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ZEF Policy Brief No. 27

Biofuels and Sustainable Development

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Bioenergy remains the biggest primary energy source in low-income developing countries. Its modernization for environmental sustainability and enhanced access to clean energy by the poor is an opportunity for development policy. At the same time, the increased biofuels production in industrial countries has potential impacts on food prices and indirect land use that can adversely impact food security. These opportunities and potentially conflicting strategies need policy attention. Innovations in the energy and food economies of developing countries must address these tradeoffs. This policy brief outlines the state of knowledge and a set of related guidelines for development policy with an emphasis on sustainability and pro-poor energy development.

Key terms and definitions

Bioenergy is energy derived from the conversion of biomass where biomass may be used directly as fuel, or processed into liquids and gases.

Biofuels are liquid and gaseous fuels produced from biomass.

Biomass is any organic, i.e. decomposable, matter derived from plants or animals available on a renewable basis. Biomass includes wood and agricultural crops, herbaceous and woody energy crops, municipal organic wastes as well as manure.

Source: IAE

June 2017

Introduction

Bioenergy accounts for about 13% of world energy consumption. Close to 3 billion people (or 38% of the global population) depend on traditional biomass, mostly fuelwood, for cooking and heating.[1] For developing countries, this share is even higher, reaching as much as 79% in sub-Saharan Africa and 51% in Asia (excluding high-income Asian countries). The traditional biomass is low in energy efficiency, may pose health hazards due to indoor air pollution, and has a high opportunity cost of family, especially female, labor.

Around 0.7% of world energy consumption comes from arable crops, mainly in the form of biofuels which constitute around 4% of world transport fuel.[2] Biodiesel and bioethanol remain the dominant types of biofuels, but the share of other biofuels, such as synthetic biomass-to-liquid fuels, cellulose-ethanol and bio-kerosene, is expected to grow. The world's total biofuel production experienced a sharp increase between 2000 and 2010 (see Figure 1). Global bioethanol production is dominated by the US (mainly from maize) and Brazil (mainly from sugarcane) while the production of biodiesel is less concentrated, with USA, Germany, Argentina and Brazil as leading producers.

Likewise, there has been an exponential growth in the biofuels trade between 2000 and 2009, with traded biodiesel increasing 20-fold, and bioethanol trade increasing by three-and-a-half times. In 2010, 110 billion liters of biodiesel and bioethanol were traded in the global energy markets. The major biofuel producing countries also account for the largest share in the biofuels trade: the USA and EU are the net importers, while Argentina and Brazil are the main exporters.

These trends may be changing, however. The OECD-FAO predicts that the demand for agricultural commodities for biofuel production will stagnate over the next decade due to lower energy prices and more conservative biofuel policies in several countries.[3] Nevertheless, as will be elaborated below, the use of agricultural land and crops for biofuel production can have significant implications for food security, the environment and rural development even at current scales.

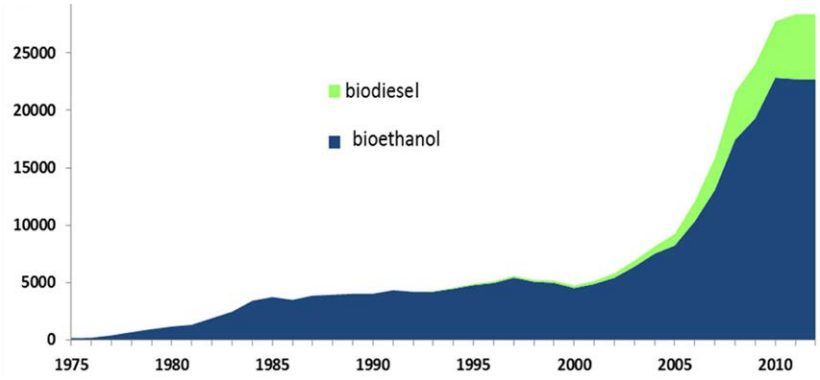

FIGURE 1:
Trend in world bioethanol and biodiesel production (in mln gallons per year)
Source: Compiled from EPI (2013)

Drivers for biofuel development

Several countries, both industrialized and developing, have adopted ambitious biofuel expansion plans, motivated by various environmental, economic, political, social, institutional and technical factors:

Fuel substitution. A major driver of modern biofuel development is its attractiveness to substitute, at least

to some extent, the fossil fuels even if full substitution seems currently unfeasible.

Job creation. Biofuel development is also expected to generate new jobs and contribute to rural development, especially in lower income countries.

Growing energy demand. Increasing demands for energy are other drivers of biofuel expansion. Expected returns from biofuel may serve as a motivation for the private sector investments, especially in more mature markets. In many cases, such private initiatives are triggered by government subsidies, tax credits and regulatory mandates.

Environmental protection. Social preferences for environmentally friendly and sustainable energy sources in the developed countries have also stimulated biofuel development. These drivers also interact closely with another set of institutional drivers, including green social mobilization, global coalitions of civil society networks, dissemination by development projects and extension services, as well as organizational innovations in the biofuel value webs.

Innovations. Bioscience and technological innovations also advance the development of the biofuel sector in numerous ways. Firstly, higher yields and stress-tolerant crop varieties increase land and water use efficiencies and improve food availability. Secondly, technologies for conversion of biomass waste and residue to energy increase use efficiency and productivity, and reduce pollution that arises, for instance, from open dumping of municipal waste. Moreover, innovations create economic opportunities for the enhanced use of byproducts, residues and wastes as feedstock, reducing pressure on food security.

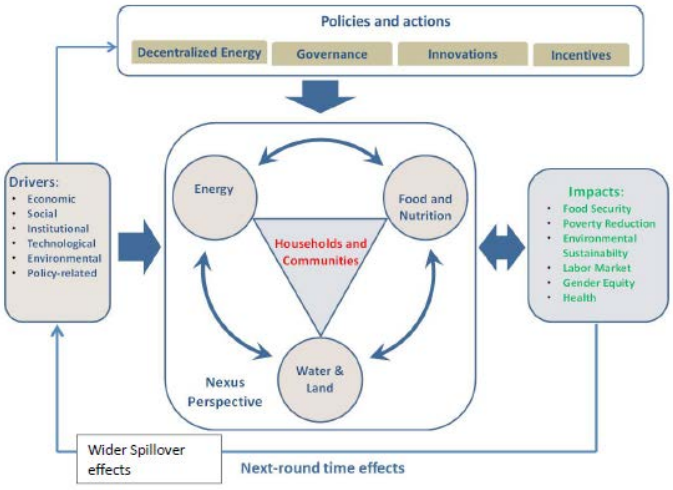

FIGURE 2: Conceptual framework of energy in a nexus concept.

Prospects for biofuel development in Africa

Despite its substantial untapped renewable energy potential, Africa is lagging behind in modern energy production, utilization and trade. As in many other developing countries, the development of modern biofuels is often constrained by numerous factors such as technical and market barriers, shortage of skilled labor, lack of transportation and infrastructural facilities, high costs of biofuels, prevalence of non-cash economy in rural areas, inadequate legal frameworks or political instabilities. Moreover, uncertain returns from cultivating energy crops in many developing countries may discourage farmers from investing into biofuel development.

The biofuel industry of sub-Saharan Africa contributes just 1% to the global market.3 Malawi and Swaziland are the

largest bioethanol producers. Bioethanol is mainly derived from sugarcane and to a lesser extent sorghum while the use of maize is limited and in some countries even prohibited. The production of biodiesel in Africa is negligible. Jatropha has been promoted as a feedstock for biodiesel, but has not lived up to expectations. An increase in the global demand for biofuels may help develop Africa's potential in biofuel production. Estimates on the potential of energy production from biomass in Africa range from 134 EJ to 317 EJ today and up to 410 EJ by 2050.[4] To promote biofuels, African countries can capitalize on their resource advantage, specifically land, which has already started attracting investments for biofuel production in several African countries. However, there are growing debates on the issue of the so-called "unproductive" land availability on the continent and the impact of biofuel production on local resources such as water availability, soil quality, the environment and biodiversity, with many environmental externalities under scrutiny. Ethiopia can serve as a vivid example of the challenges and opportunities faced by African countries in biofuel development. The government of Ethiopia has allocated about 23 million hectares of suitable land to biofuel development, typically jatropha, palm oil and castor bean. Though the government has targeted large-scale jatropha plantations on marginal lands, the water scarcity remains a key constraint and drought stress has been a key reason for the failure of many large-scale jatropha cultivation projects in Ethiopia.[5]

The development of modern biofuels requires substantial investments, but most African countries have not yet established policies to provide the necessary guidance. Moreover, the foreign and domestic investments into biofuel development in Africa have lately been constrained due to lower oil prices, major advancements in hydraulic fracturing in shale gas mining making biofuel production less attractive, as well as unrealized expectations from jatropha production.

Impacts of Biofuels on Sustainable Development

Biofuels and Food Security

Biofuel development can have complex interactions and impacts on food security. The differences in economic efficiency of resource uses in biofuel and food production mean that resources will be allocated to the activity with a higher return. Research has shown that about 25%-50% of wheat and maize used for biofuel production is not replaced by higher overall production of these crops, but come at the expense of their consumption as food and animal feedstuff.[6] This can lead to higher food and natural resource prices, such as land and water. The poor who spend a larger share of their income on food, are worst affected. Limiting the cultivation of energy crops to marginal lands could mitigate the food-fuel tradeoff and help to reduce deforestation. However, such limits can, at best, only partially mitigate food price increases, as there would be strong incentives to grow biofuel crops on more fertile lands, ultimately leading to accelerated deforestation. On the other hand, biofuel technologies are developing rapidly. Whereas the so-called first and second generation of biofuels were produced from food-based crops, such as

sugarcane, maize, soy, rapeseed or vegetable oil, the third and fourth generation of biofuels are expected to make use of algal biomass, artificial photosynthesis avoiding direct competition with food production. For example, cellulosic matter can substitute sugar or starch crops in second generation biofuels However, the big-scale commercial viability of these technologies still needs to be proven.

Biofuels and International Land Acquisitions

Competition for biomass between its uses for biofuel production versus food and fodder production is also impacting international investments and trade. This at least partially led to acquisitions by foreign and national investors of agricultural lands for the purpose of growing crops for biofuel production. At the same time, earlier reports of large-scale land grabs by foreign investors in many African countries were lately found to be unsubstantiated. An initial estimate of 227 million hectares under negotiation or transferred between 2001 and 2010 was later revised to around 50 million.[7] Moreover, the cultivation of energy crops is only one of many factors driving international land acquisitions.

In order to prevent potential disadvantages of land acquisitions for the local populations and their food security, it is necessary to apply the voluntary guidelines for responsible regulation of the land rights. Moreover, more attention needs to be paid to preserving local biodiversity and plant genetic richness when non-native plant species and their varieties are introduced as energy crops.

Biofuels and Poverty Reduction

Modern biofuel development has the potential to reduce poverty by creating employment opportunities which raises incomes and helps mitigate possible negative effects of biofuel development on food security. In Malawi, for example, the biofuel supply chain employs about 2% of the total workforce.[8] Studies carried out in Madagascar, Ethiopia, Tanzania and Mozambique found that poor rural communities can benefit from local small-scale biofuel development.[9] These studies, however, also indicate that policies should consider ancillary benefits, promotion of more productive feedstock and development of rural infrastructure. Out-grower schemes for smallholders to produce energy crops could be conducive for increasing their benefits.

Somewhat counterintuitively, another mechanism for poverty reduction through biofuel development could be through higher food prices which can result in increasing incomes of net food selling by agricultural households and higher land rental values. However, as also discussed above, higher food prices would be detrimental to the welfare of landless rural and urban poor, so the net effect on poverty reduction could be negative, and should be evaluated on case-by-case basis.

Biofuels and Environmental Sustainability

Modern biofuel development is often promoted for their expected environmental benefits through “decarbonizing” the energy production. Sustainability criteria require that modern biofuels are developed without diminishing the availability of natural resources or triggering adverse environmental externalities. There are two criteria in evaluating the

net impact of biofuels on the carbon balance: (i) the amount of CO2 absorbed by energy plants through photosynthesis, and (ii) CO2 emission in the entire life cycle of biofuel (production, processing and transportation of biomass feedstock, and consumption).

The life cycle assessments of biofuel production do not always point at net positive carbon balances, especially when indirect land use changes are taken into account. Biofuel production through converting rainforests, peat lands, savannahs and grasslands to energy crops in Brazil, Southeast Asia and USA was actually found to create a carbon debt by releasing from 17 to 420 times more CO2 than the reductions achieved by these biofuels.[10] Increases in ethanol production in the US were found to have the potential to divert 12.8 million hectares of cropland to maize production, in turn, triggering the extension of cultivated areas in Brazil, China, India and in the USA, which could double the greenhouse gas emissions over the next 30 years compared to without such a biofuel expansion.[11]

Such estimates need to be read with some caution since predicting actual impacts, is not straightforward since there is no commonly accepted approach to measure the direct and indirect land-use change impacts of biofuel policies because they are not always directly measurable and difficult to isolate from the myriad of other land-use change drivers. Many models are based on aggregate data and emission estimations and do not distinguish the quality of land, which gives rise to uncertainties. While some data on emissions from direct land-use change are available, the order of magnitude of emissions related to indirect land-use change is still subject to intensive research efforts.

Biofuel-driven agricultural expansion could threaten biodiversity, especially in areas with endemic species richness such as the Atlantic forest, Amazon and Cerrado biomes of Brazil and Guinean Forests of West Africa. In Southeast Asia, for instance, the expansion of oil palm has led to biodiversity loss, habitat fragmentation and pollution.[12] In some very specific cases, agricultural production patterns for biofuel crops was improving local biodiversity through agroforestry, establishment of perennial herbaceous plants and short-rotation woody crops.

On the other hand, the production of biofuels from waste biomass and from energy crops cultivated in degraded or abandoned agricultural lands may offer sustainable reductions in green house gas emissions. Depending on the agricultural technologies used, biofuel potential on agricultural land not needed for the production of food and feed could equal 215–1272 EJ per year.[13] The bulk of this potential is found in South America and the Caribbean (47–221 EJ per year) and sub-Saharan Africa (31–317 EJ per year).

Biofuels: Health, Gender and Employment

The use of solid fuels for cooking can have serious health impacts. The indoor air pollution (especially from particulate matter) that arises from incomplete combustion of biomass while cooking or heating can cause lung diseases, such as chronic obstructive lung disease, leading to 2.5 to 4 million premature deaths annually worldwide.[14] Women using biomass for cooking are 3 times more likely

to suffer from chronic bronchitis and emphysema than those who use cleaner alternatives such as electricity or gas.[15] About 40% of 1.3 million deaths among women due to chronic obstructive pulmonary diseases are related to indoor air pollution, while the share for men is only 12%.[16] Despite its significance, the impacts of indoor air pollution have been insufficiently researched.

Improved access to clean energy can have substantial health benefits, which in turn positively affect labor productivity and incomes. For example, better access to modern and cleaner bioenergy energy can facilitate boiling of water before consuming, thus, lowering the risks of waterborne diseases. Improvements in health through reduced indoor air pollution may also allow for reducing medical expenses for poor households, improve school and work attendance.

Biofuels for sustainable development: policy implications

The potential for biofuel development and its impacts need to be viewed within the broader food and agriculture system, the energy system, and the water use system. Moreover, the development of biofuels depends not only on biomass availability and technology, but also on the institutional and organizational arrangements and related actors. Hence deeper knowledge of stakeholder environment and the incentives and constraints of key stakeholders is important for accurate an understanding of biofuel development and its impacts.

Political economy plays a key role in the development of the biofuel sector. The success of biofuel policies is often linked to the political institutions promoting biofuel production. However, the political frameworks often do not provide a level playing field for renewable energy supply. There are many politically sensitive issues regarding the premise of job creation, reducing the dependence on fossil fuels, climate change mitigation, preserving the ecological integrity and concerns over large scale land acquisitions in developing countries and their impacts on local livelihoods and access to natural resources by the poor and marginalized. Global and national biofuel strategies should be guided by four objectives:

1. Modernizing the traditional bioenergy utilization (fuel wood and char coal) in developing countries,
2. Mitigating food-fuel tradeoffs through increased efficiency and productivity in both agricultural and biofuel production,
3. Integrating climate protection, environmental sustainability and biodiversity conservation,
4. Ensuring employment generation and wider involvement of women in biofuel production value chains.

A comprehensive policy framework will be critical for developing biofuel polices that contribute to achieving these objectives. Such frameworks will require a solid basis built upon the following factors:

- science and technology policies directed at increasing agricultural productivity to minimize the food-fuel trade-off,

- removing market distortions and lowering transaction costs for global trade in biofuels with sound environmental and social standards for optimizing the resource allocations for biofuel production,
- land rights and safety nets for the food-insecure poor to prevent adverse effects of biofuel expansion for them. The critical challenge for biofuel development lies in modernizing energy use and facilitating energy transitions in developing countries. Such energy transitions would also serve as an entry point for catalyzing co-benefits and synergies with other sustainable development goals.

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The research on which this policy brief is based was funded by the German Federal Ministry for Economic Cooperation and Development (BMZ).

BMZ Federal Ministry for Economic Cooperation and Development

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