ANNEX 1

BIOENERGY: BIOFUEL PRODUCTION CHAINS, BIOMASS FEEDSTOCK AND CONVERSION TECHNOLOGIES

Biofuel production chains describe the production process starting from the production of biomass to the technological transformation of biomass to biofuel. A biofuel production chain can be characterized by the type of biomass feedstock and the energy carrier produced (fuel). For example, a type of feedstock could be jatropha and the type of energy carrier produced biodiesel. This type of integrated approach allows analyzing the biophysical, the technical and the economic parameters that are fundamental to this analytical framework. Further, the biofuel production chain approach provides a holistic overview of the biofuel production system, allowing identification of potential implications of bioenergy production chains on food security.

Moreover, biofuel production chains are closely associated to local settings and locally-placed agricultural production systems for example small-holder farming production of jatropha in semi-arid regions of sub-Saharan Africa.

Sources of biomass feedstock for energy production include agriculture crops, agricultural and forest residues, agroforestry residues and other organic waste sources. These various sources of biomass streams can be grouped under the following broad categories:

- *Energy crops:* These are agricultural crops that are suitable for bioenergy production. These include food crops from starch crops such as maize, sugar-based crops such as sugar cane and oil seed crops such as soybean. Non-food crops exclusively grown for bioenergy production are also included in this category, e.g. be grass and woody crops.
- *Forest growth:* This includes potential available woody biomass from sustainable forest management. Using woody biomass for energy purposes however may lead to competition with the forest products industry such as timber, boards, pulp and paper, etc.
- *Primary residues from agriculture and forestry:* These residues are organic by-products from forestry and agricultural harvesting activities. These usually consist of lignocellulosic material, e.g. small branches, leaves, corn stove, that can be used for energy production.
- *Secondary residues from processing industry:* These residues are produced during the industrial processing of wood and food crops. There is a broad range of residues produced from the various industrial processes each having different characteristics.

For example: the wood processing industry produces sawmill and black liquor which can be used as feedstock for energy production. Note that the use of residues from the food processing industry such as molasses or press cake for energy production is only one of its multiple beneficial uses.[26]

- *Organic wastes:* Organic waste such as organic municipal solid waste, demolition wood or used cooking oils comprises a very diverse stream of biomass that can be used for energy production.

All these biomass categories are viable biomass sources for bioenergy production. However, since the objective of this assessment is the impact of bioenergy production on food security, a particular attention is placed on energy crops which potentially have the largest impact on food security. Other types of biomass feedstock offering a viable option for producing bioenergy with minor or no competition for agricultural inputs and food production could also be investigated in the framework analysis.

The biomass-to-energy process options are comprised of an intricate matrix of choices based on feedstock options, technology availability and end-use applications. The choice of the conversion pathway will depend on the types, quantities, and qualities of biomass feedstock available as well as the most suitable and economically-viable type of biomass to energy processing technology locally available. Thus, one can approach bioenergy development by first giving consideration to the available feedstock and then considering the technological options for its conversion. Alternatively, one can first identify the preferred energy carrier i.e. based on energy market needs, then determine the technology and feedstock options available to produce it.

The three main technology conversion routes for converting biomass to biofuel[27] can be grouped into thermo-chemical, physical-chemical and bio-chemical processes. Thermochemical processes are based on the use of thermal energy to carry out the chemical conversion of biomass to an energy carrier. The most common thermo-chemical technologies include combustion, gasification, pyrolisis and/or carbonization. Physical-chemical technologies involve physical and chemical processes such as the production of crude vegetable oil and biodiesel from oilseed crops or from used cooked oil and animal fat. Biochemical conversions are based on biological processes commonly through the use of microorganisms or enzymes to mediate the conversion of biomass or organic waste materials to produce ethanol or biogas, respectively.

26 Alternative uses of secondary residues exist, such as the use of saw mill in the particle board industry or the use of oilseed press cake as fodder.

27 Following the terminology adopted by FAO (UBET – Unified Bioenergy Terminology, 2004 (E)), biofuel is any fuel directly or indirectly produced from biomass i.e. liquid biofuel like ethanol and biodiesel, gaseous biofuel like methane (biogas) and solid biofuel like charcoal.

ANNEX 2

BACKGROUND NOTE ON THE BIOENERGY AND FOOD SECURITY INTERLINKAGES[28]

Food security (FS) is a complex concept with many dimensions and a variety of determinants. Further, bioenergy can be produced via different conversion processes and from a range of feedstocks grown in many different environments. As a result, no short note can describe every possible mechanism through which bioenergy (BE) production might affect food security. In this note, the focus will be on how BE production affects FS through changes in market-based incomes and food prices. In many circumstances, these are likely to be the quantitatively most important effects. However, there is no doubt that BE production may have effects on FS that are not mediated by incomes and prices. For example, small scale production of BE in rural areas may allow some households to stop cooking with fuelwood in enclosed spaces, thus improving their health and the ability of their bodies to more efficiently utilize nutrients contained in the food they already eat. Thus, use of BE could allow for improvements in FS even without any changes in food consumption patterns. For the rest of this note, however, such effects will be ignored, while recognizing that such effects can be very important in some circumstances.

With regard to incomes and prices, it is obvious that income is a critical determinant of food security for the poor. The more income that a given household or individual has, the more food that can be purchased, both in terms of quantity and quality. Food prices are also important determinants, but the precise effects of food prices on food security are more complex.

Food prices are critical for the welfare of the poor

In order to understand the importance of food prices for food security, it is first important to distinguish between net food producers and net food consumers. A net food producer is someone for whom total sales of food to the market exceed total purchases of food from the market, while for a net food consumer the reverse is true. This distinction is also usefully made at the level of individual commodities, as opposed to food in general.

These concepts are quite distinct from rural and urban. While nearly all urban dwellers are net food consumers, not all rural dwellers are net food producers. In fact, very small farmers and agricultural labourers are often net consumers of food, as they do not own

28 This background note was prepared by D. Dawe, Senior Economist ESA FAO, at the start of the BEFS project.

enough land to produce enough food for their family.[29] These landless rural households are often the poorest of the poor. The importance of the rural landless varies greatly from country to country. In some countries, such as India, Indonesia and Bangladesh, among many others, the landless constitute a significant portion of the rural population. In others, such as land abundant Thailand, their importance is much less.

Generally speaking, with the exception noted in footnote 1, higher food prices can substantially hurt net food consumers. In order to understand this effect, one must realize that, for the poor, a very large share of expenditures goes to food. Indeed, in many countries, food can account for 70 to 80 percent of expenditures by the poorest quarter of the population. In such circumstances, food price increases can have large effects on effective purchasing power, even if they do not directly affect nominal income per se. As one example, Block et al (2004) found that when rice prices increased in Indonesia in the late 1990s, mothers in poor families responded by reducing their caloric intake in order to better feed their children, leading to an increase in maternal wasting. Furthermore, purchases of more nutritious foods were reduced in order to afford the more expensive rice. This led to a measurable decline in blood haemoglobin levels in young children (and in their mothers), increasing the probability of developmental damage. A negative correlation between rice prices and nutritional status has also been observed in Bangladesh (Torlesse et al 2003).

On the other hand, farmers who are net food producers are likely to benefit from higher prices, which, other things being equal, will tend to increase their incomes. Since many farmers are poor, higher prices could help to alleviate poverty and improve food security. However, it must also be kept in mind that farmers with more surplus production to sell will benefit more from high prices than farmers who have only a small surplus to sell. Further, in many (but not all) contexts, farmers with more land tend to be better off than farmers with only a little land, so it may be that poorer farmers will not receive the bulk of the benefits from higher food prices.

While these are useful first approximations to the effects of higher food prices on FS, the ultimate impacts can be more complex. First, there can be second round multiplier effects as farmers' higher incomes due to higher food prices create demand for other goods and services, much of it presumably produced locally. However, it must be kept in mind that if farmers' additional income is simply a transfer from the rural landless and urban poor, these new multiplier effects will come at the expense of the previous multiplier effects generated by the spending patterns of the poor, who will now have less money to spend on non-food items as their food bills increase. The point is that a change in relative prices due to either government policy or changes in external market conditions does not create

29 It is also true that whether a given household is a net food producer or consumer depends on market prices. Higher prices will discourage consumption, encourage more production, and possibly convert some households from net consumers to net producers. Lower prices could do the opposite.

multiplier effects in the same manner as does a new technology that increases productivity, such as new seed varieties. The only way to assess the potential for net positive multiplier effects is to carefully measure the change in income distribution and compare the spending patterns of the winners and losers from the new set of relative prices. While it is true that the (marginal) propensity to consume domestic products as opposed to imports decreases from the bottom to the top of the income distribution, it is also true that net food consumers often dominate both the bottom and the top of the income distribution. Thus, it is not clear that the propensity to consume domestic products is higher for net food producers than it is for net food consumers. In practice, it seems that higher food prices are probably not likely to generate large net multiplier effects in either direction.

Second, higher food prices will increase the demand for agricultural labour, which is a prime source of income for the poor (Davis et al, 2007). Ravallion (1990), using data from the 1950s to the 1970s, concludes that the average landless poor household in Bangladesh is a net rice consumer and loses from an increase in the rice price in the short run (due to higher consumption expenditures), but gains slightly in the long run (after five years or more). This is because in the long run, as wages adjust, the increase in household income (dominated by unskilled wage labour) is large enough to exceed the increase in household expenditures on rice. However, this study used relatively old data, when rice farming was a larger sector of the economy and thus had a more profound impact on labour markets. Rashid (2002), updating the data used by Ravallion (1990), found that since the mid-1970s, rice prices in Bangladesh no longer have a significant effect on agricultural wages as employment opportunities became more diversified and agriculture became a smaller share of the economy. Thus, the extent to which induced wage increases will compensate agricultural labourers for higher food prices will depend on the extent to which the agricultural labour market affects the overall labour market for unskilled workers.

To summarize, the net effect of bioenergy demand and higher food prices on food security will vary from context to context. There will always be some people for whom food security improves, while there will always be others who experience a deterioration in food security. The exact net outcome will depend on the socio-economic structure of society, as well as on the specific commodities whose price increases, and the relative position in the income distribution of the farmers who produce the commodities that have experienced the price increase.

On balance, for the world, the net effect of higher food prices on food security is likely to be negative, even for relatively small changes in prices. For example, Senauer and Sur (2001) estimated that if there is a 20 percent increase in food prices in 2025 relative to the baseline (due, for example, to an increase in bioenergy demand), the number of under-nourished people in the world would increase by 440 million people (195 million in sub-Saharan Africa and 158 million in South and East Asia). However, this is a global figure. The situation will be different in different countries, and the outcome will also vary across regions within countries.

Bioenergy production will nearly always compete with resources used by food producers, and will thus tend to raise food prices even if the feedstock itself is a non-food crop. Even if the crop is grown on previously unused land, there will still be a tendency for BE production to put upward pressure on food prices due to use of other resources.

Prices in food markets, despite many government interventions, are still influenced substantially by changes in market supply and demand. Further, the market supply curve for food is strongly influenced by the prices and availability of various inputs: land, labour, water and fertilizer. If BE production does not compete for these resources with food crop producers, then the supply curve for food production will not be affected, and this should serve to mitigate food price increases.

For example, if BE crops are grown on previously unused land with previously idle labour without any fertilizer and exploiting previously unused water supplies, then there should be no effects on the marginal cost of food production. In some cases, these circumstances may be close to the truth; however, in many others, production of BE will seriously compete for these resources and affect the cost of food production.

To illustrate: although jatropha can grow well in marginal environments, it generates larger quantities of oil (and thus more biodiesel) if it is grown with more water. Thus, biodiesel production from jatropha grown on marginal, previously unused land without any fertilizer may still have adverse impacts on food security if it competes for scarce water resources that are currently used by agriculture. Of course, it may be possible to grow jatropha without any irrigation water, but then it will be important to understand if it is possible to produce substantial quantities of biodiesel under these conditions.

In many other situations, BE production will compete seriously for key agricultural inputs. At present, most of the world's agricultural biofuels come from sugar cane in Brazil and corn in the United States; both of these crops are grown with heavy use of inputs, including prime agricultural land, fertilizer and water. While US corn and Brazilian sugar cane are not necessarily major sources of calories for the poor, production of these crops competes heavily for land, fertilizer and water used in the production of crops that are consumed by the poor.

To summarize, an assessment of the impact of BE production on food security will need to consider in detail the inputs used in the BE production process, and how this use of inputs affects market supply curves for food production.

Production of bioenergy will generate employment at both farm and factory levels, which will help to improve food security if targeted at the poor. It is important to note that alternative uses of the land and capital necessary for BE production would have generated employment as well, and this alternative employment needs to be considered in assessing *the impact of BE production on employment and FS. In other words, a critical issue in measuring the impact of BE production on employment and FS is the relative labour intensity of BE production.*

Much of the employment that is likely to come with increased BE production, at least in developing countries, will be due to potentially increased labour use at the farm level to grow the feedstock. Here, it is crucial to understand the labour requirements of the BE feedstock per unit of area-time (e.g. per hectare per year) compared to the labour requirements of alternative land uses. If the land was previously unused, then clearly the planting of BE feedstock will create new employment. However, if the BE feedstock is less labour-intensive than the crops planted previously, then BE production will destroy employment on net at the farm level. The ultimate outcome will vary depending on what crop is used as feedstock and what crops were grown previously before the feedstock.

In terms of fuel production from feedstock, small scale BE production seems likely to generate more employment for the poor than large scale BE production, which will probably be more capital intensive and less labour intensive. Indeed, current bioethanol and biodiesel factories in the USA and Brazil require huge investments of capital, often in the range of 100 to 200 million US dollars. Further, the labour employed in these factories may favour relatively skilled workers (who are usually food secure).

While small scale BE production may be better at creating employment, it is important to consider the ability of small-scale BE production to compete with large scale BE production. Smaller plants may in general not be very competitive, and if not, any increased employment is likely to be short-lived. However, if BE production is used to enhance access to energy in small villages with poor infrastructure, then competition with large scale factories is probably not an important issue. Employment created at such small scale processing plants is likely to have a positive impact on food security at the local level.

As world commodity markets become more integrated, bioenergy production in one country will have important effects on food security in other countries as changes in food prices on international markets affect domestic markets. The effect will depend on domestic trade policies and infrastructure.

BE production may affect food security in small developing countries even if the country concerned is not involved in BE production of its own. The effect is quite simple: higher prices on international commodity markets due to, for example, increased demand for corn as an ethanol feedstock in the United States, will in many cases spill into commodity markets in developing countries. At the country level, a net food exporter will benefit from higher food prices, while a net food importer will be hurt (the effects will depend on which specific food prices increase).

It is important to realize that not all of the recent increases in commodity prices over the past few years are due to biofuels demand. First, higher oil prices lead to higher costs of food production (fertilizer and machinery), leading to higher food prices even in the absence of biofuels demand. Second, demand for maize is increasing substantially independently of its use as a feedstock for ethanol. As consumers in China, India and other rapidly developing countries gain more income, they shift consumption away from cereals toward livestock products that use substantial quantities of maize as feed. Because it requires several calories of grain to produce just one calorie of meat, increased demand for meat means substantially increased demand for grain.

Third, many of the increases in commodity prices are due to exchange rate movements, specifically the weakening of the US dollar. A weak US dollar leads to increased commodity demand (at any given US dollar price) on the part of countries whose currency has appreciated (e.g. the euro and West African currencies tied to the euro), because it is cheaper in domestic currency terms to buy the commodity. A weak US dollar also leads to an inward shift of the supply curve as farmers in countries whose currency has appreciated now receive fewer units of domestic currency (again, at any given US dollar price) per unit produced. The shift in both demand and supply lead to higher commodity prices (as measured in US dollars). This theory is borne out by history as well. For example, the weak US dollar in the mid to late 1980s led to increased commodity prices at that time.

Nevertheless, some of the recent price increases in international markets are due to biofuels demand. The precise impact of increased international food prices on domestic prices will depend upon the trade policy pursued by the country in question. In a country that allows private imports subject only to tariff protection, higher international prices will usually translate into higher domestic prices. This effect may be reduced, or even eliminated, however, if there are high transport and transaction costs that cause domestic prices to be in-between import and export parity prices. A country that permits a fixed quota of imports may not witness an increase in domestic prices after an increase in international prices, but again the result depends on other factors such as whether or not the quota is binding.

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ENVIRONMENT – CLIMATE CHANGE – BIOENERGY – MONITORING AND ASSESSMENT

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The Food and Agricultural Organization of the United Nations (FAO) has been at the forefront to support member countries in their quest to assess if bioenergy is an alternative and suitable energy option. The organization is working to promote a better understanding of the linkages between bioenergy and food security, poverty alleviation, climate change and sustainable development. The FAO Bioenergy Group is active in building the international knowledge base on sustainable exploitation of bioenergy, building and strengthening institutional capacity at all levels and facilitating opportunities for effective international exchange and collaboration. As part of the bioenergy program, FAO with generous funding from the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) set up the Bioenergy and Food Security (BEFS) project to assess if and how bioenergy developments could be implemented without hindering food security.

The publication in this report presents the analytical framework developed by the BEFS project which examines the relationship between food security and bioenergy. The report also provides an overview of the BEFS tool box used to carry out the quantitative analysis on the dynamics of the bioenergy and food security interfaces. The report is meant to acquaint the general public and in particular policy makers with the BEFS Analytical Framework, the tools that it offers and how these tools can be applied to assist policy makers in making informed decisions on the basis of clear information concerning the many varied consequences of bioenergy developments on food security, poverty reduction and agriculture development and economic growth. This analytical framework has been implemented in Peru, Tanzania and Thailand. The results of the country implementations are published in the FAO Environment and Natural Resources Management working paper series.




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