IAASTD
International Assessment of Agricultural Knowledge, Science and Technology for Development

Issues in Brief

Bioenergy and Biofuels: Opportunities and Constraints

The Earth is warming due to the accumulation of greenhouse gases (GHGs) from the intensive use of fossil fuels and other natural resources. GHGs include carbon dioxide (CO_2), methane, nitrogen oxides, water vapor, ozone and others, but CO_2 is responsible for more than half of the anthropogenic greenhouse effects. These GHGs are trapping heat over the Earth's surface, resulting in changes in temperature and other climatic processes.

The Intergovernmental Panel on Climate Change (IPCC) has concluded that "warming of the climate system is now unequivocal" and that "most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." Observed impacts include increasing frequency and intensity of extreme climatic events, such as more destructive floods, serious and sustained droughts and melting glaciers. These impacts may result in harmful effects on important livelihood sectors such as agriculture, as well as adverse effects on human health and ecosystems—effects that seriously diminish food security and hinder poverty alleviation. In fact, climate change, combined with other socioeconomic stresses, could alter the regional distribution of hunger and malnutrition, with large negative effects, especially in sub-Saharan Africa.

The Bioenergy Option

Given how crucial small-scale farmers are to efforts to decrease hunger and poverty and improve health and nutrition, it is important to identify options that promote sustainable livelihoods for small-scale producers and contribute to environmental sustainability. Increasing energy efficiency, reversing deforestation, and developing and using cleaner, sustainable energy sources are key approaches to addressing climate change. Bioenergy has emerged as an alternative to fossil fuels and is being promoted as a cleaner source of energy.

Photo: ©FAO/Giuseppe Bizzarri

The growth in bioenergy production has been stimulated mostly by biofuel subsidies, fuel blending mandates, national interest in energy security, climate change mitigation and rural development programs. However, bioenergy has also triggered controversy. This attention is related to the soaring prices for grains, which have resulted, in part, from the expansion in global biofuels at the expense of food production. The underlying causes of the most recent increases in food prices are complex and include factors such as increased demand from rapidly growing economies (especially China); poor harvests due to an increasingly variable climate (e.g., the Australian drought); the use of food crops for bio-

fuels (e.g., maize for bioethanol); higher energy and fertilizer prices; low food stocks; speculation on the commodity futures market; and, in response to the high food prices, restrictions imposed on agricultural commodity exports by a number of significant exporters (e.g., Argentina, India and Ukraine) to protect their domestic consumers.

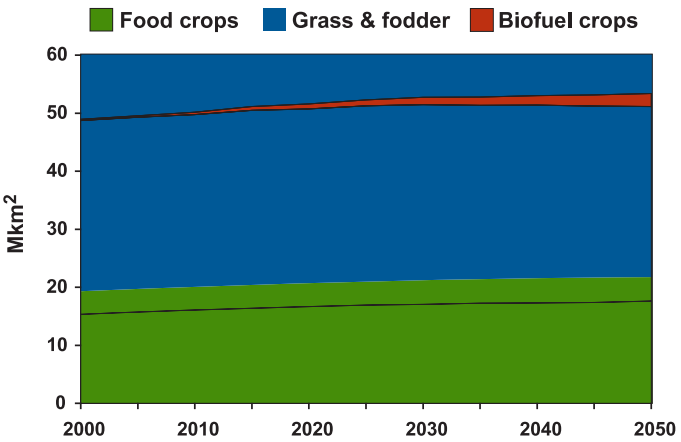
What is bioenergy?

Bioenergy refers to products of biomass that have been converted into liquid, solid or gas form, depending on the raw material base and the technology employed, for energy generation. Biomass encompasses a wide spectrum of plant materials ranging from agricultural, forestry and municipal wastes to crops grown specifically to make biofuels, such as bioethanol and biodiesel.

- Solid biofuels are plant matter such as wood chips, and other solid or woody biomass, that can be directly used as fuel, mainly in traditional cook stoves. Two of the most widely used forms are wood chips and bagasse. Bagasse has been used for decades for electricity generation at sugar mills. Millions of people in developing countries depend on traditional biofuels for their most basic cooking and heating needs; this dependence is most prevalent in sub-Saharan Africa and South Asia. In some countries, the share of biomass in energy use reaches 90%.
- Liquid biofuels are used for heating, cooking, lighting, transport and power generation. Bioethanol, biodiesel and pure plant oils are the most common forms of liquid biofuels.
- Gaseous biofuels include biogas, which is produced by digesting organic waste and is generally used for cooking, lighting and power generation at the village level.

2nd Generation Biofuels

These biofuels are cellulosic ethanol, waste based on a complex carbohydrate material, derived from non-grain parts of plants including switch grass, prairie grasses, trees and forestry. Biofuels are produced through hydrolysis/fermentation, gasification or pyrolysis technologies. Future R&D needs to focus more on making second generation sources economically viable.

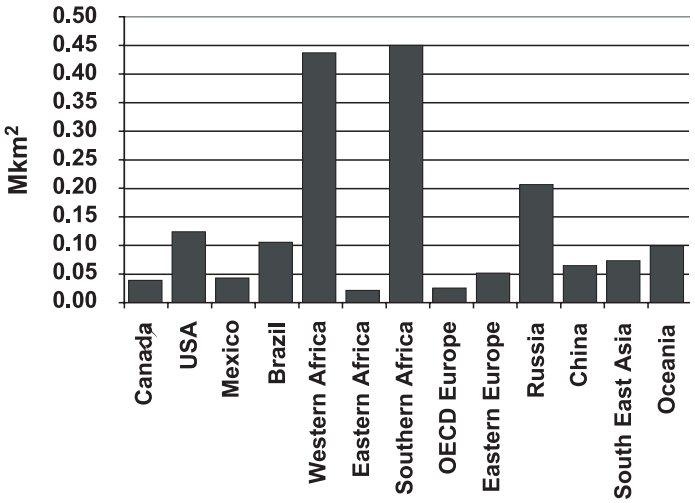


Land use change (food crops, pastureland and biofuel crops) globally, 2000 and 2005, reference run, Image model

What are the feedstocks for biofuel?

Bioethanol: Sugarcane is considered the most efficient plant species in terms of biomass and amounts of sugars and fiber produced. Switch grass (*Panicum virgatum*), beets, wheat, sorghum, maize, biomass waste and residues, and municipal solid waste can all serve as feedstock for the production of bioethanol. Enzymatic treatments and new strains of yeast are being developed at a rapid pace for producing ethanolfrom cellulose, but are not yet commercially viable.

Biodiesel: Biodiesel is made from, among other things, animal fats, rapeseed, sunflower, soybean, palm oil, coconut or Jatropha. New biodiesel technologies synthesize diesel fuels from wood and straw. The vegetable oils obtained from oil palm (*Elaeis* sp), coconut (*Cocos nucifera*) and *Jatropha curcas* can be used directly as pure oils or converted into biodiesel. By-products from livestock and fisheries industries also provide raw material for biodiesel. For many



Bioenergy area in 2050 for different regions; reference run, Image model

reasons, e.g., inefficient technologies and insufficient supplies, these feedstocks need further study. Europe imports large quantities of palm oil from Southeast Asia and is the world's leading producer of biodiesel.

Energy security

In addition to climate change as a driver, increasing concerns about energy security and the rising cost of fossil fuels are causing many countries to view biofuels as an important element of their national energy strategy. It is widely assumed that by reducing demand for petroleum, energy supplies would be more secure and expanding markets for biofuels would help boost crop prices, which could benefit farmers, but increase the number of hungry people. However, these assumptions are debatable and more studies are required to assess the potential contribution of biofuel to energy security.

Environmental concerns

A considerable debate exists over the magnitude of direct and indirect GHG emissions from biofuels; however, the intensive cultivation of energy crops is expected to produce adverse environmental impacts on soil and groundwater, and to result in deforestation and loss of biodiversity. Local, national and regional agricultural regulatory frameworks will have to take into account tradeoffs between the need for promoting higher yields and the need for environmental and biodiversity conservation.

Some practices with known negative effects include:

- Removal of crop residues, such as leaves and stalks for use in co-generation, can negatively affect soil structure, promote erosion and reduce ecosystem sustainability.
- Heavy extraction of water for the irrigation of feedstock crops could affect water availability, particularly in water stressed regions.
- In Southeast Asia, oil palm plantations for biodiesel production have caused deforestation and biodiversity losses.

Trade-related concerns

As first generation biofuels are rarely economically competitive with petroleum fuels, their production is promoted through a complex set of subsidies, regulations, trade restrictions and tariffs that create added cost. Liberalizing biofuel trade through the reduction of trade restrictions and changes in the trade classification of ethanol and biodiesel would promote more efficient allocation of production for the benefit of consumers in some countries.

International trade in biofuels and biofuel feedstocks has increased rapidly and is expected to increase further in the coming decade. Rising demand for vegetable oil, under pressure from the EU biofuel mandate, has resulted in a rapid increase in vegetable oil prices with negative impacts on biofuel costs and food prices.

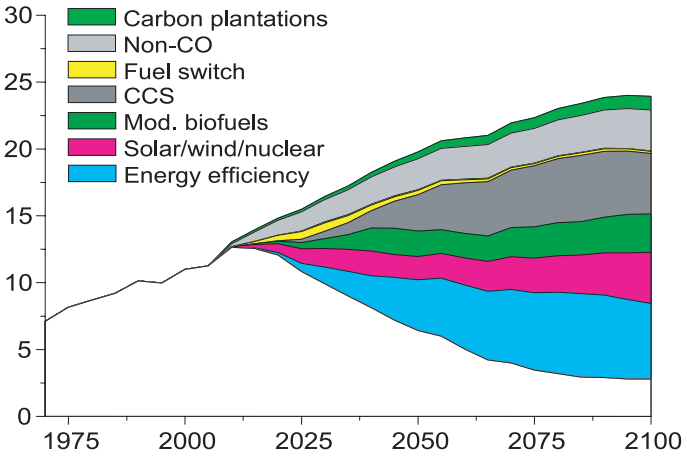
Social concerns

The traditional use of solid biofuel for cooking is time consuming; causes unsustainable logging; and increases exposure to hazardous indoor air pollution. Solid biofuels are energy inefficient. The contamination of air by smoke from incomplete biomass combustion leads to asthma and other respiratory problems, causing up to 1.5 million premature deaths per year. There are potential benefits of modern biofuels for rural communities, including improved environment and health, new jobs and income generation.

The move to biofuels is expected to create new industries and bring increased economic activity and higher incomes for those engaged in feedstock production and manufacturing, hence the move has the potential to reduce poverty for some. However, an expansion in production of first generation biofuels predominantly from agricultural crops will raise prices of agricultural produce, which can result in increased hunger and poverty. Negative effects, such as the marginalization of small-scale farmers, are likely.

Mitigation of GHGs

The viability of biofuels for climate change mitigation depends on reductions in GHG emissions as well as their relative costs compared to other mitigation alternatives. Sugarcane-based ethanol and second generation biofuels may achieve reductions in greenhouse gas emissions relative to oil, but some agricultural crops, such as maize, do not give the same result due to the fossil fuel-based inputs involved. For example, agrochemicals require fossil fuel energy for their production and transportation. Agricultural knowledge, science and technology (AKST) can play a role in reducing some of the imbalances, for example, through increasing biofuel yields per unit of land; reducing agricultural input requirements; optimizing cropping methods; and breeding higher yielding crops. Nonetheless, emissions associated with land use change and deforestation could still negatively affect the gross contribution of biofuels to reducing atmospheric carbon dioxide.



Contribution of various options in reducing greenhouse gas emissions from baseline to the 450 ppm CO_2-eq variant. Source: Image model; Van Vuuren et al., 2007

Food security concerns

With every one percent increase in the cost of food today, 16 million people are made food insecure.

Food insecurity arises when people do not have physical and economic access to sufficient safe, nutritious, and culturally acceptable food to meet their dietary needs. Food security is one of the major concerns surrounding the use of biofuels. Biofuel feedstock production competes with food, fiber and timber for land, water and fertilizers.

There are concerns that this competition could affect food security, as food crops may be used as fuel and agricultural land may be used for feedstock production. At risk are the approxi-

mately 70% of the world's poor people that live in rural areas, many of whom depend on agriculture for their livelihoods. Over 2.1 billion people live on less than US$2 per day and increasing food prices will in all likelihood increase their food insecurity.

The increasing demand for biofuels is likely to increase the cost of land, labor, and agricultural inputs. For example, demand for feedstock crops such as maize and sugarcane has contributed significantly to global food price volatility, especially in grain markets.

Other factors contributing to a growing demand for grains are increasing incomes in some developing countries, which are shifting preferences from staple crops to meat and dairy; climate change and its impact on crop productivity; a weak dollar and speculation. These changes have led to pressures on global agricultural markets and food costs. AKST could play a critical role in improving the benefits of bioenergy and reducing potential risks and costs.

Recent trends suggest that food and energy markets are likely to be more strongly linked in the future, such that fluctuations in the prices of energy would lead to corresponding changes in food prices.

Policy Considerations

It is still controversial whether biofuels, particularly first generation biofuels, deliver net GHG benefits. Policies concerning biofuel production will need to require that feedstock production practices do not create net additional emissions of GHGs directly, or indirectly through land use change, i.e., that they do not displace arable land into natural ecosystems. Additional research on the lifecycle of greenhouse gas emissions of different biofuel feed stocks and technologies is required.

Photo: ©FAO/Giulio Napolitano

It is important that national bioenergy strategies focus not only on energy opportunities, but are based on a comprehensive assessment of the effects on food security and the social and environmental benefits of bioenergy and its costs, such as increasing food prices, deforestation and competition for land and water.

A long history of policy failures and locally produced equipment that does not always perform optimally, have led to considerable skepticism about bioenergy in many countries. The development of product standards, as well as demonstration projects and better knowledge dissemination, can increase market transparency and improve consumer confidence.

Institutional arrangements and power relationships strongly affect the ability of different stakeholders to participate in bioenergy production and consumption, as well as the distribution of the costs and benefits of these technologies. The poor are expected to experience significant disadvantages from current trends in biofuel policies. The weaknesses in institutional links between the various sectors involved in food and energy production will have to be overcome through regulatory frameworks with effective multistakeholder participation in decision-making and environmental and social monitoring and evaluation. An integrated approach

is important to ensure rational policies addressing alternative renewable energy, energy efficiency, agriculture, rural development, sustainable water and land use and management.

IAASTD Intergovernmental Plenary in Johannesburg, April 2008. Source: Benedikt Haerlin.

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) provides information on how agricultural knowledge, science and technology can be used to reduce hunger and poverty, improve rural livelihoods and human health, and facilitate equitable environmentally, socially and economically sustainable development. The full set of IAASTD reports includes a Global and five sub-Global reports and their respective summaries for Decision Makers as well as a Synthesis Report, including an Executive Summary. The reports were accepted at an Intergovernmental Plenary in Johannesburg in April 2008.

The assessment was sponsored by the United Nations, the World Bank and the Global Environment Facility (GEF). Five UN agencies were involved: the Food and Agriculture Organization (FAO), the UN Development Program (UNDP), the UN Environment Programme (UNEP), the UN Educational, Scientific and Cultural Organization (UNESCO) and the World Health Organization (WHO).

IAASTD Issues in Brief are taken directly from the IAASTD Reports published in 2008 by Island Press.

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