WATER POLICY BRIEF

Issue 30

Putting Research Knowledge into Action

Water implications of biofuel crops:

understanding tradeoffs and identifying options

Biofuels are being touted as a solution to rising fuel prices, growing energy demands, and the need to curb emissions of greenhouse gases. Governments have good reasons for promoting biofuels. Yet, a headlong rush into growing biofuel crops will bring its own problems. Unless planned properly, biofuel crops are likely to escalate competition for water, especially in areas where it is already scarce.

New research shows what options policymakers have for making tradeoffs between biofuels and other uses of water. And, biofuel crops that give 'more crop per drop' lessen the negative impacts and boost the positive impacts.

Key findings

- The development of biofuels will have an impact on water, food, energy and the environment. How biofuels will affect these must be considered *before* going ahead.
- Globally, there is enough water to produce both food and biofuel. But, in countries where water is already scarce, like India and China, growing biofuel crops will aggravate existing problems.
- Producing one liter of ethanol from sugarcane takes nearly 3,500 liters of precious irrigation water in India, but just 90 liters of irrigation water in Brazil. In China, it takes 2,400 liters of irrigation for maize to yield a liter of ethanol.
- Certain biofuel crops, such as jatropha trees and sweet sorghum, are less likely to compete with food crops, use much less water, and have much less impact on food production and the environment than others.

IWMI
International
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Water, food, energy, environment and rural livelihoods—are all linked

Biofuels are attracting a lot of interest. But, policymakers need to understand that growing crops as raw materials for biofuel will have a major impact on water resources, on agricultural production and food prices, on jobs and incomes in rural areas, and on the environment (Box 1). How biofuels will affect these must be considered *before* going ahead (Box 2). Are the tradeoffs worth making? Researchers have come up with a range of options to help policymakers strike the right balance.

Box 1. Why the interest in biofuels?

- **Rising oil prices**
- **Energy security concerns**
- **Boosting jobs and incomes in rural areas**
- **Lowering greenhouse gas emissions**

But

- **Water is essential to grow biofuel crops. Most biofuel crops are thirsty and compete for already scarce water.**
- **Clearing land and forests for biofuel crops releases carbon and reduces biodiversity.**
- **Crops such as maize and wheat used as raw materials for biofuel rather than for food mean less food and higher prices.**
- **Energy from biofuel isn't cheap. Biofuel production is still mostly subsidized.**

Many studies have been done to help policymakers develop policies for water, land, agriculture and the environment. But these studies have not taken into account what kinds of impact growing crops for biofuel might have.

The Comprehensive Assessment of Water Management in Agriculture concluded that the world's water resources are enough—with the right policies and better water management—to feed the world, cut poverty and look after the environment. Now, new research highlights some of the problems of growing biofuel crops in areas where water is already scarce.

Biofuel crops compete for water

Maize and sugarcane, grown to produce biofuel crops, need a lot of water. This will add to already fierce competition for water from domestic users, industry, agriculture and the environment. It's already difficult to meet existing water demand in parts of Asia where water resources are overstretched and in sub-Saharan Africa where populations are growing. Allotting a share of water to biofuel crops in such cases could cause even more friction.

If countries go ahead with their policies and plan to produce biofuels, 180 cubic kilometers of additional irrigation water will be needed. In some areas this won't put too much stress on water supplies. Biofuel crops in rainfed regions have little direct effect on existing water allocations. But, ambitious plans in China and India to boost domestic production of biofuels raise serious concerns for future water supplies if traditional food crops—maize in China and sugarcane in India—are used (Table 1). Because of this, both countries are already looking at biofuel crops that use less water and do not compete directly with food crops.

In rainfed areas, biofuel crops use 'green water' (water stored in the soil). But, if they use this green water more intensively than traditional land uses, biofuel crops may reduce the amount of water that ends up as 'blue water' in groundwater aquifers and rivers in the long run. River and groundwater systems would therefore be affected, although there is still a lot of uncertainty as to just how the production of energy crops might affect river flows downstream.

Table 1. A fourfold increase in biofuel crops between 2005 and 2030 raises serious concerns for water supplies. Although the additional irrigation water needed to grow biofuel crops is just a few percent of the global total, the impacts in some countries could be highly significant, with serious implications for water resources. Rapidly growing economies such as China and India are unlikely to be able to meet future biofuel and food demands without greatly aggravating water scarcity, unless alternative feedstocks are used.

Country	*Main biofuel crop*	*% of total crop water used for biofuel*		*% of irrigation water used for biofuel*	
		2005	2030	2005	*2030*
Brazil	Sugarcane	10.7	14	3.5	8
USA	Maize	4	**11	2.7	**20
China	Maize	1.5	4	2.2	7
India	Sugarcane	0.5	3	1.2	5
EU	Rapeseed		17		1
World		1.4	3	1.1	4

*** includes Canada* *Source: de Fraiture et al. 2008*

Biofuel crops, food crops and livelihoods

Biofuels are mainly produced from food crops such as wheat, maize, sugarcane, sugar beet and oil seeds. If, instead of being grown for food these crops are grown to supply raw material for biofuel, this may mean less food is produced and food prices rise. And a switch from an industrial crop, such as cotton, to a biofuel crop can have a large impact on livelihoods (Box 2).

Box 2. Tradeoffs in biofuel crops, water, food prices and rural livelihoods in Ethiopia

In Ethiopia, the spread of sugarcane as a biofuel crop in irrigated regions, and other biofuel crops in rainfed areas, could boost energy production and farmers' incomes. But there would be serious consequences for water use, food prices and rural livelihoods. Many sugarcane estates in the Blue Nile region already generate their own electricity using bagasse. In some cases, ethanol is produced and blended with kerosene to make K-50, a fuel used in factories and homes. But, increasing the area of sugarcane as a biofuel crop would oust cotton. Not only would this mean less water for other food crops and thus higher food prices, but many jobs, both farm and non-farm, and Ethiopia's nascent textile industry, would disappear. Plus, pastoralists would no longer be able to graze their animals on cotton stubble.

Source: McCornick et al. 2008

While biofuels can provide jobs and new sources of income for the rural poor, particularly smallholders, poor urban consumers could suffer higher food prices. And, even though 70% of the poor live in rural areas, the overall negative impact of higher food prices may outweigh the positive impacts of higher returns for their food and biofuel crops.

But the change from growing food crops to growing crops for biofuel is only one factor in pushing up food prices. Rising energy prices push up the costs of food production. Trade barriers, subsidies, policies and marketing infrastructure are other factors affecting food prices.

Biofuels, water and the environment

The water sector already faces conflicts between environmental goals on the one hand and food and livelihood goals on the other. Biofuel crops are likely to add to these. The issue of how to resolve these conflicts with acceptable tradeoffs is going to be a major concern for policymakers in developing regions, particularly in Asia and Africa (Box 3).

Box 3. Water for biofuel crops will endanger environmental flows in the Krishna Basin

In the Krishna Basin in India, irrigated sugarcane could help to meet the growing demand for fuel through ethanol production. But major conflicts are already emerging between water for irrigation and environmental needs. For instance, the environmental flow requirements of the Krishna Basin are rarely met, especially during droughts, because more and more water is being withdrawn. At the moment, most sugarcane is irrigated by water pumped from underground. If sugarcane for biofuel expands and more water is drawn from rivers, this will have serious implications for the environment.

Source: McCornick et al. 2008

Policymakers need to encourage farmers to grow biofuel crops under rainfed rather than irrigated conditions.

Biofuels and climate change

Policymakers concerned about climate change are looking to biofuels as a key means of cutting greenhouse gas emissions. But, producing biofuels won't help countries reduce their greenhouse gas emissions if they clear their forests to make room for energy crops, or disturb or burn peaty soils in the process—this will lead to an increase in carbon emissions—not a decrease.

Options to reduce the impact of biofuel production on other uses of water

The debate on biofuels must take into account the tradeoffs between using water to produce raw materials for biofuel, and using water for other purposes. Tradeoffs will need to minimize the negative impacts while enhancing the positive.

Grow less thirsty biofuel crops—carefully

Biofuel crops such as jatropha trees (used for biodiesel) and sweet sorghum (Box 4) can be grown in rainfed areas and, as well as needing much less water than conventional biofuel, can open up opportunities for small farmers and those on marginal land. But, policymakers will need to make sure that entrepreneurs wanting to get into biofuel crops don't push small farmers off their land and, if common land is taken over, that the people who use it don't lose out. Another factor to take into account is that these new biofuel crops may be risky. Not much is known yet about how jatropha, for example, will cope with drought or pests. Plus, small farmers going into biofuel crops will be vulnerable to volatile fuel prices in world markets.

Box 4. Sweet sorghum: a biofuel crop that doesn't need much water

Sorghum is already widely grown in dryland areas—11.7 million hectares in Asia and 23.4 million hectares in Africa. New varieties of sweet sorghum have multiple uses: the grain can be used for food, the leaves to feed animals, and the stalks to make ethanol.

Scientists working in India at ICRISAT have bred sorghum varieties that have lots of sugar-rich juice. These types of sweet sorghum need only one-seventh as much water as sugarcane. So, sweet sorghum has advantages over other biofuel crops because it is not so thirsty and doesn't replace food crops.

Source: ICRISAT pro-poor biofuel initiative
http://www.icrisat.org/Media/2007/media5.htm

Grow energy crops under rainfed conditions

In terms of water, it makes a difference where biofuel crops are grown. For example, a liter of ethanol made from irrigated sugarcane in India needs more than 25 times as much irrigation water as a liter of ethanol made from mostly rainfed sugarcane in Brazil (Table 3). Policymakers need to encourage farmers to grow biofuel crops under rainfed rather than irrigated conditions. Not only could such a policy boost agricultural returns in rainfed areas but, provided food crops aren't displaced, the impact on food production would be minimal. More effective water policies and more efficient water institutions will be needed to put policies for better water use in place.

Table 2. How much water does it take to produce a liter of ethanol from crops such as maize or sugarcane? In tropical Brazil, where sugarcane is grown for biofuel, under rainfed conditions with limited irrigation, it takes only 90 liters of irrigation water to produce a liter of ethanol. But, in India, where sugarcane depends heavily on irrigation, it takes 3,500 liters of irrigation water.

Country	*Biofuel crop*	*Liters of irrigation water per liter of ethanol*
Brazil	Sugarcane – mostly rainfed	90
USA	Maize – mostly rainfed	400
Northern China	Maize – partly irrigated	2,400
India	Sugarcane – irrigated	3,500

Source: de Fraiture et al. 2008

Squeeze out more crop per drop

One of the most effective ways to deal with an increase in demand for water is to improve water productivity—to get 'more crop per drop'. The Comprehensive Assessment of Water Management in Agriculture found that there is still plenty of scope to reduce water use by increasing productivity, particularly where crop yields are low. More effective water policies and more efficient water institutions will be needed to put policies in place for more efficient water use. Less is known about water use efficiency of biofuel crops like jatropha, sweet sorghum and other non-food biofuel crops.

Look for synergies and adding value

Policymakers should look for opportunities for synergies between biofuel crops and other goals. One good example is a scheme for growing biofuel crops and, at the same time, protecting watersheds (Box 5).

Encourage new technologies

In 10 to 20 years, new ways of making ethanol, for example, from waste straw and wood chippings using enzymes, may become cost-effective. These will typically take less water than those using traditional energy crops. Policymakers' support for speeding up the development of new and more efficient technologies is going to be important.

Make sure biofuels really do reduce emissions

One of the reasons for turning to biofuels is to reduce emissions. But emissions will increase, not decrease, if forests are cleared to make room for biofuel crops and peaty soils are burned or disturbed. Policymakers should ensure that biofuel crops are only grown where this will not happen. They also need to consider how much it costs to produce and transport biofuels. Will it be cost-effective?

Box 5. Smallholder schemes protect watersheds and produce biodiesel

Production of biofuels and watershed protection can go hand in hand. In Andhra Pradesh, India, a watershed development project is helping poor villagers grow pongamia and jatropha, both raw materials for biodiesel, on 'wastelands'.
The scheme gives landless villagers rights to use and profit from biodiesel tree crops planted to rehabilitate 300 hectares of degraded common land in Velchal and Kothlapur, Ranga Reddy district.

Source: Pro-Poor Biofuels Outlook for Asia and Africa: ICRISAT's Perspective.

This Water Policy Brief is based on research presented in Biofuels and Implications for Agricultural Water Use: Blue Impacts of Green Energy, by Charlotte de Fraiture, Mark Giordano and Yongsong Liao, Water Policy Volume 10 Supplement I (2008), pp. 67-81. (http://www.iwmi.cgiar.org/EWMA/files/papers/Biofuels-Charlotte.pdf) and Other papers in that journal issue: Interactions between Water, Energy, Food and Environment: Evolving Perspectives and Policy Issues, by Petra Hellegers, David Zilberman, Pasquale Steduto and Peter McCornick; Rising Energy Prices and the Economics of Water in Agriculture, by David Zilberman, Thomas Sproul, Deepak Rajagopal, Steven Sexton and Petra Hellegers; Water–food–energy–environment Synergies and Tradeoffs: Major Issues and Case Studies, by Peter G. McCornick, Seleshi B. Awulachew and Michael Abebe; and Implications of India's Biofuel Policies for Food, Water and the Poor, by Deepak Rajagopal.

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Design and Layout: Manoj Jayasuriya

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