

MAKING SUSTAINABLE BIOFUELS WORK FOR SMALLHOLDER FARMERS AND RURAL HOUSEHOLDS

ISSUES AND PERSPECTIVES

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Andrea Rossi and **Yianna Lambrou**

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BACKGROUND

The global demand for liquid biofuels such as bioethanol and biodiesel (see box 1) is rapidly increasing. This is due mainly to the policies that numerous developed countries have recently adopted to either support or mandate the production and use of such fuels. These policies have been introduced to pursue multiple goals, such as reducing dependence on oil imports and increasing energy security, cutting GHG emissions from the transport sector and opening new markets for farmers[1].

Largely in response to this growing demand, the production of liquid biofuels is expected to grow significantly in tropical and subtropical developing countries. These countries, due especially to their agro-ecological conditions, are particularly well suited for the production of agricultural crops used to make liquid biofuels (so-called liquid biofuel feedstocks) such as sugarcane and palm oil. Large-scale plantations of these crops are currently being established in these countries for liquid biofuel production. Small-scale liquid biofuel production schemes for local applications (for power generation, heating and cooking) are being established as well in numerous developing countries.

[1] The potential for biofuels to achieve some of these objectives has been challenged in a number of recent studies (e.g. Gallagher, 2008; Oxfam, 2008).

Box 1
Liquid Biofuels: Key Facts and Figures

Global biomass consumption was equal to about 45 EJ in 2007, contributing around 10 percent of world primary energy demand (470 EJ), mostly in the form of non-commercial solid biomass for cooking and heating. Commercial biomass consumption was equal to about 9EJ in 2007, with around 2.6 EJ used for liquid biofuel production (FAO, 2008a).

Liquid biofuels are liquid fuels that can be produced from agricultural and forest products or the biodegradable portion of industrial and municipal waste. The two most common forms of liquid biofuels are bioethanol and biodiesel. These two fuels are used mainly in the transport sector, either in pure form or blended with gasoline (bioethanol) and diesel (biodiesel). In 2007, liquid biofuels contributed around one-two percent of world road-transport fuel demand; according to projections by the International Energy Agency, this percentage should increase to 2.3 percent by 2015 and 3.2 percent by 2030 (FAO, 2008). Liquid biofuels may also be used for heating, cooking and generating electricity.

Bioethanol is produced from agricultural products such as starchy and cereal crops (sugarcane, corn, beets, wheat and sorghum), while the main feedstock used in biodiesel production are oil crops and trees such as rapeseed, soy, sunflower, palm, jatropha or coconut (Dufey, 2006).

Second-generation liquid biofuels will be produced using a wider range of biomass resources, including agriculture and forest residues. This requires advanced conversion technologies, which will not be commercially available on a large-scale at least for another decade, especially in developing countries.

INTRODUCTION

In developing countries, liquid biofuel production (LBP) - particularly if small in scale - offers potential opportunities for poverty reduction and rural development, through the creation of both income-generating opportunities for farmers and jobs for agricultural workers. If used locally for cooking, heating or power generation, liquid biofuels may also improve availability of and access to modern energy services in rural areas, where most households are without electricity and rely completely on firewood for their energy needs.

The rapid expansion of LBP, however, may also give rise to risks for developing countries, such as land and water degradation, loss of agro-biodiversity, potential exclusion of smallholder farmers and women, and increased food insecurity. As will be discussed in the next section, part of these risks have already been observed for other commercial agricultural production systems.

This paper provides an overview of the main risks and opportunities that may arise from liquid biofuel production and use in developing countries[2]. Both the potential environmental impacts and the socio-economic effects of liquid biofuel production and use are discussed, focusing, in particular, on the household-level implications. A few country-levels impacts, which might trickle down to the household level, are discussed as well.

As will emerge from the discussion, unless appropriate measures are adopted and implemented in liquid biofuel development policies and projects, all else equal, smallholder farmers (especially female-headed households) and women might be particularly exposed to the

[2] For an extensive discussion of the technical and economic potential of biofuels in developing countries and of the associated risks and opportunities, see FAO (2008).

risks associated with LBP, and have, at the same, limited opportunities to engage in and benefit from it. This is due mainly to the traditional lack of access of smallholder farmers to land, capital, technology and markets in most developing countries, as well as to men's and women's different roles and responsibilities within rural economies and to pre-existing socio-economic inequalities between them, particularly in terms of access to - and control over - productive assets. Assessing the specific effects of liquid biofuel production and use on these different groups is essential in order to identify potential winners and losers from the recent "biofuels boom".

Recommendations on how to minimize the risks and maximize the opportunities of liquid biofuel production and use are provided in the final section of the paper[3]. In particular, measures are recommended to exploit the rural development and poverty reduction potential offered by liquid biofuels. This requires strengthening the participation of smallholder farmers (particularly female-headed households) in the production of these fuels and ensuring that both men and women may engage in and benefit from their production and use.

[3] The recommendations provided pertain only to the environmental sustainability of biofuel production and use and to its socio-economic effects on smallholder farmers and rural households. Other technological and economic aspects of biofuel production and use are not covered here.

1 LIQUID BIOFUEL PRODUCTION: RISKS AND OPPORTUNITIES FOR DEVELOPING COUNTRIES

Both the nature and the magnitude of the environmental and socio-economic effects of liquid biofuel production and use in developing countries will depend on a number of biophysical, technological and socio-economic factors, including the type of liquid biofuel and feedstock considered, the scale of production, the previous uses of the land and the structure of land ownership[4]. However, some general facts and trends (discussed in the following sections) may be identified.

1.1 RISKS[5]

Some of the environmental and socio-economic issues associated with LBP and discussed here (such as the potential exclusion of small farmers and women) have already been observed for other commercial agricultural production systems. Evidence from these other systems and lessons learnt from them can thus be used to address these issues in a prompt and effective way.

At the same time, LBP is giving rise to new challenges, such as the competition with food and feed production, which require substantial research efforts and new policy tools in order to be adequately understood and addressed. Most of these challenges arise from the fact that LBP is exacerbating existing, growing pressures on natural resources (including land and water), agriculture and food production from factors such as population and income growth,

[4] The recommendations provided pertain only to the environmental sustainability of biofuel production and use and to its socio-economic effects on smallholder farmers and rural households. Other technological and economic aspects of biofuel production and use are not covered here.

[5] The discussion on the risks in this paper is largely based on Rossi and Lambrou (2008).

dietary changes, climate change[6] and so on[7]. The discussion about liquid biofuels should thus take place within this framework and take into account these increasing constraints.

As already mentioned, the risks of LBP discussed below might affect men and women (and thus male-headed households and female-headed households) differently, due in part to pre-existing gender-based inequalities that these risks could even contribute to reinforce.

1.1.1 Potential exclusion of small farmers and women

Large-scale plantations for LBP require an intensive use of land, capital and technology. Small farmers traditionally have limited access to these resources, making them less likely to participate in LBP. An example of smallholder exclusion from commercial liquid biofuel production chains is found in Honduras. In this country, 80 percent of palm oil producers, due to a lack of access to transportation, cannot participate in preferred supplier arrangements entailing direct contracts with extractor companies, and thus are obliged to sell their produce to intermediaries. For this reason, the profit margin is lower for these producers, who also risk exclusion from participating in the chain (Fromm, 2007).

The risk of exclusion from LBP is particularly high for women and female-headed households. This is due to widespread and persistent gender-based inequalities in most developing countries, particularly in terms of access to - and control over – the following resources and assets: land, water and other natural resources; complementary inputs such as seeds and fertilizers; new crop varieties and farming technologies; agricultural extension; credit, particularly formal credit schemes; and markets (IFPRI, 2008a).

Firstly, there are significant gender gaps in land ownership. For instance, in Cameroon, while women undertake more than 75 percent of agricultural work, they own less than 10 percent of the land. In Brazil, the percentage of land owned by women is 11 percent, while in Peru is 13 percent. Similar disparities have been identified in Tanzania, Kenya, Nigeria and other countries in Sub-Saharan Africa (UNICEF, 2007). As LBP expands and land becomes more valuable, access to land of rural poor and women might be further reduced[8]. For instance, while in parts of Malaysia communities have been able to assert their land rights in response to high land values from palm oil, in Indonesia there has been an erosion of land access (CFC, 2007). Recently, major displacements of local farmers and communities in order to make room for large-scale plantations for LBP have been reported in Africa (Knaup, September 8, 2008).

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[6] As reported by Chatham House (2008), climate change increases the number of people at risk of hunger and might lead to an increase of 40-170 million in the number of undernourished people.

[7] Since biofuel production is mostly driven by policies and particularly mandates, it is not affected by and responsive to these constraints.

[8] For a discussion of the potential impacts of the "biofuels boom" on access to land of smallholder farmers and poor people, see Cotula et al. (2008).

Secondly, generally women lack access to formal credit schemes, thus being limited in their ability to acquire agricultural inputs. In Nigeria, for instance, only three percent of women receive credit from banks, against 15 percent of men; moreover, although the average value of the loan obtained by women is only 42 percent of that of men, the percentage of collateral required is regularly higher for women (Saito *et al*., 1994).

Finally, significant gender gaps have been found also in possession of farming equipment. In Nigeria, for instance, female-headed households possess less than half of the farming equipment owned by male-headed households (Saito *et al*., 1994).

Due to all these factors, female-headed households, in relation to male-headed households, might face more barriers to participating in LBP.

1.1.2 Increasing pressure on natural resources

The rapid expansion of LBP might exacerbate the pre-existing competition for land between forests, agricultural and urban uses, contributing to deforestation[9]. In addition, large-scale liquid biofuel feedstock plantations, with their high input requirements, may lead to water and land degradation. These plantations may be associated, in particular, with soil erosion and increased soil and water pollution (from fertilizer and pesticide use) (UNEP, 2007). In addition, the production of liquid biofuels (particularly bioethanol) may require significant water withdrawals in certain countries[10], contributing to water scarcity[11] (De Fraiture *et al*., 2007).

The potential reduction in the availability of firewood and clean water due to LBP, would place an additional burden on rural farmers' work and health. In particular, it would force women and girls, who are traditionally responsible for firewood and water collection (see Appendix I), to travel longer distances and allocate more time to these tasks, thus reducing the time available for other income-generating activities and education. There is evidence, for instance, that in Malawi women who live in areas with moderate to severe wood deficits, spend more time on housework and less time on self- or wage-employment (Nankhuni, 2004).

Energy crop plantations may also be established on fallow fields and wildlands, threatening the wild edible plant species that grow on these lands. This would have negative repercussions on the livelihoods of rural poor, who are largely dependent on natural resources for their

[9] For a comprehensive review of the effects (particularly indirect ones) of biofuel production on land-use and its changes, see Gallagher (2008).

[10] In India, for example, 3,500 liters of water withdrawals are required, on average, to produce the amount of sugarcane for one liter of bioethanol (De Fraiture *et al*., 2007).

[11] As reported by Chatham House (2008), global water demand has tripled in the last 50 years. Currently, around half billion people live in countries with chronic water shortages and, by 2050, this number is likely to rise up to four billion.

food security, and would also threaten the knowledge and skills associated with the collection and the utilization of such species for food, fodder and medicine, all activities traditionally performed by women (FAO, 1999).

1.1.3 Potential loss of agro-biodiversity

The establishment of large-scale plantations for LBP would cause, in the affected areas, a reduction in the variety of plants and animals – including crops, livestock[12], forestry and fisheries - used directly or indirectly for food, fodder, fiber, fuels and pharmaceuticals. This would make farming systems less stable, robust, and sustainable, reducing the resilience of rural livelihoods to both bio-physical and socio-economic shocks, such as pathogen infestations, adverse weather conditions and fluctuations in the price of cash crops (FAO, 2008b).

At the same time, the extensive knowledge and the traditional skills of small farmers in the management, selection and storage of local crops (all activities performed mainly by women) might be reduced. If grazing lands are replaced by energy crop plantations in certain areas, the knowledge related to the management and use of different animals and animal-derived products would be threatened as well, particularly among men, who are often responsible for the management and use of ruminants such as cattle and buffalos (FAO, 2008b; FAO, 2006).

1.1.4 Food security risks

The complex interrelationship between bioenergy and food security and the challenges posed by the growing demand for food and fuel in an increasingly carbon-constrained world were discussed during a High-Level Conference that was convened by FAO in June 2008.

As emerged from the background papers that were prepared for this conference, as well as from numerous other studies, the growing global demand for liquid biofuels may affect, in particular, three dimensions of food security – availability, access and stability.

Large-scale plantations for LBP, with their high input requirements, may divert land and other resources (such as water) away from food crops (UN Energy, 2007). In addition, these plantations, due to their high profitability, may be established on high-quality lands, reducing the availability of such lands for growing food and subsistence crops. The potential loss of agro-biodiversity discussed above poses a serious threat to rural livelihoods and long-term food security as well. Finally, LBP may also have a negative impact on the livestock sector,

[12] The livestock sector may be affected by biofuel production through the conversion of part of the grazing lands to energy crop plantations and through the increase in the price of livestock feed caused by the growing demand for agricultural commodities for biofuel production.

which is key to the food security of rural households, through a reduction in the availability of grazing land and an increase in the price of livestock feed (due to the growing use of agricultural commodities for LBP). All these factors, combined, might negatively affect food availability.

At the same time, LBP has an impact on food access. The emerging liquid biofuel industry is a new, fast growing source of demand for agricultural commodities such as sugar, maize, oilseeds, palm oil and cassava (FAO, 2008c). This, combined with other factors such as income and population growth (demand side), adverse weather conditions (supply side), and new or additional trade barriers and export restrictions[13], has contributed to higher food prices[14]. Some studies have tried to measure the impact of LBP on food prices, reaching different conclusions. According to IFPRI's estimates, in 2000-2007 increased demand for liquid biofuels has contributed to 30 percent of the growth of cereal prices (calculated as a weighted average).

Demand for agricultural commodities for food, feed and, in particular, fuel is expected to continue to increase rapidly in the future. OECD/IEA (2008) estimates that, between 2008 and 2017, 20 percent or world vegetable oil production and 13 percent of world coarse grain production could shift to LBP, up from nine and eight percent in 2007. Regarding the future impact of liquid biofuels on food prices, IFPRI (2008) projects that, in 2020, real prices of oilseeds and maize will be 18 and 26 percent higher than in the scenario with LBP at 2007 levels[15]. According to OECD/IEA (2008), current biofuel support measures alone are expected to increase average vegetable oil prices by about 19 percent, maize by around seven percent and wheat by about five percent in 2008-2017.

Higher food prices represent an opportunity for food-exporting developing countries, which can enjoy increased export revenues; similarly, at the household level, net producers of food stand to benefit from increased food prices, through a positive income effect, which might result in an increase in food access for these households.

Most Least Developed Countries (LDCs), however, are net importers of food (43 out of 52). Significant increases in food prices threaten the trade balance[16] and, more in general, the macroeconomic stability and overall economic growth of these countries, which will

[13] In order to minimize the effects of increased food prices on their populations, 15 countries (as of April 2008), including major producers, had imposed export restrictions on certain agricultural commodities. China, India, Tanzania and Ethiopia, for instance, had banned export of major cereals, including maize and rice. Argentina had raised export taxes on several commodities, including maize and soybean, while a number of other countries had imposed new or additional price controls (IFPRI, 2008).

[14] Other factors include the relative inelasticity of supply, historically low stock levels and some speculative investment (Chatham House, 2008).

[15] These estimates do not take into account speculation and triggered trade restrictions (IFPRI, 2008).

[16] As of 2008, the annual food import basket of Least Developed Countries and Lower Income Food Deficit Countries costed over twice than in 2000 (FAO, 2008a).

also struggle to meet domestic food demand[17]. According to OECD/FAO (2008), projections show greatly increased vulnerability and uncertain food supplies for these countries, due to high commodity prices and high price volatility[18].

As increases in food prices are transmitted from the global to the local markets, households that are net purchasers of food, particularly those that are also at risk of being excluded from LBP (such as female-headed households), will be negatively affected as well (IFPRI, 2008; Schmidhuber, 2007). Most households in LDCs and particularly Low Income Food Deficit Countries (LIFDCs) fall into the category of net food purchasers. In Malawi and Bangladesh, for instance, only 11.8 and 15.7 percent of households, respectively, are net staple food sellers, with higher percentages in rural areas and lower in urban areas. Among poor rural households (with less than a dollar a day), the percentage of net sellers is even lower: 8.6 in Bangladesh and 7.6 in Malawi.

Poor rural households spend 50 to 70 percent of their budget on food (IFPRI, 2008). In addition, in low-income households, staple food commodities such as corn and wheat account for a larger share of food expenditures (USDA, 2008). Access to food might be considerably reduced for these households[19]. In addition, higher food prices reduce the purchasing power of net-food-buyer households, affecting the purchase of other goods and services such as drinking water, health care, education, and lighting, all of which represent important inputs into nutrition and are, at the same time, key to the welfare and health of household members (IFPRI, 2008).

The welfare losses (or gains) associated with food price increases do not seem to be equally distributed among female-headed households and male-headed households. According to FAO (2008c), in most national, rural and urban samples, female-headed households suffer greater proportional welfare losses (or benefit from smaller proportional welfare gains) than male-headed households (table 1); this is the case both for the population as a whole and for the poorest segments of it. Where female-headed households are over-represented among the poor (or are more likely to be poor), it is expected that their welfare losses will be higher, due to the fact that poorer households spend a greater percentage of their incomes on food than richer ones. However, even when male-headed households are over-represented among the poor, female-headed households may still have greater welfare losses (such as in Nicaragua). This is due to two main factors. Firstly, it has been observed, in many different contexts, that, all else

[17] The food price increase that occurred in 2007-2008 caused social unrest and food riots in a number of developing countries around the world.

[18] Countries such as Eritrea, Niger, Comoros, Botswana, Haiti and Liberia are especially vulnerable, due, among other things, to very high levels of chronic hunger and high dependence on imports of major grains (such as maize, wheat and rice) for domestic consumption (FAO, 2008a).

[19] A 50 percent increase in staple food prices causes retail food expenditures to rise six percent for a consumer in a high-income country, resulting in an increase in the percentage of income spent on food from 10 to 10.6 percent. With the same increase in staple food prices, food expenditures will increase by 21 percent for a consumer in a typical low-income food-deficit country, while the percentage of income spent on food will rise from 50 to 60 percent (USDA, 2008).

Table 1
Gender Bias in poverty and welfare effects of staple food price increases

	Urban			Rural			National		
Country/Year	Share FHH (%)	Over-represented among Poor*	Welfare losses higher**	Share FHH (%)	Over-represented among Poor*	Welfare losses higher**	Share FHH (%)	Over-represented among Poor*	Welfare losses higher**
Ghana (1998)	32.8	FHH	--	24.9	MHH	FHH	27.5	MHH	FHH
Madagascar (1993)	20.8	FHH	FHH	13.2	FHH	--	14.6	FHH	FHH
Guatemala (2000)	18.8	MHH	--	11.9	MHH	--	14.5	MHH	--
Nicaragua (2001)	33.3	MHH	FHH	18.1	--	FHH	27.0	MHH	FHH
Bangladesh (2000)	7.7	--	--	5.9	MHH	FHH	7.6	MHH	FHH
Pakistan (2001)	6.3	MHH	--	6.7	MHH	FHH	6.6	MHH	FHH
Viet Nam (1998)	37.8	--	FHH	16.9	MHH	FHH	21.6	MHH	FHH

Reproduced from: FAO (2008c).
Notes: FHH stands for female-headed households, and MHH stands for male-headed households; "--" indicates that there is no statistical difference between MHH and FHH at the 95 percent confidence level.
*Poor households identified as those with per-capita expenditures below two Purchasing Power Parity dollars in 2000 prices.
**Or welfare gains lower.

equal, women tend to spend on food a greater share of their income than men. Secondly, as was already discussed, female-headed households have less access to land, capital, technology and markets than men and thus are less able to participate in commercial agricultural production and to benefit from an increase in the price of agricultural commodities (FAO, 2008c). This is emerges clearly particularly among rural samples (see the table 1).

Finally, the rising demand for liquid biofuels could make the prices of food more unstable. This would have negative repercussions in particular for poor households and vulnerable groups (including women), which tend to be particularly exposed to chronic and transitory food insecurity, due also to their limited access to income-generating activities.

1.2 OPPORTUNITIES

Beside the risks discussed above, liquid biofuel development also offers a number of opportunities for developing countries, particularly in terms of income and employment opportunities, and increased energy availability and access in rural areas. As in the case of the risks, these opportunities will not be equally distributed across different groups and individuals, unless specific measures are taken.

On the production side, for instance, the traditional lack of access to land, capital, technology and markets of smallholder farmers (particularly female-headed households) will limit their ability to engage in - and thus benefit from – the production, transportation and processing of liquid biofuel feedstocks. The "biofuels boom" might thus reinforce the exclusion of smallholder farmers, particularly women, from commercial agricultural production.

At the same time, on the demand side, the lack of availability and affordability of modern cooking, heating and lighting appliances among most rural households will prevent them from using liquid biofuels, thus weakening the potential contribution of these fuels to the spread of modern energy services in rural areas.

Understanding and addressing these constraints is essential in order to fully exploit the rural development opportunities and the poverty reduction potential of liquid biofuels.

1.2.1 Rural development potential

The growing global demand for liquid biofuels may create new economic opportunities in rural areas, associated with the production, transportation and processing of liquid biofuels. Rural communities can also derive income from the processing of by-products and co-products of LBP (particularly biodiesel production), such as high-protein livestock feeds, fertilizers, soap and medicine (UNDESA, 2007). As was already discussed, however, in order to exploit these opportunities, it must be ensured that small farmers and women have adequate access to suitable land, capital, technology and markets.

There are significant economies of scale in LBP, particularly in the case of bioethanol[20], though they are relatively less important in the production of feedstock than in the processing stage[21] (Peskett *et al.*, 2007). This tends to favor larger producers and land concentration. Economies of scale are expected to be particularly substantial in second-generation liquid biofuel technologies, due to their requirements for more capital intensive, complex production facilities, giving a further advantage to large producers (ESMAP, 2005).

Although, in general, large-scale LBP schemes tend to be more efficient and competitive, small-scale schemes seem to offer greater opportunities for employment generation and poverty alleviation[22]. All else equal, smaller-scale LBP systems offer higher social returns on public

[20] Biodiesel feedstocks in general require less extensive tracts of land for efficient production than do bioethanol feedstocks, and may be grown in combination with other crops. In addition, most perennial biodiesel crops can be grown on marginal lands and require, on average, less care compared to bioethanol crops (CFC, 2007; UNDESA, 2007).

[21] Feedstock, however, represents the largest cost of production in all current LBP systems (Peskett *et al.*, 2007). According to Schmidhuber, in large bioethanol production plants, for instance, feedstock costs can account for about 70-80 percent of total costs (Schmidhuber, 2007). Maximizing the efficiency of feedstock production is therefore essential in order to minimize overall production costs of liquid biofuels.

[22] Large-scale and small-scale LBP schemes, however, are not mutually exclusive and can interact successfully through various arrangements, including outgrower schemes, service contracts and marketing associations (CFC, 2007).

investments, due to the lowered demand for social-welfare spending and the greater social and economic multiplier effects (UNDESA, 2007). This hypothesis is supported by evidence coming from various countries. In several sub-Saharan countries, for instance, small-scale LBP schemes for local use have shown positive results, providing higher agricultural productivity, more efficient management of natural resources, increased income for local communities and improvement of women's working and living conditions[23] (UNDESA, 2007). Similarly, experiences in Brazil, France, Germany, Mauritius and the United States, among others, have shown that small, locally-owned LBP facilities tend to generate higher local revenues and lower social spending[24] (UN Energy, 2007).

As discussed later in this paper, the rural development potential of liquid biofuels will also depend on the extent to which these fuels increase energy availability and access in rural areas and on the quantity and quality of jobs created by the liquid biofuel industry.

1.2.2 Employment opportunities

LBP may create new employment opportunities in rural areas. In China, for instance, the expansion of the liquid biofuel industry is expected to create up to 9.26 million jobs over the next few years (Bhojvaid, 2006). The impact of LBP on rural employment depends on the type of liquid biofuel crop considered - with oil seed crops such as palm oil and castor oil being particularly labour intensive - and the scale of production - with higher impacts likely to be oriented around local small-scale production and processing for local consumption (ICRISAT, 2007; CFC, 2007).

Beside the (net) job creation potential of LBP, it is also important to consider the quality of the employment opportunities generated by this industry.

These employment opportunities, which tend to decrease with the growing efficiency of the liquid biofuel industry and the gradual mechanization of liquid biofuel feedstock production[25], are targeted mainly to low-skilled agricultural workers, who are increasingly employed on a seasonal or casual basis (SDC, 2007). A growing number of these workers are women (around 40 percent of the total in Latin America and the Caribbean and even more in Africa) (ILO/FAO/IUF, 2007).

The cultivation of liquid biofuel feedstocks such as sugarcane and palm oil has been linked, in several developing countries, to unfair conditions of employment, health and safety

[23] As discussed in the next section, another positive outcome of these schemes is the increased access to energy services in these countries.
[24] For an extensive collection of case studies of small-scale bioenergy initiatives and a discussion of the associated livelihoods impacts see Practical Action Consulting (forthcoming).
[25] In Brazil, for example, despite a strong increase in the production of sugarcane (the main bioethanol feedstock), between 1992 and 2003 total employment in the sugarcane industry decreased from 670,000 to 450,000 (CFC, 2007).

risks, child labour and forced labour, due in part to a lack of agreed or enforceable labour standards in many countries, and lack of labour representation (CFC, 2007; Dufey, 2006). Women working on plantations (including those of liquid biofuel feedstocks) generally tend to be particularly disadvantaged compared to men in terms of wages, working conditions and benefits, training and exposure to safety and health risks (Loewenson, 2000). In Malaysia, for instance, women, who represent about half the workforce on plantations, are often recruited as sprayers of chemical pesticides and herbicides, without proper training and safety equipment (Oxfam, 2007).

1.2.3 Increased energy availability and access

Currently, around 1.6 billion people lack access to electricity and 2.5 billion people (and up to 89 percent of the population in Sub-Saharan Africa[26]) still rely on traditional biomass fuels for cooking (UN Millennium Project, 2005). Lack of access to modern energy services leads to a vicious cycle of poverty, poor health, low productivity and household food insecurity, particularly among women and female-headed households (see box 2). Small-scale production of liquid biofuels for local use[27] may increase energy availability and access in developing countries[28], as shown by the recent positive experiences in some of these countries. In order for liquid biofuels to have these positive effects, however, a number of obstacles must be removed. In particular, liquid biofuels may increase energy availability and access in rural areas only if suitable technologies and devices are made available to local populations for using these fuels to process food, cook, pump water and so on.

Liquid biofuels such as biodiesel or pure-plant oils (also known as "straight vegetable oils") offer opportunities for power production at relatively small scales and, in particular, for small and medium-size electricity grids at village or community levels[29] (UN Energy, 2007). These fuels may be particularly appropriate for remote land-locked regions and small islands, where high transportation costs and poor infrastructure can make liquid biofuels a highly competitive alternative to both traditional (solid) biomass fuels and fossil fuels for domestic uses and small-scale industries (CFC, 2007).

Modern energy services such as electricity and modern cooking fuels may have a positive effect on productivity, health, education, and communication services. Access to these services is thus fundamental to fulfilling basic social needs, fueling human development[30]

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[26] All 31 low human development countries (except for Haiti) are located in this region, with levels of electricity consumption per capita below 1,000 kWh (Gaye, 2007).

[27] For a collection of case studies of small-scale biofuel production schemes for local use in Sub-Saharan Africa, see: UNDESA (2007).

[28] Other "modern" bioenergy technologies have a great potential as well (see box 3).

[29] The adaptation of the many existing diesel engines to use liquid biofuels has enormous potential (UN Energy, 2007).

[30] Pasternak (2000) has analysed the relationship between electricity consumption and the Human Development Index (HDI) in the 60 most populous countries in the world see Pasternak (2000) (cited in Gayle, 2007). According to this study, a threshold of annual electricity consumption of 4,000 kWh per capita is required to achieve an HDI value of 0.9 or greater.

and driving economic growth (Gaye, 2007). The shift from traditional to modern bioenergy services may benefit especially women, by reducing the time they spend collecting firewood and charcoal (see Appendix I) and by limiting their exposure (and the associated health risks) to indoor pollution from the use of traditional, solid fuels (see box 2). It should be noticed, however, that, in most developing countries, only up to one or two percent of the population with access to electricity use it for cooking, while the large majority of households still rely on firewood and charcoal[31] (World Bank, 2008). Food processing (such as threshing, milling and pounding of grains) and water pumping using electric or liquid biofuel-powered devices might have positive implications for food utilization (one of the four dimensions of food security), and a positive effect on women's work burden and time-use as well. In order to determine the net impact of modern liquid biofuels on women's time-use, however, it should be considered that, while introducing these fuels may free (at least in part) women from collecting firewood and water, it could also generate additional work if women produce the biomass to make the fuel (such as for biogas) (UN Energy, 2007).

Box 2
The socio-economic costs of traditional energy production and use

Traditional bioenergy production and use in developing countries gives rise to significant social and economic costs, which affect especially women. As discussed in Appendix I, in most developing countries, women are traditionally responsible for firewood collection and expend large amounts of time and physical effort to supply fuel for their household and productive needs. There is evidence that wood collection exposes women and girls to potential health and safety hazards (Gaye, 2007) and that it limits the time available to them for education and income-generating activities (Nankhni and Findes, 2003). A strong reliance on traditional energy sources also has negative health impacts associated with the use of these sources. Burning of solid biomass in inefficient stoves and/or in unventilated spaces (as is the case for most households in developing countries) produces pollutants, such as particulates, carbon monoxide and formaldehyde, resulting in indoor pollution. Exposure to these pollutants is a major cause of acute respiratory infections, low birth weight and chronic obstructive pulmonary diseases, and it increases the risk of premature death by a factor between two and five[32] (World Bank, 2008; Gaye, 2007; UN Millennium Project, 2005). Once again, women, who carry out a disproportionate amount of cooking activity, are likely to carry a disproportionate disease burden (UN Millennium Project, 2005). Young children, who spend a significant amount of time inside the household with their mothers, are particularly exposed to and affected by indoor pollution as well[33]. There is evidence that indoor air pollution is responsible for 1.6 million premature deaths per year, of which 60 percent are women, with death rates being highest among the poor in Sub-Saharan Africa and Southeast Asia (Bruce et al., 2000). Since traditional bioenergy production and use has more negative impacts on women than men (especially in terms of health and time use), it contributes to the relative disempowerment of women as a gender group (UN Energy, 2007).

[31] The only exception is represented by East Asian countries, where rice cookers are a common purchase in electrified households (World Bank, 2008).
[32] As reported by UN Millennium Project (2005), recently there has been significant progress in identifying, measuring and documenting quantitative links between solid fuel use for cooking and the associated health impacts and disease burden.
[33] According to the World Health Organization, respiratory infections account for up to 20 percent of the 11 million child death each year (WHO, 2002).

Box 3
Energy services for rural areas: alternative options

The potential for locally-produced liquid biofuels to meet the energy needs of rural populations depends on a number of factors, including existing liquid biofuel feedstock sources in the area considered, technology availability and capacity, and skill set base at the local and community level (UNDESA, 2007).

The use of liquid biofuels for power generation, heating and cooking, however, is only one of many solutions for increasing availability of and access to energy services in rural areas. Among other modern bioenergy options, biogas (which can be obtained from animal manure and sewage sludge) has been successfully used in a number of developing countries for electricity production and cooking. Other renewable, locally-available energy solutions in rural areas include microhydro, wind energy, and solar systems such as cookers and water heaters. Fossil-fuel based options should be considered as well, at least in the short- and medium-term. In many instances, for example, the shift from traditional biomass to liquid petroleum gas (LPG) for cooking can significantly reduce wood demand, heavy human work and smoke-related problems (UN Energy, 2007).

Local conditions (both biophysical and socio-economic) should be considered in order to identify the most efficient and cost-effective mix of solutions for each specific rural area.

1.2.4 Increased energy security and better trade balance

Finally, although these potential benefits will not necessarily trickle down to the household level, it is important to consider that, at the macroeconomic level, LBP might have a positive effect on the energy security and the trade balance of certain developing countries. As a matter of fact, it should be noted that energy security and the improvement of the trade balance are among the main drivers and objectives of the liquid biofuel development policies and programmes that have been adopted by some developing countries, such as Brazil and Thailand.

Of the world's 50 poorest countries, 38 are net importers of petroleum and 25 meet their total petroleum demand through imports (UN Energy, 2007). Oil import dependency is especially acute in Sub-Saharan and East Asian countries, where 98 percent and 85 percent of their oil needs are met by imports, respectively (ESMAP, 2005). Domestic LBP offers developing countries an opportunity to reduce their dependence on oil imports, making these countries less vulnerable to oil price increases and the associated impacts. The 2005 oil price surge, for instance, reduced GDP growth of net oil importing countries from 6.4 percent to 3.7 percent; as a result, in these countries the number of people in poverty rose by up to four-six percent, with nearly 20 countries experiencing increases of more than two percent[34]. The potential for liquid biofuels to reduce the dependence on oil imports (and on oil in general), however,

[34] Due to the recent oil price increases, some of the world's poorest countries now spend twice the money on fuels as on poverty reduction, and others spend as much as six times on fuel as they do on health (UN Energy, 2007).

should not be overestimated. Despite the rapid increase in LBP, so far liquid biofuels have only replaced around one-two percent of global fossil fuel use for transport and a much lower percentage of total fossil fuel use (FAO, 2008).

Several countries also see in liquid biofuels an opportunity to develop new export markets for their agricultural produce. This is the case, especially, for tropical and sub-tropical countries producing sugarcane and palm oil, whose energy content is significantly higher than grain or cereals, making these crops particularly suitable for LBP. This potential increase in export revenues, combined with the partial replacement of oil imports with locally-produced liquid biofuels, would lead to an improvement in the trade balance of these countries[35] (CFC, 2007). The development of a successful export-oriented liquid biofuel sector in these countries, however, requires getting access to the technology to produce liquid biofuels efficiently and in compliance with relevant technical standards in importing markets, and developing a suitable transport infrastructure (roads, waterways and ports) to reach these markets (CFC, 2007).

[35] According to Dufey (2006), for instance, replacing imported gasoline with bioethanol saved Brazil around US$ 43.5 billion between 1976 and 2000.

2 MAKING LIQUID BIOFUEL PRODUCTION SUSTAINABLE AND PRO-POOR

As was discussed in this paper, the production of liquid biofuels is rapidly increasing in developing countries, due mainly to the policies that numerous countries have recently adopted to promote or mandate the use of these fuels. These policies aim to achieve multiple goals, most notably climate change mitigation, increased energy security and availability, and rural development[36].

As shown in this paper, liquid biofuels certainly offer opportunities for developing countries, but only if measures are adopted to minimize the risks and to maximize the opportunities discussed above. In particular, in order to exploit the rural development potential of liquid biofuels, it is crucial to ensure that these fuels are produced in a sustainable way and that small farmers (especially women) and local communities may engage in and benefit from their production and use. To this goal, liquid biofuel development policies and strategies should aim to:

- **Promote additional research** on the environmental impacts and both the socio-economic risks and opportunities of liquid biofuel production and use in developing countries. This research should inform both the liquid biofuel policies and strategies that several developing countries are currently introducing and the international debate on sustainable biofuel principles and standards.

- **Pursue both food and energy security through an integrated approach**. This could be done by:

[36] Biofuel production is only one of multiple options for achieving these policy objectives, thus it is important to compare the pros and cons of these different options and the costs and benefits of the policies and incentives needed to support them.

1. **Ensuring that the establishment of plantations for LBP integrates** – rather than replaces – **existing local agri-food systems**[37]. Whenever possible, non edible crops that can be grown on low-quality and arid lands with limited input requirements should be used for LBP, in order to reduce competition (both direct and indirect) with food production (UNDESA, 2007). In particular, the sustainable cultivation of multi-purpose, short-duration annual crops that can either be grown in rotation with food crops or simultaneously yield fuel along with food, fodder and/or other by-/co-products, could be promoted[38] (Rajagopal, 2007). This would provide additional seasonal income for local farmers, while preserving their traditional agricultural activities, skills and specialized knowledge, which are crucial to the food security and long-term resilience of rural communities.
2. **Supporting the local use of liquid biofuels** (including pure plant oils) **for power generation, cooking and heating**, together with other sustainable, renewable energy and bioenergy options (box 3). This would help increase access to modern energy services for rural communities still heavily reliant on solid biomass for their energy needs.
   Reliability, local maintenance and monitoring capacity, and affordability are in many cases key barriers to the spread of modern bioenergy technologies in rural areas. These barriers should be identified and addressed. Where the shift from traditional to modern bioenergy fuels is not (yet) feasible, traditional bioenergy use should be improved and made more sustainable (UN Energy, 2007).
3. **Promoting**, over the longer term, **the development and commercialization of second-generation liquid biofuels** produced from agriculture and forest residues and by-products (and thus not interfering with food production). The availability of second-generation liquid biofuel technologies in developing countries and small producers' access to them should be ensured.

- Promote the environmental sustainability of LBP. This requires ensuring that LBP does not contribute to deforestation and to biodiversity loss (or to greenhouse gas emissions) through either direct or indirect land-use changes. At the same time, the adoption of sustainable farming practices (such as multi-/inter-cropping, rotations, conservation tillage and use of organic fertilizers) should be promoted, in order to preserve soil health and minimize water and agrochemical inputs. As shown recently in a number of studies (e.g. Fargione *et al*., 2008), ensuring the environmental sustainability of LBP is also essential for exploiting the greenhouse gas mitigation potential of such fuels.

- Promote the "social sustainability" of LBP. This requires ensuring that the establishment and expansion of large-scale plantations for LBP does not lead to the displacement of local communities and their activities, with a particular focus on vulnerable groups (such as indigenous peoples and women) with limited - if any - access to land.

[37] In line with this argument, from a policy perspective it is important to ensure the integration of bioenergy development into existing rural development policies.

[38] Among bioethanol feedstocks, sweet sorghum yields sugar as well as grain and stalk (excellent livestock feed after the sugar is extracted) (ICRISAT, 2007).

In the identification of suitable land for LBP, developing country governments should carefully assess and consider all existing uses of the land, including activities such as livestock grazing and gathering of wild products conducted by local communities on marginal or seemingly abandoned land[39]. The other ecosystem services provided by the land, particularly those that are most essential to subsistence farmers and the rural poor, should be considered as well.

It should also be ensured that LBP does not reduce the access of smallholder farmers and rural households to water for irrigation and household purposes.

Finally, decent work should be promoted for both male and female workers in the liquid biofuel industry, in line with ILO's international labour standards. This entails, among other things, the recognition of farmers' unions and trade unions.

- Strengthen the participation of small farmers in LBP. This requires addressing the same constraints that small farmers traditionally face in food production, most notably lack of access to land, formal credit schemes (and thus capital), technology (such as farming equipment) and markets.

  Access to land, in particular, is key to being able to participate in LBP. For this reason, when land is allocated to liquid biofuel feedstock production, the ownership and use structure of the land should be assessed, in order to determine whether rural households (particularly female-headed ones) own land or can obtain usufruct rights on it for growing energy crops; potential barriers should be identify and removed (UNDESA, 2007).

  Another challenge that prospective small-scale liquid biofuel and liquid biofuel-feedstock producers have to face is the obtainment of credit from traditional financing institutions, due to less favourable risk-rating of liquid biofuel projects compared to more established energy technologies (UN-Energy, 2007). In those cases, governments can either offer policy and technical support to these producers (in order to reduce the perceived risk), or directly provide loan guarantees, soft loans or alternative credit delivery systems such as microcredit (CFC, 2007).

  Finally, given small farmers' traditional lack of access to technology, support should be provided to local development and production of liquid biofuel technologies, products and equipment (UNDESA, 2007). In addition, capacity building and technological assistance should be provided, including training of farmers and transfer of technical and managerial skills. In particular, agricultural extension services should be offered to small-scale liquid biofuel feedstock producers, in order to disseminate best practices, facilitate farmer-to-farmer participatory learning, and encourage and address farmers' requests for technical advice[40] (UN Energy, 2007). Access to these extension services should be ensured for both male and female producers.

[39] For a discussion of the potential for bioenergy production on abandoned lands, see Campbell *et al.* (2008).

[40] International capacity-building activities could help to build the know-how that is a prerequisite for extension services (UN Energy, 2007).

Small farmers' participation in LBP may also be strenghtened by supporting the establishment of cooperatives, in which both men and women, as well as male- and female-headed households, should have equal representation. By organizing themselves in cooperatives, small farmers may take advantage of the economies of scale associated with the production of liquid biofuel feedstocks and meet more easily and efficiently the feedstock volume and reliability needs of conversion facilities[41].

Small farmers' participation in LBP may also be promoted, for instance, through the provision of tax incentives to those companies that source their feedstock from small-scale farms (e.g. the "Social Seal" system in Brazil) (CFC, 2007).

Finally, social and economic multiplier effects of LBP are expected to be highest when small farmers' participation in - and ownership of - value-added parts of the production chain, such as transport and processing (of the biomass), is ensured (CFC, 2007). Policy interventions should aim to strengthening small farmers' participation and ownership in the value chain and to promoting revenue sharing along it. An interesting example may be found in Mauritius, where small sugarcane farmers share the revenues from large-scale bagasse-based cogeneration plants (CFC, 2007).

Ensuring support to small-scale liquid biofuel production schemes is essential in order to maximize the rural development potential of LBP. As discussed in this paper, smaller-scale liquid biofuel production systems, particularly those directed to meet the energy needs of rural populations, offer higher social returns on public investments, due both to the lowered demand for social-welfare spending and to greater social and economic multiplier effects (UNDESA, 2007).

- **Ensure that women and female-headed households may engage in and benefit from the sustainable production of liquid biofuels**. This entails removing pre-existing gender-based inequalities, particularly in terms of access to - and control over – key productive resources and assets, including land, capital and technology[42]; these inequalities have been linked with production inefficiency (IFPRI, 2008a). This is all the more important as the number of households headed by women is growing, with around 40 percent of the total in Southern Africa and 35 percent in the Caribbean (UNDESA, 2000).

  If gender-based inequalities are not considered and addressed in the development and implementation of liquid biofuel development policies and strategies, the majority of these households might be excluded from LBP and most of the rural development and poverty reduction opportunities offered by liquid biofuels would be missed. In addition, without specific attention to gender issues and appropriate measures to address them, liquid biofuel development might reinforce gender-based inequalities, increasing resource imbalances.

[41] Where large groups dominate the bioenergy industry, farmer cooperatives are particularly effective in linking independent growers to these large groups (UN Energy, 2007).

[42] This could be done, for instance, by strengthening and enforcing women's property rights.

APPENDIX 1
FIREWOOD AND WATER COLLECTION: IMPACTS ON THE TIME-USE OF MEN AND WOMEN

Traveling distance and time spent collecting firewood and fetching water depend on the availability and accessibility of each of these resources, land ownership, property or usufruct rights for water and household size. In most developing countries, firewood and water collection are extremely time- and energy-intensive activities, particularly in remote rural areas. Generally, women are mostly responsible for these activities. Evidence from Sub-Saharan Africa, for instance, shows that women spend, on average, up to three or four hundred percent more time than men fetching water and collecting firewood (see table 2). In the case of water, there is also evidence that women tend to collect higher volumes than men (Rosen and Vincent, 1999). Often, firewood and water collection are also associated with child labour. Although evidence is not conclusive if boys or girls spend more time on these activities, Nankhuni (2004) found that in Malawi being female was the most significant determinant of a child participating in firewood and water collection. According to the same study, girls were more likely than boys to be involved in these activities while simultaneously attending school (World Bank, 2006). Data on the time spent by boys and girls for firewood and water collection in three Sub-Saharan countries are reported in table 3.

Table 2
Time spent per day on firewood and water collection by all women and men[43] (in hours and minutes)

		Benin (1998)			Ghana (1998-99)			Madagascar (2001)		
		W	M	W/M	W	M	W/M	W	M	W/M
Fetching water	Urban	16	6	267%	33	31	106%	16	10	160%
	Rural	1h2	16	388%	44	34	129%	32	8	400%
	Urban and rural	45	12	375%	41	33	124%	27	9	300%
Collecting firewood	Urban	3	1	300%	44	51	86%	3	6	50%
	Rural	23	5	460%	37	28	132%	8	27	30%
	Urban and rural	16	4	400%	37	30	123%	7	13	54%

Adapted from: World Bank (2006).

Table 3
Time spent per day on firewood and water collection by girls and boys aged 6 to 14 (in hours and minutes)

		Benin (1998)			Madagascar (2001)		
		W	M	W/M	W	M	W/M
Fetching water	Urban	16	10	160%	17	17	100%
	Rural	1h3	24	263%	37	16	231%
	Urban and rural	46	19	242%	31	16	194%
Collecting firewood	Urban	2	2	100%	2	6	33%
	Rural	17	7	243%	7	24	29%
	Urban and rural	12	5	240%	6	19	32%

Adapted from: World Bank (2006).

[43] Even when only women and men engaged in firewood and water collection are considered, women spend more time than men performing these tasks.

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Gender, Equity and Rural Employment Division
Economic and Social Development Department

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