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Focali Brief: 2013:03

The bioenergy and water nexus – a complex relationship

This Brief is mainly based on the report "The bioenergy and water nexus", published 2011 by The United Nations Environment Programme (UNEP) together with the Oeko-Institut and IEA Bioenergy Task 43, involving about 40 authors and reviewers. The brief examines the complex relationship between water and bioenergy and highlight the reports policy recommendations. Selected additional references are provided as suggested further reading.

THE DEMAND for bioenergy has increased rapidly during the last decade. The ambition to displace a share of present fossil fuel use with biomass based fuels (in transport as well as in stationary energy sector) offers considerable opportunities for the agriculture and forestry sectors, which can find new markets for their products and also make economic use of biomass flows previously considered to be waste. Bioenergy is integrated into the agriculture investment portfolio in many countries, seen as essential for improving rural livelihoods, boosting the national economy and reducing vulnerability to oil-price fluctuations. The rapid growth in bioenergy demand in recent years has induced debate about the sustainability of bioenergy. Policy makers are understandably concerned that risks are properly taken into account when further expansion is being contemplated or incentivised - be it related to food prices, land use change impacting natural ecosystems, biodiversity and carbon balances, or to so-called "land grabbing" where land is transferred to large investors at the expense of local communities (Karlsson, 2012; Cotula, 2012). Of course, many of the challenges pointed to in the bioenergy debate are not exclusively related to bioenergy expansion. For instance, a range of factors contribute to food price spikes and "land grabbing" occurs to make place for a range of activities including food, feed and fiber production, mining, industries and hydropower development. Thus, the challenges should be addressed within a wider "land-water-food-energy" context. However this Focali Brief specifically addresses the water implications of bioenergy, which have also received increased attention recent years outside the scientific domain (Berndes 2002, 2008; Bossio et al., 2012; Hoff 2011; Kay & Franco 2012; Smaller & Mann, 2009).

Photo: Marie Widengård

About this brief

This Brief is produced in collaboration with the following organizations: UNEP (United Nations Environment Programme), IEA Bioenergy Task 43, IINAS (International Institute for Sustainability Analysis and Strategy), and SIWI (Stockholm International Water Institute) through SIWI Associate Göran Berndes who authored the Brief together with Maria Ölund at Focali. The views presented in the Brief do not necessarily reflect the views of the organizations involved.

Different bioenergy types have different water implications

The use of biomass for energy is nothing new. Traditional use of biomass (e.g., wood, manure, charcoal) for cooking, space heating, and lighting presently accounts for roughly 80 per cent of global bioenergy use. So-called "modern bioenergy" - which is the production and use of refined solid, liquid, and gaseous biofuels for electricity, heat, and transport - accounts for the rest. The use of food and feed crops for the production of biofuels for transport, which has the focus of much recent debate, currently account for a relatively small share. It is also small relative to the food sector: presently only 3 per cent of global cropland is used for cultivating biofuel feedstock (Foley et al. 2011). However substantially larger areas than at present will have to be dedicated to the production of biomass for energy in a scenario where bioenergy contributes significantly to the future energy supply. Technologies for the conversion of lignocellulosic material into biofuels will broaden the resource base for the biofuels industry if they become commercially available.

As for many other industrial activities, the process of biomass conversion to energy products can require a substantial volume of water. Most of this water is returned to rivers and other water bodies and is therefore available for further use. However, the feedstock production can require much more water than the subsequent processing. Water use in feedstock production is also different in that much of the water is evapotranspirated back to the atmosphere and is therefore not available for biological production until it returns as precipitation. Rainfed feedstock production does not require water extraction from groundwater, lakes, and rivers, but it can still reduce downstream water availability by redirecting precipitation from runoff and groundwater recharge to crop evapotranspiration.

Varying water use efficiency

Water use efficiency varies among crop types and the efficiency of a specific crop also varies with climate, growing period and agronomic practice and there are several options for modification of the water use efficiency. Thus, different types of bioenergy system will have different consequences for land and water and the net effect depends on the local context including the previous land use. For example the use of residues can mitigate water pressures: the water that is used to produce the food and conventional forest products is the same water that will produce the residues and byflows potentially available for bioenergy. However, residue extraction rates need to reflect what can be sustainably removed without severely impacting soil texture and structure, which greatly influence water infiltration, permeability, and water-holding capacity.

“Marginal” lands and bioenergy

The use of so-called “marginal”, or degraded, lands for bioenergy plantations is seen as an opportunity to bring land back into production. Furthermore, proper plant selection and land management can make better use of available water, improve soil productivity and increase the carbon sink. An additional benefit is that the use of such lands mitigates the competition for prime croplands and reduces the deforestation pressure. However, the use of marginal land with sparse vegetation for establishing high-yielding bioenergy plantations may lead to substantial increases in evapotranspiration which might reduce downstream reduce downstream water availability, either as a consequence of irrigation water use or if rain fed cultivation is used due to that less of the rainwater is channeled to groundwater recharge or runoff to downstream areas. This may become unwelcome effects requiring management of trade-off s between upstream benefits and downstream costs. Large fertilizer inputs may also be required for reaching high yields, which can increase eutrophication. In addition, lands defined as “marginal” may be vital for the livelihoods of small-scale farmers, pastoralists, women, and indigenous peoples. Transfers of such land to bioenergy investors can consequently cause serious socioeconomic and cultural impacts (Rossi and Lambrou 2008).

Not only volume that counts

As noted in the Nexus report, studies assessing impacts on water may fail to recognize that it is not only the amount of water used that needs to be accounted for. Besides estimates of required volumes of water contextual factors are needed to study impact on water resources and to compare different projects, crops and methods. Since bioenergy is produced in varying biophysical circumstances assessments of local conditions, such as inter-seasonal variability and water scarcity at the basin level, are necessary as a complement to water inventories that use spatial and temporal aggregations. Social and environmental risks and trade-offs should further be identified. Examples of water related risks to consider in impact assessments of biofuel production are presented in box No.1 below. Tools and policy instruments for water sound desisions are presented on following pages.

Appropriate assessments

The nexus report discusses both positive and negative environmental and socio-economic consequences as well as options for improved water use efficiency. The report states that: *“Given the complexity of the interlinkages between bioenergy and water, an assessment framework is critical if operators are to be able to evaluate the positive and negative effects of bioenergy development on water resources.”* (Report page 15). Three key elements are suggested for inclusion in such an assessment framework:

1) Water intensity of the proposed activity.

2) The state of water resources in the proposed area.

3) Impacts of the proposed activity at the local level.

Examples of water related risks with bioenergy production:

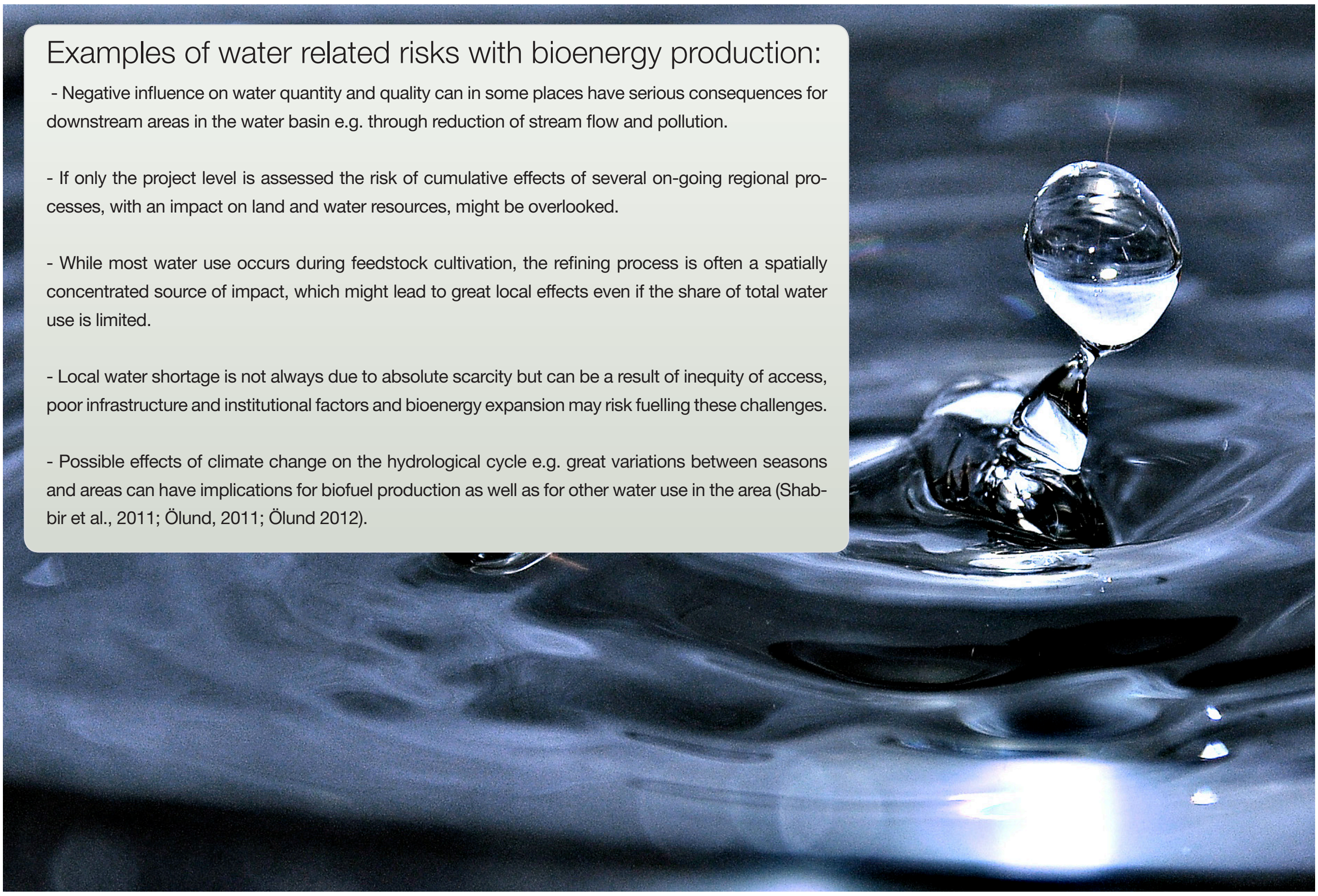
- Negative influence on water quantity and quality can in some places have serious consequences for downstream areas in the water basin e.g. through reduction of stream flow and pollution.

- If only the project level is assessed the risk of cumulative effects of several on-going regional processes, with an impact on land and water resources, might be overlooked.

- While most water use occurs during feedstock cultivation, the refining process is often a spatially concentrated source of impact, which might lead to great local effects even if the share of total water use is limited.

- Local water shortage is not always due to absolute scarcity but can be a result of inequity of access, poor infrastructure and institutional factors and bioenergy expansion may risk fuelling these challenges.

- Possible effects of climate change on the hydrological cycle e.g. great variations between seasons and areas can have implications for biofuel production as well as for other water use in the area (Shabbir et al., 2011; Ölund, 2011; Ölund 2012).



Box No.1. Photo: Jesper Karlsson

In order to conduct a comprehensive analysis both quantitative and qualitative data is needed concerning potential influence of a proposed activity on the socio-ecological situation, including resilience to water scarcity. This type of information has to be gathered in the specific area since it most likely is not already available.

Certification schemes

In response to social and environmental concerns sustainability standards and certification schemes are developed to guide bioenergy producers and to assure consumers that the bioenergy they use meets certain requirements. The nexus report presents an overview and analysis of the main voluntary certification schemes relevant for bioenergy production, including feedstock-related schemes such as the Roundtable on Sustainable Palm Oil (RSPO), the Round Table on Responsible Soy (RTRS) and the Better Sugarcane Initiative (BSI); bioenergy-specific schemes such as the Roundtable on Sustainable Biomaterials (RSB), the International Sustainability and Carbon Certification (ISCC) and the Green Gold Label (GGL) programme; forestry-related schemes such as the Sustainable Forestry initiative (SFI) and the Forest Stewardship Council (FSC); agriculture-related schemes such as the Sustainable Agriculture Network (SAN)/Rainforest Alliance; and water-related schemes such as the Alliance for Water Stewardship (AWS). Based on a review of these schemes the report concludes that while certification can assist in the promotion of sustainable biofuel production and handling of water resources the efforts can be undermined by other activities within the watershed and by a country's overall water policy. Hence, integrated water basin planning and management involving all affected parties is crucial. Another challenge raised in the report concerns the practical application and effectiveness of the schemes in actually delivering the intended prevention or mitigation of harmful impacts: careful monitoring and evaluation is warranted. Effective policy and stakeholder involvement at different levels is further a prerequisite for the success of any certification scheme in the long term.

Policy instruments and recommendations

Policy instruments can directly or indirectly influence how bioenergy production affects water availability and quality and can also influence the wider socio-ecological implications of bioenergy production such as job creation and approaches to land and water management. To be effective, policy instruments targeting bioenergy-water aspects need to be coherent with policies in related sectors such as the water sector and concerning agricultural practices. Synergies between policy instruments in different sectors should be sought even though they can be difficult to achieve since water related policies are implemented by different agencies and ministries that all have their own specific area of responsibility (e.g. environment, agriculture, health, energy, fisheries and construction). The fragmentation of water management should be addressed through improved co-ordination between relevant sectors. The Nexus report concludes that there is a need to furhter develop mechanisms for handling conflicting interests between sectors, and for weighing broader risks and benefits of proposed water-related interventions.

The complex relationship between bioenergy and water is a topic that deserves serious attention. Methods for assessment and practice need to take account of both the risks and the opportunities that exist. The nexus report lists recommendations for addressing water related aspects of bioenergy production within a wider land-water-food-energy context, a selection of them are summarized in box No.2 below.

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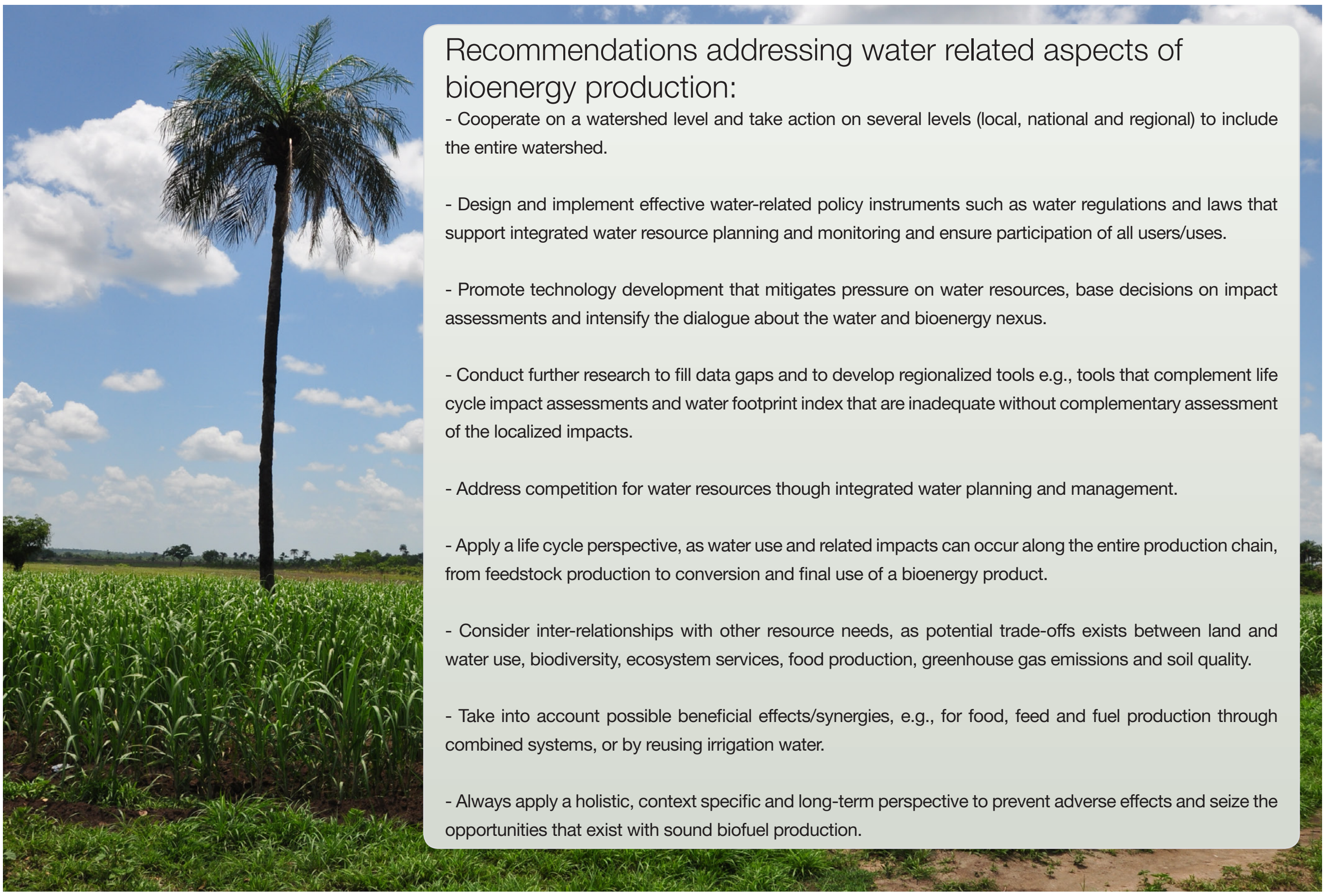

Recommendations addressing water related aspects of bioenergy production:

- Cooperate on a watershed level and take action on several levels (local, national and regional) to include the entire watershed.

- Design and implement effective water-related policy instruments such as water regulations and laws that support integrated water resource planning and monitoring and ensure participation of all users/uses.

- Promote technology development that mitigates pressure on water resources, base decisions on impact assessments and intensify the dialogue about the water and bioenergy nexus.

- Conduct further research to fill data gaps and to develop regionalized tools e.g., tools that complement life cycle impact assessments and water footprint index that are inadequate without complementary assessment of the localized impacts.

- Address competition for water resources though integrated water planning and management.

- Apply a life cycle perspective, as water use and related impacts can occur along the entire production chain, from feedstock production to conversion and final use of a bioenergy product.

- Consider inter-relationships with other resource needs, as potential trade-offs exists between land and water use, biodiversity, ecosystem services, food production, greenhouse gas emissions and soil quality.

- Take into account possible beneficial effects/synergies, e.g., for food, feed and fuel production through combined systems, or by reusing irrigation water.

- Always apply a holistic, context specific and long-term perspective to prevent adverse effects and seize the opportunities that exist with sound biofuel production.

Box No.2. Photo: Jesper Karlsson

A channel at the Tendaho Dam and Irrigation project situated in the lower Awash river valley in the Afar regional state in Ethiopia. The aim of the project is to develop 60 000 hectares of irrigated sugar cane plantation, for sugar and ethanol production. The Awash river is the main permanent river in this semi-arid and drought prone region and hence vital for the local population's livelihoods e.g. irrigated farms, riverine forests and dry-season grazing areas. Minimizing negative impacts e.g. for downstream water users and ecosystems is therefore important. This illustrates the necessity of conducting context specific socio-ecological analysis to address potential competing interests over water resources and to promote water sound bioenergy production (Ölund, 2011; Ölund, 2012). Photo: Maria Ölund

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