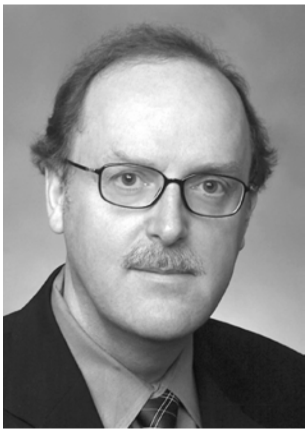

KEYNOTE ADDRESS

When Food Makes Fuel: The Promises and Challenges of Biofuels

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Introduction

World agriculture is at a turning point, with high demand due to economic growth accelerating food prices. In addition, energy and climate change are re-defining the equations of supply and demand. Biofuels have a high place on the global agenda, largely due to rising concerns about national energy security, higher energy prices, and increasing concerns about global climate change, as well as the income expectations of farmers and other investors (von Braun and Pachauri 2006). The idea of using biofuels is in itself not new, but what is new are the strides in technology development which have facilitated greater access to biofuels such as ethanol, biodiesel and biogas. These strides are far from complete and expectations are high — for example, regarding second-generation technologies where cellulose is converted into ethanol from residues such as stalks and leaves.

JOACHIM VON BRAUN, a citizen of Germany, joined the International Food Policy Research Institute (IFPRI) as its Director General in September 2002. Prior to that, he was Director of the Center for Development Research at the University of Bonn, Germany. Von Braun's association with IFPRI includes seven years as a research fellow and three years as director of the Food Consumption and Nutrition Division. He has worked in developing countries for many years and is known for his work on food security and on mitigating and preventing famines. He holds a doctoral degree and a professorial title, both in agricultural economics, from the University of Göttingen in Germany. Von Braun has published widely in his various areas of expertise, including the economics of biodiversity and biotechnology in low-income countries, and the relationship of development to governance, trade, food and agriculture, and information and communications.

The newer forms of biofuels are cleaner and more efficient than traditional forms of biofuel, and a favorable CO_2 balance could help mitigate global climate change. This has increased dependency on natural vegetation and crops grown specifically for energy. While further development and use is high on the global political agenda, it is necessary to carefully assess the consequences that this development will have on the poorest of the poor. Biofuel production may introduce new food security risks and new challenges for the poor. This will particularly be the case when natural resource constraints causes greater trade-offs between food production and biofuel production.

In this paper, discussion of the current food and energy situation as well as of the potential of countries to engage in biofuel production will be followed by a review of the opportunities and challenges associated with increased biofuel production. In the conclusion a framework will be suggested for policy and action needed to achieve win–win outcomes in terms of economic development, energy security, and food security for the poor.

The world food and energy system: forces of pressure and change

The world is not food secure. Old pressures continue, with global population expected to grow from the current 6.5 billion people to about 9 billion by mid-century before leveling off (PRB 2006), income growth of 8% in Asia and 6% in several African countries, increasing scarcity of land and water resources, and extended periods of serious under-investment in agricultural science and technology (S&T) threatening productivity growth.

Progress in reducing poverty and hunger has been limited in many developing countries in recent years. Without China, the absolute number of the hungry has increased between 1990/92 and 2002/04 from 823 to 830 million (Fig. 1). Nutrition problems related to a lack of healthy diets have remained severe. Early childhood undernutrition contributes more than 50% of the 11 million child deaths per annum (WHO 2005); while micro-nutrient deficiencies affect more than twice the numbers of calorie-hungry people (Micronutrient Initiative and UNICEF 2004).

In the light of these pressures on the world food system and the continued dependency on fossil fuels, biofuels pose both opportunities and challenges. Energy supply has grown impressively; fossil fuels supplied 80% of the world's energy in 2000 (Holdren 2007).

Bioenergy includes fuel sources that have been used for millennia, such as fuel wood, charcoal and cow dung. These sources of energy dominated energy use until 150 years ago. Also, the historical transport innovations of the Otto motor and the Diesel engine originally ran on biofuels, i.e. on ethanol and on ground nut oil. However, expanding biofuel production needs to take into account the new situation of world agriculture. The circumstances of today's crowded, food-insecure and energy-hungry world provoke contentious questions around biofuels, including:

- where are the opportunities for biofuel production and for whom?
- what are the associated risks and challenges?
- how can opportunities be tapped while addressing risks and challenges?

Biofuel expansion plans and potentials

The trends in biofuel production are startling (Fig. 2). Global ethanol fuel production, which accounts for over 90% of total biofuel production, more than doubled between 2000 and 2005. In contrast, global oil production increased by only 7% during the same period. Brazil, the pioneer in ethanol production since the mid-1970s, was surpassed in 2005 by the United States as the largest ethanol producer. Global biodiesel production, while much smaller than ethanol production, nearly quadrupled between 2000 and 2005. The European Union (EU) is the largest producer and consumer of biodiesel and continues to set very ambitious targets for itself.

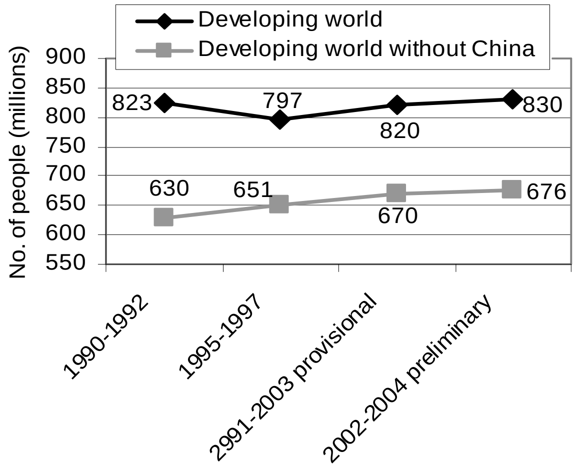

Figure 1. Number of people undernourished (FAO 2006)

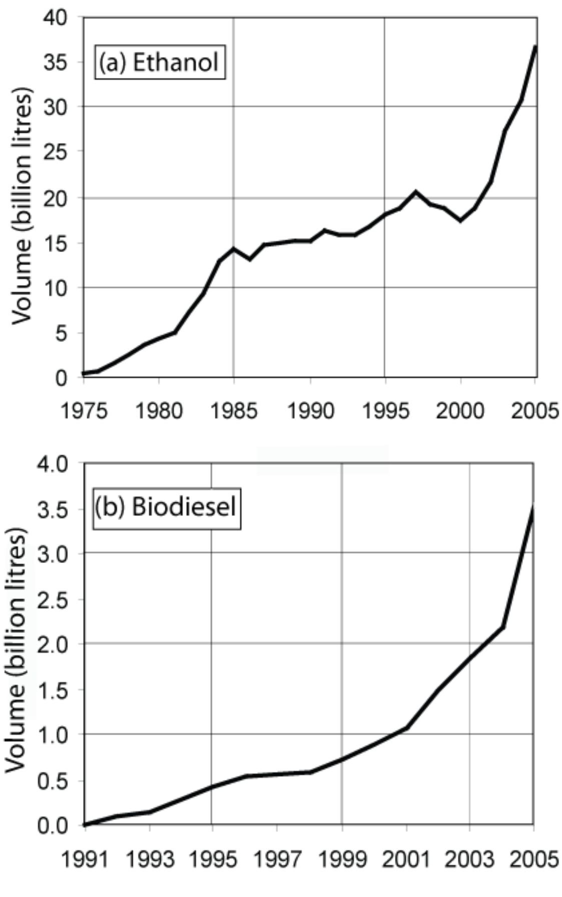

Figure 2. World ethanol and biodiesel production. Note that the scales differ by a factor of ten. (Worldwatch Institute 2006)

Plans for expanding biofuel production around the world in the coming years are enormous, both in developed and developing countries. At the same time it is fair to say that, while many of these plans have been made with very little analytical basis, they now have become policy.

A study by the International Energy Agency (IEA) assessed the impact on cropland if the United States and EU expand biofuel production according to current plans (IEA 2004). The results show that up to 43% of cropland would be needed for biofuel production. A blending target of 15% of transport fuel by biofuels (a goal that is aimed for in a number of countries) would mean that for instance in Japan, 300% of the country's actual crop land be needed and therefore Japan can increase its biofuel usage only if it imports biofuels or biomass.

Just looking at land requirements, however, is not sufficient because this would ignore the fact that crops need water and people need food. In the assessment of potentials — or lack thereof — in this paper, three variables and their combinations are taken into consideration:

- the availability of arable land;
- the availability of water;
- the levels of current food insecurity of a country.

The assumed blending target for this calculation is 15% biofuels in the transport fuel for each country included in the analysis. Only countries with populations of more than 5 million people were included.

Of the 102 countries considered, 50 have the potential to reach the blending target according to their land resources; 77 have sufficient potential from a water perspective, and 64 adequate potential from a food security perspective. However, when the three variables were considered in combination, 36 of the 102 countries do not have potential for biofuel production with current technologies (Fig. 3). Even though the term 'potentials' is not a very rigorous concept and these results need to be taken with some caution, the picture that does emerge is that plans and potentials do not yet form a sound strategy.

Energy and agriculture in a broader conceptual framework

Instead of simple trade-offs between food and fuel, a broader conceptual perspective is required for assessing biofuel issues. The three main domains upon which biofuels impact, namely the political, economic and environmental domains, interact when agriculture and energy get more closely linked through biofuels (Fig. 4).

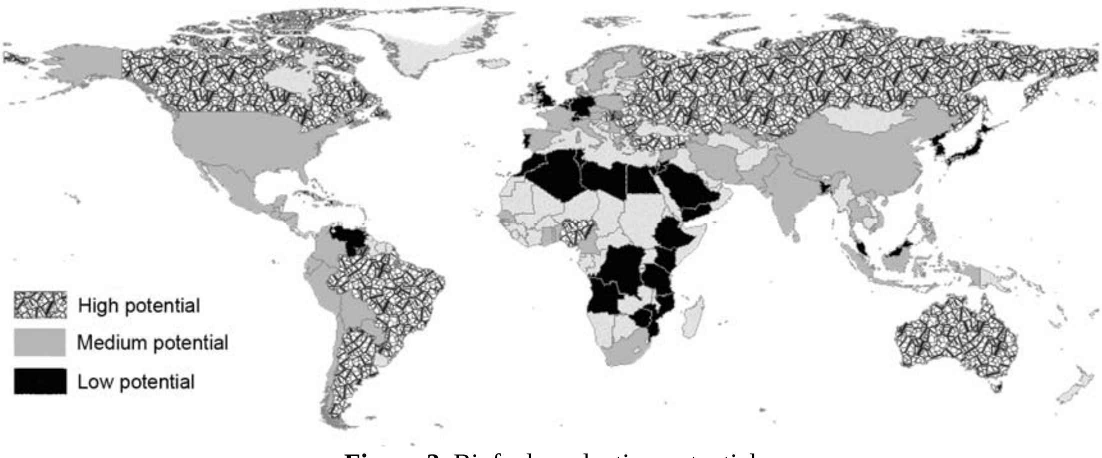

Figure 3. Biofuel production potential

Sources: Data on food insecurity are from FAO 2006. The land availability index is derived by the author based on data from FAO 2007, IEA 2007a,b and USDA 2006. Data on water availability are from WRI 2007.

Notes: Potential is determined by water availability, current arable land availability and food insecurity. Countries that have high water availability and current arable land availability and are not food insecure are considered to have 'high potential' for biofuel production. When a country has at least one severely constraining indicator, it is considered to have 'low potential' for biofuel production. All other countries are considered to have 'medium potential.' Countries with fewer than 5 million people are not included in the assessment.

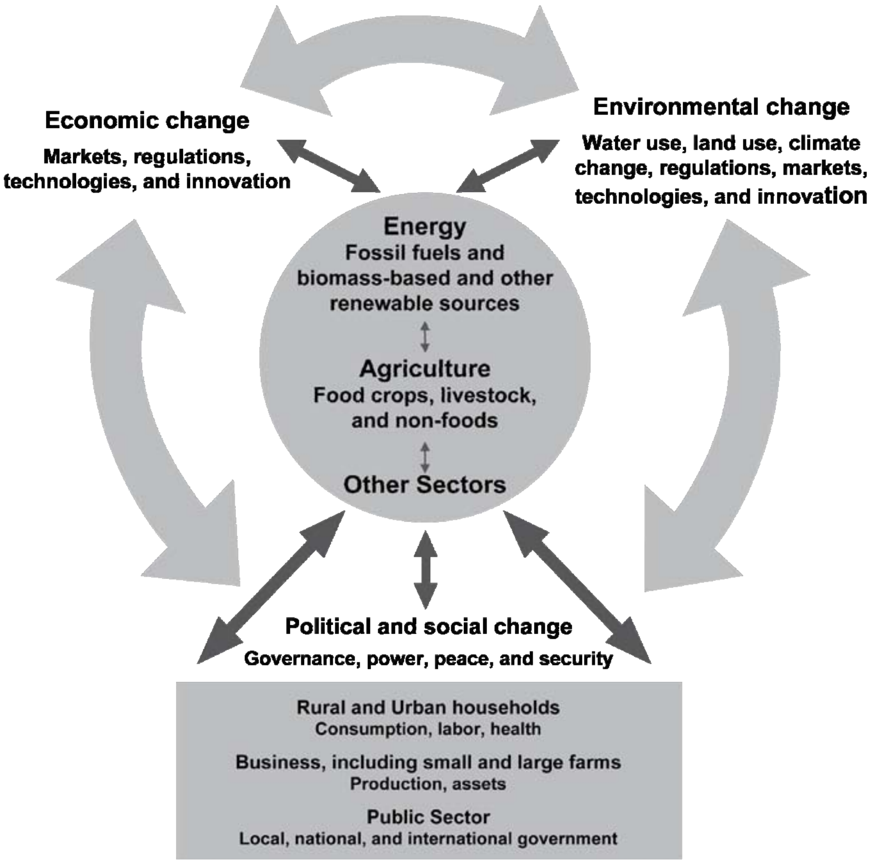

Figure 4. Energy-agriculture linkages within a broader conceptual framework

As the three elements interact with different sectors in an economy, the whole dynamics of agriculture will also change as well and affect households, businesses and the private sector.

Participants in the biofuel discussion are wide ranging and include farmer representatives, the energy industry, global environmental movements, large capital funds and S&T lobbies. The extent to which biofuels remain on the agenda will depend on political pressures and security concerns. High levels of rent-seeking as well as political lobbying are already part of the biofuels political dynamics, and their impact is evident in the current widespread and incoherent subsidy and trade policies. Biofuel subsidies are regressive and anti-poor because the poor loose much on the food consumption side if food prices rise, but gain little on the energy side if energy prices decline.

How do agriculture and energy fit together? At a first glance, there is a big mismatch in scales, structures, and power between the energy sector and the agricultural sector: energy production is highly concentrated, while about 400 million small and medium-sized farms dominate world agricultural production. The value of internationally traded energy is about 2.5 times larger than the value of agriculture trade. However, the agri-food sector is clearly bigger than the energy sector in terms of production value. The energy sector cannot be considered a dominant force when compared with the more than one trillion dollar global food processing and retail industries.

Biofuels: a wide range of impacts

The impact of biofuels on the environment is highly relevant but will be discussed only briefly in this paper. One of the arguments in favor of biofuels is that they could positively affect net carbon emissions as an alternative to fossil fuels and that added social benefit might justify some level of subsidy and regulation, since these external benefits would not be internalised by markets. Furthermore potential forest conversion for biofuel production as well as the impacts on soil fertility are environmental concerns that need attention. As is the case with any form of agricultural production, biofuel feed stock production can be done in sustainable or in damaging ways, so sound process standards are needed.

Clear environment-related efficiency criteria need to be established that internalise the positive and negative externalities of biofuels. The production of biofuels must be done in such a way that the energy output is greater than the amount of energy used to produce them, i.e. the resulting energy balance must be positive and competitive with any alternative energy sources. Maize ethanol, of which the United States is currently the largest producer, has been controversial because until recently it had a negative energy balance. Brazil's large sugarcane-based ethanol industry is well established as a positive net energy producer.

In terms of economic impact, global biofuel expansion will affect prices, crop and energy markets, labor and land markets, and — if moved to a larger scale — macro-economic variables, including exchange rates.

Scenario analyses at IFPRI with the *Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII) MIRAGE model suggest that biofuel expansion will have a positive impact on growth in some countries and regions, but this will not be the case in most. The MIRAGE scenarios that were developed included:

- ***Scenario 1,*** which simulates fossil fuel endowments reduction and fossil fuel price increases similar to projections by the International Energy Agency (IEA 2007c).
- ***Scenario 2,*** which simulates higher substitutability between biofuels and other energy sources in addition to the biofuel shock introduced in Scenario 1.

Both scenarios isolate the impacts of energy shocks on the world economy, and they project that crop and energy prices do change the rate of growth of value-added in agriculture, as well as in industry and services. Under Scenario 1, agricultural value-added in Brazil grows 7.8% over the baseline level and 10.6% under Scenario 2 (Fig. 5). India, the United States, and the EU would also register positive incremental growth in agriculture. However, the incremental change of agricultural value-added for Africa, the Middle East and most other developing countries and regions would be negative.

The scenario analyses also show that biofuel shocks could have a substantial impact on employment opportunities in some countries. Under Scenario 1, agricultural employment in Brazil increases by 7.5%. Significant employment increases also occur in the United States and India (at rates of 1.9–3.6%), whereas in other countries increased agricultural employment opportunities are relatively small, and in Sub-Saharan Africa there would be a small negative incremental impact on employment in agriculture under both scenarios.

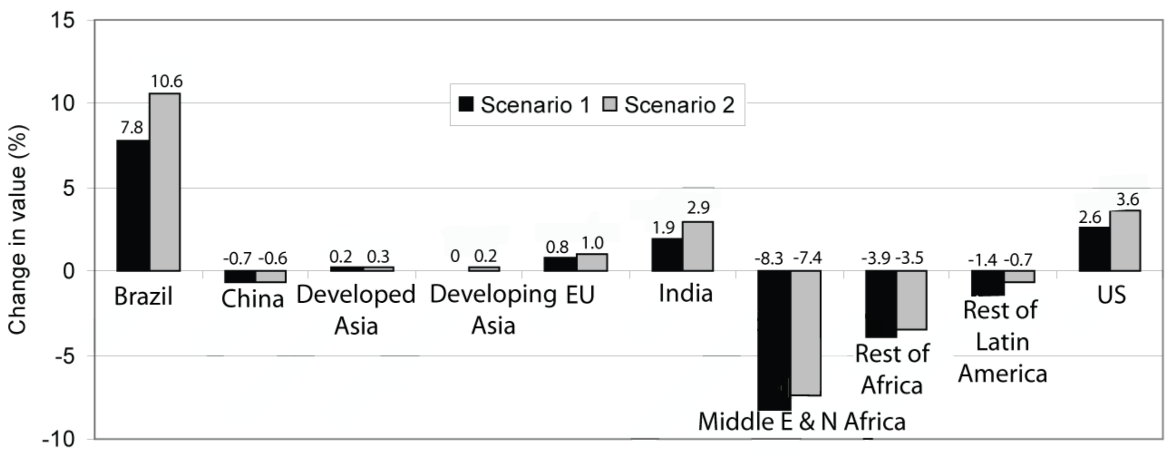

Figure 5. Change in agriculture value added by 2020: scenarios compared with baseline (MIRAGE Projections)

Competitiveness in the context of new technology

With oil prices ranging between US$60 and $70 a barrel, biofuels have become competitive with petroleum in many countries even with existing technologies. The efficiency benchmarks will vary for different biofuels, and ultimately production should be established and expanded where comparative advantages exist.

Feedstock represents the principal share of total production costs. For ethanol and biodiesel, feedstock accounts for 50–70% and 70–80% of overall costs respectively (IEA 2004). Net production costs, which refer to all costs related to production including investments, differ widely across countries. For instance, Brazil produces ethanol at about half the cost of Australia and one third the cost of Germany (Henniges 2005). Feedstock costs have significantly increased over the past few years (by 50% and more), and these price changes impinge on comparative advantage and competitiveness. While the biofuel sector will contribute to price changes, it will also be a victim of the feedstock price changes.

Biofuel production is an area in which great technological strides are expected in the coming decades. By converting cellulosic biomass to liquid fuels, new conversion technologies would create added value by both utilising waste biomass and doing so with less need for land. These second-generation technologies, however, are still in the making, and third-generation technologies are being conceptualised. Future technology development will very much determine the competitiveness of the sector.

Technology, however, will not overcome the food-fuel competition. The tradeoffs between food and fuel would actually be accelerated when biofuels become more competitive relative to food. Simultaneous investment in bioenergy and other agricultural technologies is needed to soften the tradeoff, and the CGIAR has a vital role to play in this process.

Embarking on large-scale biofuel production does not make economic sense at this time for all countries. In many developing countries it would make more sense to wait for the emergence of second-generation technologies, and to plan to 'leapfrog' to these technologies later.

Prices now and in the future

Both agricultural commodity and energy prices have increased significantly since 2002. Although there was no significant correlation in the past, in recent years the correlation seems to have increased; especially after 2002 (Fig. 6).

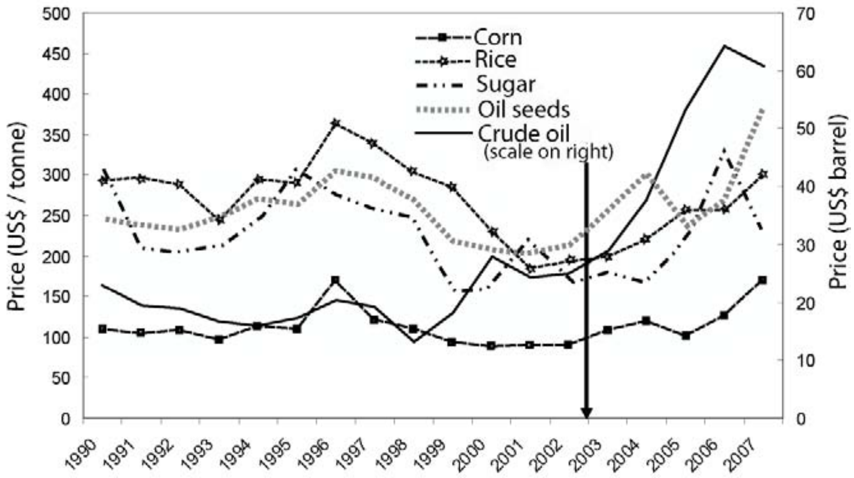

Figure 6. World prices of selected commodities, 1990–2007

Sources: Data on corn, rice, sugar, and oilseeds are from OECD 2005 for 1990–2005 and World Bank 2007 for 2006–07 (US$/tonne) . Data on crude oil are from IMF 2007 (US$/barrel on right-hand scale of the figure).

Notes: 2007 data for corn, rice, sugar and oilseeds are for January–June 2007 only; 2007 data for crude oil are for January–April 2007 only.

Higher agricultural prices are not only a result of increased biofuel production, however, as several factors have recently contributed to the greater demand for agricultural products. These other factors include strong demand in Asia and weak supply due to droughts for instance in Australia, and slow supply response due to input constraints, for example, in Africa. Agricultural product stocks are now at the lowest levels for 25 years, and this has lead to nervous reaction in world markets. As agricultural prices are becoming increasingly linked to fluctuating energy prices, potentially greater food-price fluctuations can also be expected. For all major crops, price variability has been higher in the past five years than in the five years before. For corn, the variation is up from 9% to 22% and for oilseeds up from 12% to 20%.

Scenario analysis with IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade and Water Simulation (IMPACT-WATER) model looks into selected price effects as they may occur in the future. The developed scenarios include:

- ***Scenario 1,*** which is based on the actual biofuel plans of countries and assumed biofuel expansion for identified high-potential countries
- ***Scenario 2,*** where a more drastic expansion of biofuels is assumed, doubling the production expansion rate over Scenario 1 levels.

Under the planned biofuel expansion scenario (Scenario 1), prices increase for oilseeds by 18% and for maize by 26%. With the more drastic biofuel expansion scenario (Scenario 2), the rise of corn prices goes to 72% and oilseeds to 44%.

Would the poor go even hungrier with biofuel production?

In the scenarios mentioned, the increase in crop prices resulting from expanded biofuel production is also accompanied by a net decrease in availability of and access to food. Calorie consumption is estimated to decrease across regions under all scenarios compared to baseline levels (Fig. 7). Food-calorie consumption falls the most in Sub-Saharan Africa, where calorie availability is projected to decrease by 8% if biofuel production expands drastically.

Poor people spend a much bigger share of their overall expenditure on food than they do on energy. Both the urban and rural poor in a selected number of developing countries spend between about 50% and 70% of their expenditure on food and about 1% to 10% on energy (Ahmed *et al.* 2007). A Bangladeshi five-person household living on one dollar a day per person typically spends its 5 dollars as follows: 3 dollars on food, 50 cents on energy and 1.5 dollars on non-food items. A 20% increase in both food and energy prices would require that they cut or reallocate 70 cents of their expenditures—and doing so from their 1.5 dollars in initial nonfood expenditures would be extremely difficult given the quasi-fixed costs of housing, school fees, transport, and so on. As a result, cuts will likely be made to food expenditure, exacerbating diet quality and micronutrient malnutrition.

The world food equation is changing as a result of many factors including energy shortage and climate change. When food becomes fuel, the world is confronted not only with agriculture and energy policy issues, but also with broader social, environmental and security issues. Biofuel expansion will further diversify world agriculture and increase its trade orientation. It will accelerate globalisation of agriculture, which does not need to be a negative trend.

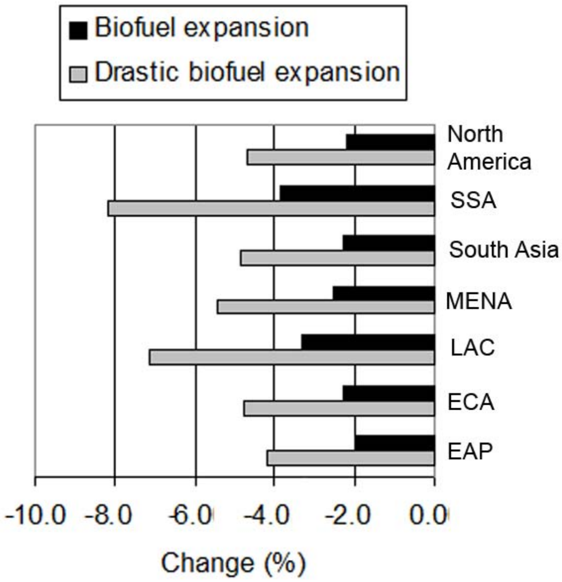

Figure 7. Calorie availability changes by 2020 compared to baseline (IMPACT projections) (SSA = Sub- Saharan Africa; MENA = Middle East and North Africa; LAC = Latin American countries; ECA = Europe and Central Asia; EAP = East Asia and Pacific)

Increased value in agricultural production will draw capital to rural areas even if a large share of capitalisation due to higher prices is captured by land values.

Two risks for the poor arise:

- higher and more unstable food prices and badly designed policies on which the poor have little influence — for example, involving subsidies and trade restrictions
- overly ambitious biofuels programs that compete with other development investments, such as roads, agricultural development or health.

Implications for policy

A comprehensive policy framework will be fundamental to developing biofuels in such a way that they contribute towards energy security and environmental sustainability, and are pro-poor. Such a framework requires three pillars:

1. *Science and technology policy strategy*, which calls for accelerated agricultural productivity to maintain and improve food security, accompanied by an expanded focus on agricultural and biofuel technologies and close coordination with biofuel users — for example, the automobile industry.

2. *Markets and trade policy strategy*, which calls for building a global system for biofuel markets and trade that is undistorted and operates with low transaction costs. Transparent standards are also needed, including sustainability and performance-based standards rather than technology-based standards that will quickly become outdated.

3. *An insurance and social protection strategy for the food-insecure poor* is a necessity given existing large-scale food and nutrition insecurity and the growing complexities of food system changes with the expansion of biofuels. Such protection could include employment programs, conditional and unconditional cash transfer programs, and social security systems for the poorest.

In light of the above, a very different Green Revolution is needed, one that accounts for energy (biomass) and climate change. There is an urgent need for additional institutional arrangements: for instance, collaboration between the energy and the agricultural research systems in public-private partnerships (PPP). The Consultative Group for International Agricultural Research (CGIAR) should reach out to the energy research communities to generate pro-poor agriculture-based energy solutions while serving the food security interests of the poor through technological advances in crop and animal production.

The biofuels opportunity can go terribly wrong for the poor. Only in the presence of appropriate *economic, trade, science and social policies* will biofuels contribute to energy security without jeopardising food security of the poor. That must be worked out in the diverse context of the world food and agriculture system.

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