based conceptual framework for assessing the synergies and trade-offs between food and bio-energy with due consideration of the social, economic and environmental dimensions of sustainability.

Summary Of Key Questions

The discussion on agriculture, biofuels and watersheds revolved around four (4) fundamental questions into the water-energy-food nexus. These questions pertained to

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the research into the Water-energy-nexus with relevance to the emerging drivers of agricultural water use in the watershed through development of the biofuel industry.

1 How can bio-energy development be modernised to achieve economic development, energy security and food security without undermining the long-term agricultural productivity and environmental sustainability?
2 Why should differentiation of gender roles in agricultural landscapes be recognized in achieving the water-energy-food nexus at a local scale?
3 To what extent does cereal production for domestic human use decline under the scenario of increasing oil seed prices due to the rising biofuel demand on the global market?
4 What is the most effective strategy for improving watershed ecosystem services provisioning without compromising local food supply?

Question 1 underscores the need for understanding the complex linkages that characterise the water-energy-food nexus in the rapidly evolving global context with a more tightly interlinked relationship between energy and food markets. For example, bio-energy development could provide opportunities for increased access to alternative and renewable energy sources in rural areas that heavily rely on traditional biomass for energy [1]. Bio-energy development could also provide opportunities for higher agricultural household incomes [2] . However, high global energy prices and aggressive bio-energy development may increase the demand for bio-energy crops leading to intensive competition for water and arable land with food crops.

Knowledge of the synergies and trade-offs in the nexus, as exemplified in the foregoing paragraph, can be attained through comprehensive quantitative and qualitative research to evaluate and communicate the nexus linkages. However, in this regard, there is a lack of quantitative evidence-based and trans-disciplinary research illuminating the role of energy and its interactions, synergies and trade-offs with other nexus components, especially in the context of developing countries. The implication of this gap is that the nexus approach may lack practical applications at the local scale or lead to misinformed action programs.

Question 2 addresses the need to recognise that gender is a significant factor in land use and land cover change associated with agriculture. This is essential to resolving conflicting perspectives in achieving the water-energy-food nexus. A case study of a watershed in Indonesia [3] showed that there were differences between women and men in land use decisions for food or bio-energy production. This was in addition to contested rules between the state and local communities over use and protection of natural resources that affected environmental services and livelihoods in the forest marginal areas. Therefore, future research in the water-energy-food nexus should more often rely on sex-disaggregated data collection and analysis protocols.

Question 3 draws attention to the potential adverse effects of the growing biofuel demand to the effect that increasing oil seed prices on the world market are likely to cause a decline in food crop production [2]. This scenario undermines the attainment of food security objectives outlined in various agricultural policies in developing countries.

Finally, Question 4 calls for an effective strategy that should ensure the attainment of food security objectives at a local scale without compromising the important ecological function of watersheds of providing ecosystem services. The issue to be addressed is watershed degradation due to intensification and urbanisation of watersheds for food and bio-energy production. Watershed degradation in this sense is not adequately addressed by economic instruments such as the polluter-pays-principle. An incentive-based watershed management strategy is needed to engage farming communities in practices that will enhance restoration of watershed services, while ensuring continuity of food supply [4].

There are no easy and direct answers to the problems outlined in this paper. However, the discussions around the questions emphasised the need for nexus thinking approaches that would bring together various players including scientists, policy makers and other stakeholders to a common platform. Such a platform will serve to develop evidence-based action programs and incentive frameworks so as to ensure sustainability of the social-ecological system in the context of water, food and energy interactions.

Key messages and recommendations

the key messages from the sessional discussions on agriculture, biofuels and watersheds in the water-energy-food nexus can be outlined thus:

1 There is need for new and innovative theoretical and conceptual frameworks to quantify and analyse trade-offs and synergies in the water-energy-food nexus as a basis for more integrated and trans-disciplinary research.
2 There are potential net welfare benefits such as poverty reduction, increased income for rural and urban

households, and decarbonisation associated with bio-energy development.

3 Increasing global energy prices may lead to increased demand for bio-energy crops and cultivated land at the expense of food crops. Technology development can help to alleviate energy-food trade-offs, but effective land governance mechanisms are also needed especially in the developing world.

4 Gender can be a significant factor in land use change associated with agriculture; the water-energy-food nexus research should thus more often rely on sex-disaggregated data collection and analysis protocols.

5 Agriculture is often associated with watershed degradation. Incentive-based watershed management approaches can help to promote watershed restoration services, and as such research is needed to identify the best conditions under which incentives can be integrated with existing regulatory instruments.

Reference to Session

This report is based on the Session A04 at the International Conference on "Sustainability in the Water-Energy-Food Nexus. Synergies and Trade-offs: Governance and Tools at various Scales" held in Bonn, Germany on 19th and 20th of May 2014. The session was chaired by Jan BÖrner, from the Centre for Development Research (ZEF), Bonn, Germany.

Speakers:

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[2] Müller, M. (2014). *"Impact of Increasing World-Market prices for Oilseeds on West African Agriculture"*. Centre for Development Research, ZEF, Bonn, Germany.

[3] Villamor, G.B. (2014). *"Local actors and gender perspectives in dealing with water, food and energy trade-offs: a case from Jambi, Indonesia"*. Centre for Development Research, ZEF, Bonn, Germany.

[4] Osuna, V.R. (2014). "Managing Water, Environment, Food trade-offs in the Brazilian Atlantic Forest: A case study. Centre for Development Research, Z