1. Introduction

1.1 Context and purpose of this study

Biomass has been used for energy since the early days of humanity. Today, 52% of the population of the developing world, including 575 million people in sub-Saharan Africa, rely on traditional biomass, particularly fuelwood and charcoal, for their household energy (IEA, 2006). But recent years have witnessed a massive and growing expansion of a particular form of biomass-based energy: liquid biofuels. Although bioethanol and biodiesel still account for a very small share of global energy consumption in Western countries – the equivalent of 1% of total consumption of fuel for road transport – that share is growing fast (IEA, 2006). In addition, the wider implications of biofuels constituting even a small share of global energy consumption - for instance, in terms of land use - may be very significant.

As the industry grows, so does the debate over the merits and demerits of biofuels. Contentious issues include the ability of biofuels to mitigate climate change effectively, the role of biofuels in recent food price hikes, and the threat of biofuel production to natural ecosystems. A number of major reviews in recent years (e.g. Kojima and Johnson, 2005; Worldwatch Institute, 2006; UN-Energy, 2007) have provided detailed and balanced analyses of the likely impacts of biofuels on local and global economies, society and environment. Food security is highlighted as a major concern.

Food security has multiple dimensions – availability, access, stability and utilisation – and a key determinant of all of these is how access to land is distributed and controlled within society (FAO, 2007). Land means much more than provision of food, however. Land also has major historical, political, cultural and spiritual significance. But the more detailed reviews have so far tended to discuss land only briefly, and largely in terms of food security.

This study aims to open up discussion of the way in which biofuels are likely to impact on access to land. Many observers and activists have raised concerns that the spread of biofuels may result in loss of land access for poorer rural people in localities that produce biofuel crops. However, since liquid biofuels are a relatively new phenomenon in most countries (with exceptions such as Brazil and Zimbabwe), there is as yet little empirical evidence. This study aims to pave the way for future empirical research on how the biofuels boom affects land access, by raising key issues, presenting a basic conceptual framework and presenting a suite of (primarily anecdotal rather than empirical) evidence from around the world.

The recent nature of the biofuels debate, coupled with the scarcity of empirical research on the linkages between the spread of biofuels and land access, raise challenges for a desk-based study on this issue. Owing to these circumstances, we relied on internet-based grey literature, on newspaper articles and on personal communications (telephone calls and face-to-face conversations) to a greater extent than in many research efforts. As a result, the findings of this study can only be considered as preliminary. The aim here is not to provide definitive answers, but to pave the way for future empirical research, through developing a conceptual framework for such research and through taking stock of data available in the literature. Preliminary experience however does provide some pointers for policy and practice by governments and the private sector, which are outlined in the concluding chapter.

The impacts of the spread of biofuels on land access for poorer groups are likely to be similar to those generated by the spread of other cash crops in the past. Indeed, some biofuels feedstocks, such as palm oil and soy beans, are already major cash crops for fodder, food and cosmetics. The key difference with the current biofuels boom is that biofuels lie at the interface between the agriculture and energy sectors. Therefore, not only are biofuel crops likely to be much more highly regulated than other agricultural commodities, government consumption targets are creating an artificial demand that is unprecedented among cash crops, and which is likely to persist beyond the usual length of a "commodity boom" cycle. Nonetheless, commonalities enable us to learn from recent and historical experiences with rapid expansion of commodity crops.

As part of its paving the way to more research and debate on these issues, the study aims to promote greater exchange between biofuels and land tenure specialists. In order to do this, it seeks to be accessible for both sets of readers: those working on biofuels who have no specific background in land access issues, and those working on land access who have no specific expertise on biofuels. As a result, some of the conceptual and introductory parts may appear elementary to the relevant specialist. Box 1 presents definitions and discussion of the key terms used through the text.

The report is organised as follows. The next section provides a short overview of trends in – and drivers of – biofuels production. Chapter 2 maps out the anticipated links between the spread of biofuel crops and land access. Chapter 3 discusses available evidence concerning these links, while the final Chapter 4 draws some conclusions and suggests ways forward.

1.2 The biofuels boom: drivers and trends

Government policy has been the key driver of the expanding market for biofuels. Governments all over the world – including those in China, India, Brazil, the US and the EU – have enacted mandatory targets for use of biofuels in transportation fuels, creating guaranteed market for biofuels for decades to come. Government policies have also provided financial incentives to the private sector (e.g. subsidies and tax breaks; see Jull et al, 2007 for a detailed global review of recent legislation). Legislation on biofuels is becoming the norm rather than the exception: 27 of 50 countries surveyed in 2007 had enacted, or had under consideration, mandatory requirements for biofuels to be blended with traditional transport fuels, and 40 had legislation to promote biofuels (Rothkopf, 2007).

Governments are not always explicit about their reasons for promotion of biofuels. Mitigation of climate change is often presented as a key policy goal, but there are growing doubts on the efficacy of biofuels in reducing carbon emissions, largely because of the impacts of large-scale land use change (e.g. Searchinger et al, 2008 and Fargione et al, 2008). More compelling reasons for governments to pursue a switch from oil to biofuels are threefold (Dufey et al, 2007):

Box 1. Key terms

Biofuels are liquid fuels manufactured from biomass. They are used mainly for transport or heating. They can be produced from agricultural products, and forest products, or from the biodegradable portion of industrial and municipal waste. Bioethanol and biodiesel account for more than 90% of global biofuel use. Biofuels are made from biofuel feedstocks, plant or animal materials that may be produced especially or may be by-products or wastes from other industries.

Bioethanol is a distilled liquid produced by fermenting sugars from sugar plants and cereal crops (e.g. sugarcane, maize, sugarbeet, cassava, wheat, sorghum). A ***second generation*** of bioethanol – lignocellulosic - makes use of a range of lignin and cellulose materials such as short-rotation wood coppices and energy grasses. Bioethanol can be used in pure form in specially adapted vehicles, or blended with gasoline.

Biodiesel is produced from organic oils, usually from the oily fruits of crops such as rapeseed, sunflower, soya, castor, oil palm, coconut or jatropha, but also from animal fats, tallow and waste cooking oil. A ***second generation*** of biodiesel technologies synthesises diesel fuels from wood and straw. Like bioethanol, biodiesel can be used in pure form in specially adapted vehicles or blended with automotive diesel. A ***third generation*** of biodiesel technologies will use oils from algae.

Access to land is broadly defined as the processes by which people, individually or collectively, are *able* to use land, whether on a temporary or permanent basis. These processes include participation in both formal and informal markets, land access through kinship and social networks, including the transmission of land rights through inheritance and within families, and land allocation by the state and other authorities (e.g. customary institutions).

Land tenure refers to the arrangements (rules, institutions and processes) through which people gain legitimate access to land, they use land and participate in the benefits deriving from it, and they hold, manage and transact it. These arrangements involve diverse sets of ***land rights*** – from outright ownership to a range of other land holding and use rights (leasehold, usufruct, servitudes, grazing rights, etc), which may coexist over the same plot of land. Land rights may be held by individuals or groups (e.g. private property) or by the state (ownership, trusteeship, etc). They may be based on national legislation, on customary law or on combinations of both.

Land *access* is therefore broader than land *rights* in a legalistic sense. Land rights do determine access, not only rights of full ownership but also a much wider range of entitlements (e.g. various types of use rights). But access to land is also shaped by social relations, including control over markets, capital and technology, by relations of power, authority and social identity, and by relations of reciprocity, kinship and friendship. These factors may entail a disconnection between having a legal *right* to use land and being *able* to claim and enjoy that right in practice (Ribot and Peluso, 2003; Cotula, forthcoming).

Security of land rights refers to the extent to which land users can be confident that they will not be arbitrarily deprived of their land rights and/or benefits deriving from these. This confidence includes both objective elements (nature, content, clarity, duration and enforceability of rights) and subjective elements (the land users' perception of the security of their rights).

On the other hand, ***land use*** is "characterised by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it" (FAO, 1999). "Land use concerns the products and/or benefits obtained from use of the land as well as the land management actions (activities) carried out by humans to produce those products and benefits".

- Energy security: with oil at over US$100 per barrel and future supplies uncertain, countries are seeking alternative energy sources to increase long-term energy security and reduce energy import bills.
- Rural development: a new and profitable land use will provide better opportunities and long-term security for farmers and employees, plus - if processing facilities are near to farms - for value-addition to profit rural areas.
- Export development: for countries with favourable endowments of land, labour and trade conditions, biofuels are an opportunity to develop new export markets and improve the trade balance.

In response to policy signals, the industry is expanding rapidly. Biofuels production comprises, crudely, production of the feedstock followed by manufacture of the liquid biofuel. For second generation biofuels, feedstocks will comprise wastes from the forestry and agrifood industries (e.g. wood offcuts, crop residues), other domestic and industrial waste products (e.g. waste paper, household rubbish) and purpose-grown grasses and coppice woods. Thus the feedstocks of second generation biofuels are low-cost – but the manufacturing processes require sophisticated technologies, largely still under development. First generation biofuels, by contrast, rely on relatively simple manufacturing processes, suitable even for small-scale implementation in remote villages, but need feedstocks that are high in fats (for biodiesel) or sugars/carbohydrates (for bioethanol). Second generation biofuels are beginning to come on-stream with pilot plants in Japan and the US, but for the time being most biofuels will be first generation.

Production of the feedstock and manufacture of the biofuel can occur a substantial distance apart. Oil palm kernels, for instance, are partially processed in onsite mills in Malaysia and Indonesia, then shipped in large quantities as crude palm oil to biorefineries in the Netherlands and Germany, where biodiesel is manufactured. But transport can be a prohibitive cost. For a bulk crop such as sugarcane, used to manufacture bioethanol, there is little point in exporting the unprocessed feedstock. These factors explain the prevailing global patterns of biofuel production. The countries that produce most bioethanol are Brazil, where 45-55% of the national sugarcane crop is used as biofuel feedstock, and the US, where, pushed by strong federal governmental support, bioethanol production has recently surpassed that of Brazil (F.O. Licht, 2008). European countries are currently the leading manufacturers of biodiesel, processing vegetable oils from locally grown crops (e.g. oilseed rape), but increasingly reliant on imported feedstocks (e.g. crude palm oil imported from Indonesia and Malaysia).

Production is established and expanding rapidly in many other countries with more recent or less prominent biofuels tradition. Zimbabwe began manufacture of bioethanol to supply a 5% mix in road fuel in the early 1980s, following the lead of Brazil’s already well-established industry. China and India began production of bioethanol in 2000, and are now the third and fifth largest global producers respectively (F.O. Licht, 2008). China’s 2006 production was up to 2,000 million litres, while India manufactures 300 million litres annually (Worldwatch Institute, 2006:6). India is also investing heavily in jatropha cultivation for biofuels (Gonsalves, 2006). Malaysia and Indonesia, major producers of oil palm, are now expanding into biodiesel manufacture. Malaysia is the leading producer of biodiesel in Asia, with five biodiesel plants already in operation and another 91 given government approval (F.O. Licht, 2008:157).

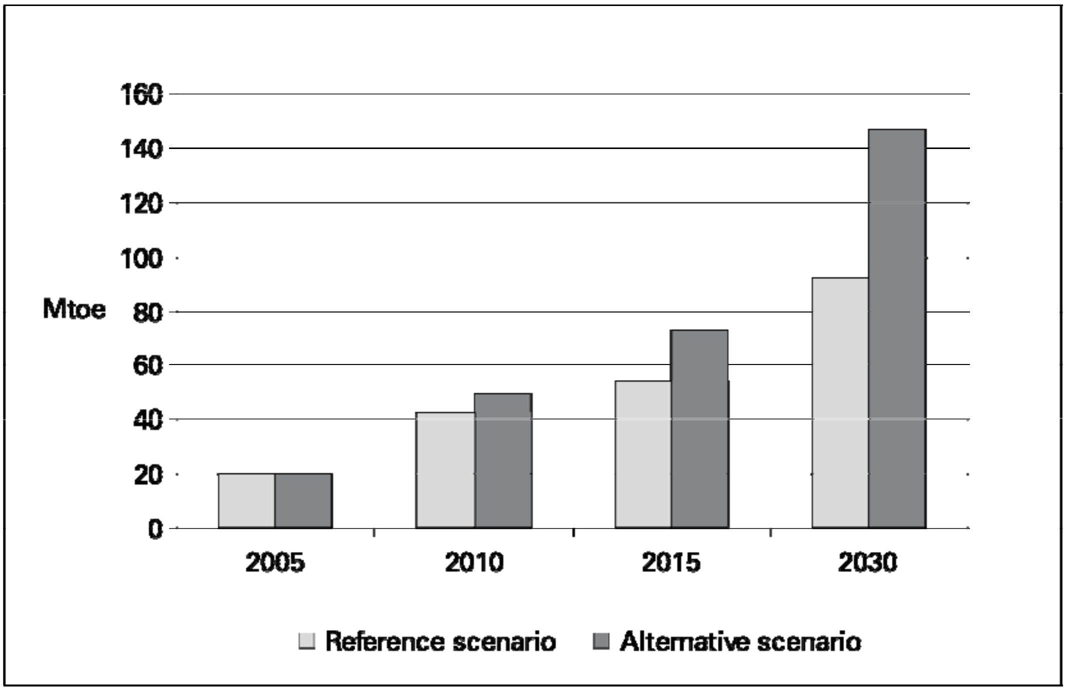
The future will see accelerating growth in production of feedstocks and manufacture of bioethanol and biodiesel using first generation technologies. For example, in Brazil, biofuel production (mainly bioethanol) is predicted to rise to 44,000 million litres by 2016, an increase of 145% on the country's 2006 output (OECD-FAO, 2007: 20). Likewise, bioethanol production in China is expected to reach 3,800 million litres per annum by 2016, an increase of 250% on 2006 output (OECD-FAO, 2007:20).

In Africa, several governments have made moves to promote biofuels production. In South Africa, the government plans to invest US$437 million in five biofuel projects, and a conglomerate of commercial maize farmers plans to build eight ethanol plants (GRAIN, 2007:40). In Ghana, the government pledged US$2 million to assist a large-scale jatropha cultivation scheme in the centre of the country (GRAIN, 2007:38). Sugar cane and cassava in Nigeria, jatropha in Tanzania and Kenya, and palm oil in Cameroon have also been attracting significant investment from both public and private sectors (GRAIN, 2007).

The Indian government is implementing a National Biodiesel Mission with the aim of kick-starting the country's biodiesel production in two phases. Phase I (2003-2007) involves the cultivation of the cultivation of 400,000 ha of jatropha, and a series of jatropha oil extraction and biodiesel plants. The ambitious Phase II aims to provide 20% of India's diesel requirements by 2012, which is estimated to require the cultivation of 14 million ha of jatropha (Gonsalves, 2006:22, 40). Production of biodiesel from jatropha is focused in the southern state of Andhra Pradesh. Naturol Bioenergy Limited (NBL), a joint US-Austrian private venture, has been granted 120,000 ha in the state for jatropha cultivation (Gonsalves, 2006:30). NBL's first biodiesel plant in Kakinadad, Andhra Pradesh started commercial production in October 2007 (with a capacity of 100,000 tonnes per annum).

On the global level, IEA (2006) has predicted trends under a Reference Scenario, based on the assumption that current national biofuel policies will remain in place, and an Alternative Policy Scenario, which takes into account enhanced policies to stimulate the biofuel industry (such as subsidies for producers and consumers, support for the car industry, increased research and development spending, and reduced barriers to trade). Under the Reference Scenario, biofuel production to 2030 is predicted to rise sharply from 20 Mtoe (2005) to 54 Mtoe by 2015 and to 92 Mtoe by 2030 (Figure 1). Under the Alternative Policy Scenario production rises even more steeply to 73 Mtoe (2015) and to 147 Mtoe (2030). This represents an annual biofuels growth rate of 6.3% in the Reference Scenario, and of 8.3% in the Alternative Policy Scenario. While biofuels currently meet 1% of global demand for transport fuel, this share is set to rise to 4% in Reference Scenario and to 7% in Alternative Policy Scenario by 2030.

Figure 1. Predicted biofuel production 2005-2030



Source: IEA (2006:394-395)

1.3 Linking the biofuels boom, food security and access to land

Biofuels production may offer income-generation opportunities in rural areas. By generating income, biofuel production may help improve prospects for food security - namely, by enabling farmers to purchase food on the market. It may also offer an opportunity for farmers - traditionally squeezed by low agricultural prices - to get better terms of trade; and for countries having abundant land areas but poor in other natural endowments to pursue new development opportunities. In addition, biofuel production may help poorer countries and communities move towards energy security and mitigate the negative impacts of high oil price – and, through that, help promote food security.

On the other hand, biofuels production may compete with food crops and have significant negative impacts on food security - the so-called “food versus fuel” debate. Recent hikes in world food prices have not been caused primarily by biofuels - rather, the main drivers have been weather-related shortfalls, reduced global stocks and increased demand for food and fodder from growing economies (e.g. in Asia). However, competition between biofuels and food, as an end-use of the same crop (e.g. maize, sugarcane) or as alternative land uses (e.g. oil palm versus food crops), may increase pressures over world food prices over the next few years. Several studies predict significant future increases in world food prices due to demand for feedstocks for biofuel production (e.g. IFPRI, 2006; OECD-FAO, 2007). These concerns are particularly relevant for large-scale commercial biofuel production, which tends to take place on lands that would be suitable for food production.

Rising food prices are likely to have negative effects on access to food for poorer and more vulnerable groups. It is for this reason that the UN Special Rapporteur on the Right to Food, Jean Ziegler, provocatively condemned the growing use of biofuels as a "crime against humanity".[1] These pressures are likely to be exacerbated by the strong demographic growth and the rising urbanisation common in African, Asian and South American countries. Demographic growth increases pressure on food supply. Urbanisation makes growing shares of the population dependent on food supply from rural areas. In turn, this increases vulnerability to hunger and malnutrition among poor urban consumers, as well as among poorer farmers, who tend to be net food consumers rather than net food producers (Dufey et al, 2007).

One of the impacts on food security is through impacts on access to land for people who depend on land-based agricultural livelihoods. Policy and market incentives to turn land over to biofuels production will tend to raise land values. While in some cases this could give new opportunities to poor farmers, it could also provide grounds for displacement of poorer people from land. As biofuels begin to push up prices of food and people are hence most in need of land for production, poor people's access to that land is liable to be weakened.

It must also be noted, however, that land access is not just a means for food production and a mechanism for food security. In many parts of the world, land is a source of political power, a basis for complex relations of alliance and reciprocity, and a central component of social identity. Securing land access for poorer groups is a challenge that overlaps significantly with, but is not subsumed within efforts to promote food security.

[1] BBC News, 30 November 2007 (www.bbc.co.uk).

2. Anticipated impacts of biofuels on access to land

2.1 Conceptualising impacts of biofuels expansion on access to land

The spread of commercial planting of biofuels crops, whether for export or for internal markets, has significant implications for land use and access in producer countries. These implications reflect complex relations among the diverse production systems for the cultivation of biofuels, on the one hand, and diverse land access relations, on the other. This chapter maps out these relations and outlines the impacts on land use and land access that might be anticipated given current projections and trends.

Figure 2 below synthesises the analysis in a single diagram. While visual representations may help clarify concepts and linkages, they also inevitably entail a simplification of complex issues. In this case, the diagram provides a basis for examining each of the linkages from biofuel expansion through to land access impacts in turn: first the relationship between increased demand for biofuels and increased demand for land, then the effects of increasing land demand on land access, and finally the set of mediating factors that affect outcomes for land use and land access. The remainder of this chapter explores these questions and issues in turn.

2.2 Increased demand for biofuels and increased demand for land

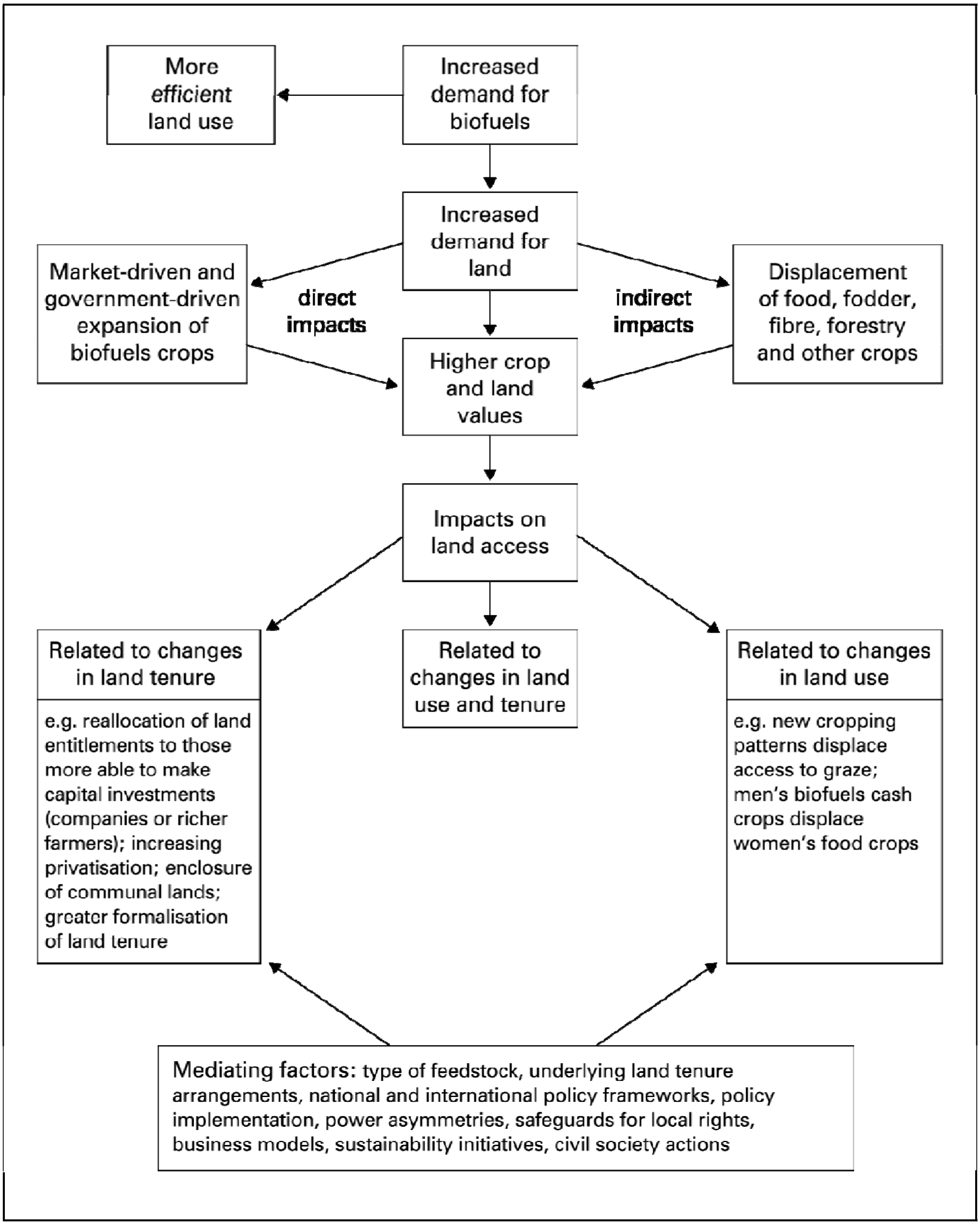
Before considering impacts on access to land for poor people in rural areas, there is an underlying question of just how much land biofuel feedstocks may be expected to occupy in coming decades: the link between biofuels demand and land demand. The questions outlined below work through the key issues and the projections of agricultural analysts.

To what extent can increased demand for biofuels feedstocks be met by more intensive land use rather than more extensive land use?

The increased demand for biofuels can be met on one hand by technical improvements in production: more efficient processing and higher yields of feedstocks per unit area. Second generation and third generation biofuels are likely to accelerate efficient land use, making better use of waste products, marginal land and space-saving technologies. Even for first generation biofuels, more intensive land use, producing higher yields, could meet a proportion of the increased demand for feedstocks. During the Green Revolution of the 1970s, impressive yield increases of around 4% per year were achieved in Asia and Latin America, due largely to use of new varieties, irrigation and chemical fertilisers. By contrast, from the 1970s through to the 1990s cereal yields stagnated at around 1 t per ha in Africa, which was effectively bypassed by the Green Revolution (Dentzer and Rose, 1996). Today yields continue to grow globally, but at a much slower rate. Up to 2020, annual increases in cereal yields are expected to be about 1.3% globally, with 0.9% in developed countries and 1.7% in developing countries (Pinstrup-Andersen et al, 1999).

Looking at biofuel feedstocks, we can expect yields of cereal feedstocks for bioethanol to increase at similar rates (1-2% per year). Non-cereal feedstock yields are likely to increase at lower or similar rates, depending on investments in technology and research (as most crops have lagged behind cereals in terms of yield increases). Perhaps among the more newly commercialised crops, such as jatropha, future yield increases might happen more rapidly. For example, D1 Oils plc's early plantings used locally collected seeds, but are now shifting to improved hybrid varieties (D1 Oils plc, 2008).

Figure 2. Conceptual linkages between the spread of biofuels and land access



Clearly, we cannot rely on yield increases alone to supply the rapidly growing demand for biofuel feedstocks. In addition, gains in yields will not be spread equally. Africa did not benefit from the Green Revolution, with crop yields across the continent declining slightly during the 1970s and beyond. Yield increases are often confined to the large-scale farming sector, with small-scale producers unable to take advantage of new technologies and high cost inputs (though when they do have access, their yields are comparable with large-scale farms, as demonstrated by palm oil smallholders in Malaysia; Vermeulen and Goad, 2006). Climate change will cause additional uncertainties and variability in conditions for crop production.

For the purposes of this report, a final point worth noting is that intensification of land use can also have impacts on land access. Use of high-cost inputs (seeds, fertilisers, pesticides) may be associated with agribusiness contracts that are inaccessible to farmers who do not meet the entry criteria (e.g. large enough farm size, sufficient financial capital, master farmer certificate).

How much land is required to meet projected demand for biofuels feedstocks?

In 2006 an estimated 14 million ha of land was used for the production of biofuels and by-products, approximately 1% of globally available arable land (IEA, 2006:413). A number of analysts have since come forward with projections of future land needs for biofuel production. One recent study estimates that demand for maize-based ethanol from the US alone will put 12.8 million ha under maize in the US by 2016, thereby bringing 10.8 million ha new agricultural land into production, mainly in Brazil, China, India and the US (Searchinger et al, 2008).

At the global level, according to IEA's "World Outlook 2006" projected growth in biofuel production to 2030 will require 35 million ha of land (2.5% of available arable land, approximately equal to the combined area of France and Spain) in the Reference Scenario (see Chapter 1), and 53 million ha of land (3.8% of available arable land) in the Alternative Policy Scenario (IEA, 2006:416). For comparison, a recent review of a range of economic estimates of future biofuels demand claims that even modest greenhouse gas regulations, combined with successful development of second generation biofuels, could lead to 1,500 million ha, equivalent to the current total global farmland, under biofuel crops by 2050 (Field et al, 2007).

How much land is actually available to meet these needs[2]?

The Global Agro-ecological Assessment (Fischer et al, 2002), based on satellite imagery, provides the most comprehensive survey of global agricultural potential. At the global level, 2,541 million ha of land have potential for cultivation: 2,541 million ha in the "very suitable" and "suitable" categories and a further 784 million ha in the "moderately suitable" category. A large proportion of the world's land surface is not cultivable due to being too dry, too cold, too steep, too nutrient-poor or a combination of these factors.

[2] Thanks to Paolo Groppo and colleagues at FAO for guidance on this section.

The proportion of the cultivable land that is actually under cultivation or under other land uses differs widely around the world. In Asia, Europe and North America, almost the total cultivable area is either under cultivation or under forest in which cultivation would have “severe environmental consequences” (Fischer et al, 2002:ii). In these regions, expansion of biofuel crops can only come about as a substitution for other crops or through ecologically risky expansion into forest areas.

In effect 80% of the world’s reserve agricultural land is thus in Africa and South America (Fischer et al, 2002). Estimates based on satellite imagery from 1995-1996 give a total cultivable land in Africa and South America of 807 and 552 million ha respectively (all three suitability categories minus land under forest), of which 197 and 159 million ha respectively are under cultivation. The underestimation of the actual use, according to the authors, ranges from 10 to 20%, which would increase the “cultivated land” up to about 227 million ha (Africa) and 183 million ha (South America). However, it is not clear how land under shifting cultivation and fallow systems is included in these measurements. In Africa, a ratio of five plots under fallow to every plot under cultivation would give a range of the total “cultivated” land from a minimum of 227 ha up to a maximum of 1135 ha – well above the available reserves. In addition, since 1994, there is likely to have been an increase in land under agriculture in Africa, plus a decline in available agricultural land due to competing land uses.

There is a widespread policy preference for biofuels crops to be planted on “marginal” lands rather than prime agricultural land. Taking marginal land to be equivalent to Fischer et al’s “moderately suitable” land category, regional totals of unforested marginal land amount to 154 million ha (Africa), 96 million ha (South America), 79 million ha (North America), 147 million ha (Europe and Russia), 99 million ha (Asia) and 35 million ha (Oceania), giving a global total of 610 million ha (calculated from Fischer et al, 2002:11). De la Torre Ugarte (2006) looked at under-utilised agricultural land in temperate regions and estimated that 53 million ha arable land could be brought back into production (14 million ha in the US, 6 million ha in Europe and 33 million ha in Russia and former USSR).

Another estimate is based on the data of Houghton (1990 and sequential; quoted in Field et al, 2007), in which the total area of degraded land globally was estimated as 500 million ha, with 100 million ha in each of Asia and South America and 300 million ha in Africa. Degraded land in this study was defined as tropical lands formerly forested but not currently used for agriculture or other purposes. Field et al (2007) used more recent (2004) satellite imagery to calculate the current abandoned agricultural land to be 386 million ha globally, noting a very wide (> 50%) margin of error.

Both the Fischer et al (2002) and Field et al (2007) studies show that large-scale assessments of land availability are subject to high levels of uncertainty, even when good data and sophisticated analyses are used. What is clear, however, is that reserves of land with high agricultural potential are extremely limited except in certain parts of South America and Africa. Indeed, about half of the cultivable land reserves are in just seven countries: Angola, Democratic Republic of Congo, Sudan, Argentina, Bolivia and Colombia (Fischer et al, 2002). “Marginal” and “abandoned” lands may be more widespread, but there are likely to be major obstacles to commercial production of biofuels on these lands: most importantly lack of adequate water for viable harvests, but also fragmented rather than continuous land holdings and inaccessibility from markets. Another important consideration is that over-use of land that is already “marginal” can easily result in long-term or permanent ecological damage such as salination or severe erosion (Eves, 1997). Finally, there are a number of social implications of use of marginal lands for biofuels production, which are discussed in Section 2.2 below.

In which countries is increased production of feedstocks likely to happen?

The countries that are the current leading processors of biofuels (e.g. the United States for bioethanol and Germany for biodiesel) do not have the land available to grow the feedstocks required for future outputs. As a result, a significant share of the growing biofuel demand, both in Europe and North America and globally, will continue to be met through importing biofuels, or raw materials to produce biofuels, from countries with land available for feedstock cultivation. A supply-and-demand analysis carried out by the Stockholm Environment Institute showed that, by 2020, developed “energy consuming nations will need to import a substantial amount of their biofuel requirements from the developing world” (cited in Rothkopf, 2007:574).

A huge growth in agricultural trade is predicted, particularly of vegetable oils (70% internationally traded by 2016; OECD-FAO, 2007). Ethanol imports to the EU rose by 43% in the first three quarters of 2007 up to 650 million litres, primarily from Brazil, the US and Pakistan (F.O. Licht, 2008:163). Future regions for expansion of export of biofuels are predicted to Brazil and low-cost producer countries in Asia, Africa and the Caribbean (Dufey et al, 2007). In the longer-term, tropical countries will likely play an increasingly important role in feedstock production, due to favourable biophysical conditions and generally lower costs of land and labour, so long as suitable trade arrangements and stable conditions for investment prevail.

2.3 Limitations to use of “available” and “idle” land

A major hope for biofuels is that feedstock crops can be grown on idle and marginal lands. Governments have claimed that significant land areas are under-utilized and available for biofuel production. For instance, the government of Mozambique has stated that only 9% of the county’s 36 million ha of arable land are currently in use and that there is the possibility of bringing into production an additional 41.2 million ha of marginal land currently not being used (Namburete, 2006). Similarly, in Indonesia, the Department of Agriculture recently held that there are approximately 27 million ha of “unproductive forestlands” that can be offered to investors and converted into plantations (Colchester et al, 2006, quoting national press).

Based on these and similar estimates, several governments have taken steps to identify “idle” land and to allocate it for commercial biofuel production. The Indian government has initiated large-scale jatropha cultivation over more than a million ha in Andhra Pradesh and Jaipur (Chan et al, 2006). In southwest China, the main target area for jatropha development, provincial governments plan to expand jatropha acreage to one million ha of “barren land” over the next decade and a half, i.e. a 15-fold increase over the current area (Weyerhaeuser et al, 2007).

Yet growing evidence raises doubts about the concept of “idle” land. In many cases, lands perceived to be “idle”, “under-utilised”, “marginal” or “abandoned” by government and large private operators provide a vital basis for the livelihoods of poorer and vulnerable groups, including through crop farming, herding and gathering of wild products (Dufey et al, 2007). In India, for instance, the widespread planting of jatropha on “wasteland” has been brought into question because of the heavy reliance of rural people on these lands for collecting fuelwood, food, fodder, timber and thatch (Rajagopal, 2007). The tenure status of such lands may also be complex, with governments asserting land ownership but exercising little control at local level, and local groups claiming resource rights based on local (“customary”) tenure systems that may lack legally enforceable status.

For instance, in Tanzania, an area provisionally identified for sugar cane plantations in the Wami Basin is reported to be used already for rice production by thousands of smallholders; there have also been reports that a thousand rice farmers may be evicted as a result of the project. Other ongoing or planned large land allocations in Tanzania have been reported to involve the displacement of local farmers (ABN, 2007).

In southwest China, much of the “barren” land identified for jatropha production is owned not by the state but by village collectives, with use rights granted to individual households. In Yunnan, for instance, a recent provincial survey found that 76% of forestland is owned by collectives, and the remaining 24% by the state. Most private investment in biofuels has so far been limited to state-owned land - with a few exceptions, including a four-year project begun in 2006 and involving cooperation with individual growers. But the ambitious targets for scaling up jatropha production are likely to encounter problems of land availability, and will have to extend cultivation to collective lands (Weyerhaeuser et al, 2007).

2.4 Effects of increasing land demand on land access: direct and indirect linkages

Increasing demand for land for biofuels will result in changes to land access for poor people through two routes: direct linkages that involve direct land use change to biofuels crop production from other uses, and indirect linkages that involve changes in land use triggered by biofuels expansion elsewhere. These two pathways are discussed in more detail below.

Direct linkages

Direct linkages relate to effects on land access that can be directly ascribed to the spread of cultivation of biofuel crops. Possibly the most straightforward example is where the government takes (“expropriates”, “dis-allocates”, “withdraws” - depending on the country context) land from local users and allocates it to biofuel producers, based on the assumption that biofuel crop production is more economically viable than existing forms of land use.

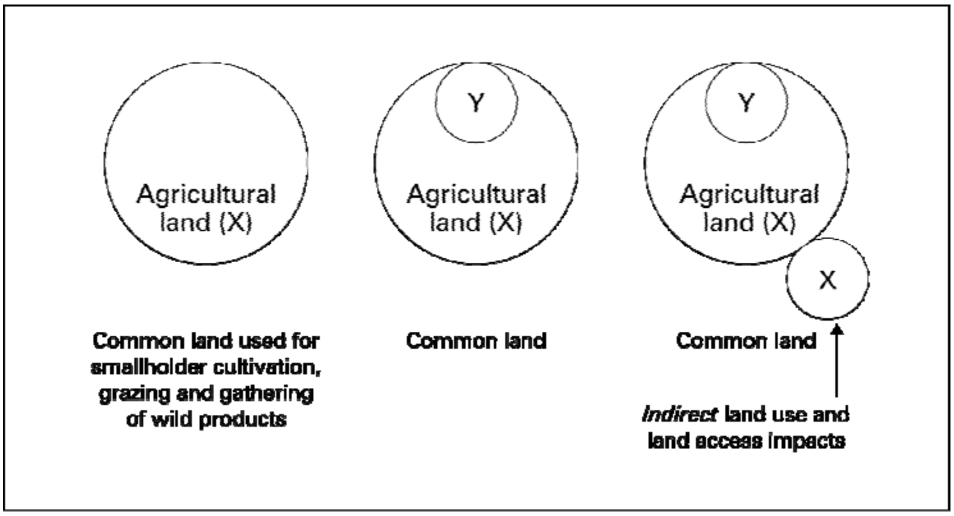
A more complex type of direct linkage relates to the operation of market forces. The spread of biofuels to meet growing internal and international demand tends to increase the value of land - whether this is expressed in terms of market prices or, where land markets are limited or informal, in terms of opportunity costs and preferential allocation to particular uses. This may result in poorer land users being priced out of land markets (either sale or rental markets). It may also foster changes in land access along gender lines as control over increasingly high-value land may shift from women to men.

Indirect linkages

Indirect linkages between biofuels and land access refer to effects on land access which are produced not directly by the spread of biofuel crop production, but rather by other factors which are in turn caused by the spread of production of biofuels crops. Increases in food prices linked to the spread of biofuels may change the economic terms of trade between agriculture and other sectors of the economy, and between rural and urban areas. Higher rates of return in agriculture will reinforce trends towards higher land values, particularly in more fertile lands.

Indirect linkages are often known as "displacement" or "leakage" and have been particularly explored with regard to deforestation rather than land access (Dehue et al, 2007; Searchinger et al, 2008). In this context, they refer to deforestation caused (not directly by biofuel cultivation but) by food crops in turn displaced from higher-value lands by the spread of biofuels. Similar processes can occur with regard to land access issues. As food crops are displaced from higher value lands, they may retreat to areas that are less fertile but still fit for farming, pushing current users onto other lands. Figure 3 below illustrates these dynamics.

Figure 3. Visual representation of "displacement" (after Dehue et al, 2007)



In Figure 3, Y represents new land demand from the biofuel sector. X is the expansion of existing cultivation into common land as a result of the displacement effect. While in this case the displaced area X = area Y, in many real cases the displaced area is larger than the area it replaces, because of differences in land prices, soil fertility or farming practices. For example, displacement of farmers from the cerrado to the Amazon in Brazil may be associated with multiplier effects in land clearance (Grieg-Gran et al, 2007). Displacement effects will also occur between different crops. For example, diversion of European rapeseed oil into biodiesel manufacture will create a demand for substitute oils in the food and cosmetics industries, with palm oil expected to increase in supply to fill much of the gap. This will have significant implications for deforestation and displacement.[3]

Indirect linkages present greater challenges than direct linkages in terms of availability of evidence and clearly established causal relations. Owing to these challenges, this study acknowledges the importance of understanding both direct and indirect linkages in order to fully capture the land access implications of the spread of biofuels but the empirical evidence (chapter 4) mainly focuses on direct linkages.

2.5 Effects of increasing land demand on land access: anticipated impacts on small-scale land users

A first issue to be clarified concerns the relationships among land use, land tenure and land access (see Box 1 for definitions). Land use relates to the ways in which land is used, while land access emphasises *who* has access to it and uses it. Land use changes associated with cultivation of biofuels can occur through both direct and indirect pathways as described above. Land use change may involve conversion from one crop to another, from pasture to cropland, from unutilised to utilised farmland, or from low intensity management (e.g. shirting cultivation) to high intensity. As the economic opportunities linked to biofuel production improve, agricultural producers may shift from food or cash crops to feedstocks. For example, small-scale jatropha projects implemented in Mali have involved a shift from cotton to jatropha, linked to falling cotton prices and rising perceived (monetary and non-monetary) values of jatropha (Togola personal communication; described further in Chapter 3). Another important form of biofuel-induced land use change involves conversion of forest. Large-scale land use changes from forest and conservation areas to biofuels crops are predicted (Fargione et al, 2008). Vast land use changes from forest to cash crops have already occurred. The spread of oil palm in Indonesia, for example, has resulted in the clearance of 18 million ha of forest over the past 25 years, although only 6 million ha have actually been planted (Colchester et al, 2006).

The spread of biofuels may cause changes in land use that do not impact in any way on land access (a simple change from one crop to another crop under the same communal or individual system of management). Alternatively – the subject of interest in this study – production of biofuels crops may cause impacts on land access. Some cases will involve changes in land tenure (formal or socially legitimised access to land) while other changes will be more subtle, without any highly visible changes to tenurial arrangements, but a range of less visible implications for access to land-based resources. We do not explore these more subtle changes in any detail in this report, but, as examples, a biofuels crop rather than a food crop might mean: landless people are excluded from post-harvest gleaning; husbands take over land from their wives now that the crop is cash rather than subsistence; fallow periods are shorter meaning less land in total for communal livestock grazing.

As emphasised in Figure 2, this report is mainly concerned with the cases where cultivation of biofuels crops has major impacts on both land use and land tenure – particularly the cases in which control over land shifts away from pre-existing small-scale land users. We anticipate that the highest levels of impact will be associated

[3] Thanks to Rob Bailey for emphasising substitution effects among different oilseed crops.

with development of large-scale biofuels plantations. But small-scale biofuels developments can also potentially have major effects on land access by pre-existing resource users. Sometimes it is small-scale farming rather than large-scale plantation that leads the advance of the agricultural frontier into forested territories of hunter-gatherer indigenous peoples, with irreversible impacts on their use of and control over their traditional lands.

We also anticipate that most impacts of expanding cultivation of biofuels on access to land by pre-existing, small-scale farmers and other resource users will be exclusionary: both in terms of exclusion from land use and from the benefits of land use and in terms of exclusion from decision-making over land use and sharing of its benefits. However, this does not mean that all impacts of biofuels cultivation on land access will be negative. Biofuels may be able to strengthen land access for some poorer land users. Experience shows that higher crop and land values can renew people's interest and investment in land and encourage small-scale farmers to seek more secure individual or communal tenure over their land resources (e.g. Williams and Vermeulen, 2005). In South Africa, women have planted tree crops (future second generation biofuels) specifically to secure their claims over land contested by their late husbands' families (Mayers and Vermeulen, 2002).

A central hypothesis is that much of the impact of biofuels on land access will be an outcome of increased land values (Figure 2). Rising values of biofuels crops with knock-on prices for other crops, exacerbated by changing diets in major markets (India and China) and climate change, will in turn lead to rising land values. Trends towards higher land values may be further compounded where biofuel production is promoted through public subsidisation, as the economic gains made possible by subsidies are capitalised into land values. In addition, changes in land values may also influence land access by other means. For instance, there have been reports that, in Brazil, large landowners who had previously acquiesced to the principle of land redistribution are now holding more tightly to the land. This is reportedly due to the higher economic returns that may be generated by biofuel cultivation.[4] In this case, impacts on land access relate not to a compression of existing access but to lost opportunities for greater access through redistributive reform.

In the longer term, growing biofuel production is likely to entrench changes in land tenure. Research has shown that, in the past, the spread of cash crops and the associated increases in land values led to greater individualisation of land rights previously held in common and to the greater commercialisation of land rights where these previously operated outside a market logic (Mortimore, 1997; Amanor, 1999; Cotula with Neves, 2007). Those with better access to financial resources are likely to be better able to gain or secure access to land, while poorer and more marginalised groups may see their access to land eroded (Odgaard, 2002; Cotula and Toulmin, 2007). Specific social groups, such as pastoralists, shifting cultivators and women, are especially liable to suffer exclusion from land caused by rising land values (Box 2), while people who are already landless are likely to see the barriers to land access increase further.

[4] Discussions at the forum "Policies Against Hunger VI: Bioenergy and Food Security", Berlin, 16-19 December 2007.

Box 2. Possible impacts of biofuels on land access for specific social groups

Pastoralists and shifting cultivators
Several feedstocks (e.g. jatropha) can be successfully grown on lands that may have previously been of limited significance for farming but of strategic importance for pastoralists, providing vital dry season grazing or livestock corridors. Longstanding misconceptions about pastoralism in East and West Africa, for example, have resulted in widespread perceptions about the extent to which this form of resource use can be deemed to satisfy productive use requirements. As a result, in many places, pastoralism has lost significant land areas to other forms of resource use, which are perceived by governments to be more productive (Hesse and Thébaud, 2006). Some of the countries that have more enthusiastically embraced the biofuels agenda host significant numbers of pastoralists. In Tanzania, for example, the IEA has noted that "More intensive cattle-raising could also be necessary to free up grassland [for biofuels] currently used for grazing" (IEA, 2006). In moist forest areas, shifting cultivators face similar problems to pastoralists in semi-arid areas: lack of policy recognition for their production systems, which are considered inefficient and non-viable, coupled typically with insecure and contested land rights. For reasons such as these, shifting cultivators in south-east Asian countries such as Cambodia have had limited success in defending their land access against competing interests such as large-scale commercial crop production (MacInnes, personal communication).

Women
A recent IUCN report noted that women are "more vulnerable to displacement from the uncontrolled expansion of large-scale mono-crop agriculture" (IUCN, 2007). While local energy self-sufficiency projects have the potential to improve women's livelihoods and reduce time-consuming dependence on traditional bioenergy (fuelwood), women's land rights risk being eroded by large-scale biofuels expansion, due to existing gender inequalities. In Kenya, for example, despite providing 70% of agricultural labour women only own 1% of the land they farm (DFID, 2007). This is replicated across the developing world with only 5% of women farmers owning their land (IUCN, 2007). In addition, women's land is often registered to male members of the family, and widowed women and single mothers risk being thrown off the land or denied land titles (DFID, 2007). Female-headed households and women within male-headed households are less likely to have access to the best farming land and are more likely to be displaced from the marginal lands on which they depend as areas under biofuels crops expand (Rossi and Lambrou, 2008). More progressive gender-neutral land legislation has recently been enacted in many developing countries (Cotula, 2006), but these new laws are often implemented in gendered contexts that continue to deny women equal access to land. This is compounded by women's lack of awareness of the statuary laws (Kameri-Mbote, 2006). This baseline situation shows the existing fragility of women's land tenure security.

2.6 Mediating factors that affect outcomes for land use and land access

Both direct and indirect linkages between biofuels and land access are mediated through a range of policies and processes. These include processes at the international level, such as fluctuations in international commodity prices and the level of barriers to trade in biofuels; at the national level, such as policy and legal frameworks on biofuels and on land tenure; and at the local level, such as the balance between traditional and formal land rights. Some of the mediating factors may exacerbate the tendency towards loss of land access by poorer people and smaller-scale land users –

such exacerbating factors might include national government policies to promote expansion of export-oriented feedstock plantations, or deep-seated power asymmetries between current small-scale land users and prospective large-scale land users. In counterpoint to these exacerbating factors is a set of mitigating factors: a new and growing assemblage of good practice and innovative business approaches towards more equitable and sustainable land management.

The interplay of these mediating factors shape the way the spread of biofuels affects land access. The next chapter discusses available evidence on the biofuels-land access nexus in light of some of these mediating factors.

3. Evidence on likely impacts of biofuels on access to land

Debates on biofuels tend to be polarised. In reality, the land access implications of biofuels cultivation vary enormously. Different feedstocks and different land tenure systems lend themselves to very different models of biofuels production, ranging from local energy self-sufficiency schemes through to large-scale export-oriented plantations. Differences in the relative importance of agriculture in the national economy tend to differentiate land access impacts: countries with smaller rural populations and less dependence on agriculture will experience less impact from land use change towards biofuels crops. Land access issues are likely to be far more acute in countries where much of the population depends on land and natural resources and where poverty has a significant rural dimension.

As outlined in Chapter 2, while biofuels may give some small-scale land users opportunities to strengthen access to land, in general we might expect rising land values to provide grounds for increased land access to more powerful interests at the expense of poorer rural people. Major concerns associated with such changes include increasing land concentration, lack of respect for existing land tenure, especially where it is sanctioned through traditional rather than legal authority, lack of prior informed consent in land acquisition, and in some cases aggressive land seizure.

In light of these considerations, this chapter organises available evidence as follows. First, examples are given of small-scale and large-scale biofuels feedstock production projects to illustrate the diversity of models for energy crop production, control and use. Second, the major concerns outlined above are provided. Third, we give examples to illustrate some - but by no means all - of the mediating factors shaping land access impacts.

Some of these mediating factors are exacerbating factors that could magnify the likelihood of small-scale land users losing access to land. These include power asymmetries, unclear and poorly enforced legal frameworks, investment promotion policies and agencies, and environmental policies that may create perverse incentives with respect to land access, such as the Clean Development Mechanism. Other factors could mitigate negative impacts of rising crop and land values on poorer people's access to land. These are largely intentional "good practice" approaches and include novel business models that specifically provide for involvement of local land owners and land users, policy safeguards to protect local land rights, sustainability initiatives and civil society "watchdog" actions.

The outcomes of either "exacerbating" or "mitigating" factors are not hard and fast; results on the ground are likely to be mixed. Investment promotion agencies, for example, may well bring increased opportunities for rural development and employment at the same time as encouraging large-scale land use change that might erode local land access. Similarly, novel business models may look promising on paper but in practice reinforce inequitable arrangements. Our aim here is not to pass judgement on the basis of little evidence, but rather to present a set of experiences to date that show possible outcomes for future biofuels developments. Actual future outcomes will depend on specific case-by-case circumstances, depending, as we have emphasised, on a wide range of factors from the nature of the feedstock and local tenurial systems through to prevailing global economic conditions.

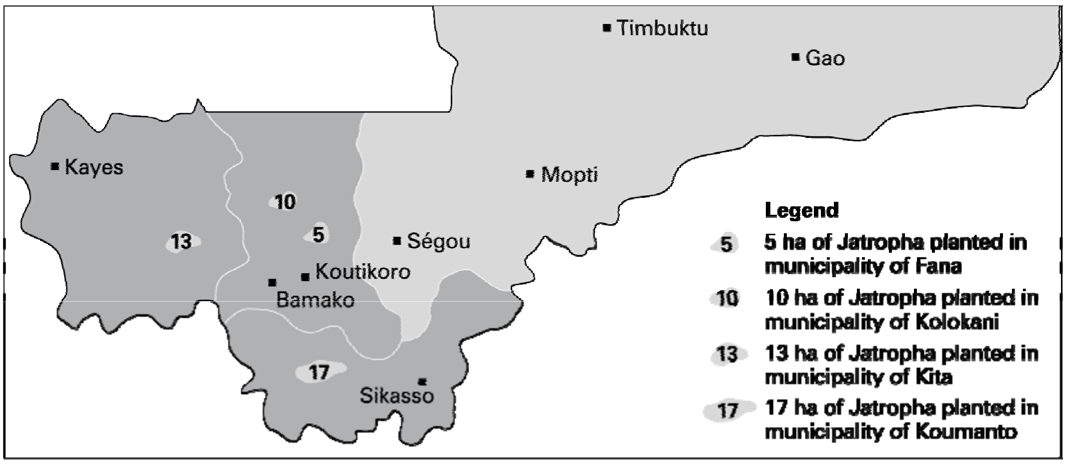
It is also important to note that much of the evidence comes from production of crops that can be used as biofuel feedstocks but are currently used predominantly for food, animal fodder and non-edible uses – crops such as soy, palm oil, sugarcane and cereals. We assume that changing the end use of these crops to biofuels will not change their impacts on land access.

3.1 Small-scale biofuels projects

Local energy security strategies and rural development efforts have underpinned recent interest in the cultivation of biofuels feedstocks as part of rural development projects. High oil prices and scarce access to electricity in many rural areas have sparked interest in jatropha as a basis for local energy supply.

In Mali, for instance, small-scale jatropha cultivation to meet local energy needs has been promoted by both government authorities and development agencies. The Ministry of Mines, Energy and Water is implementing a US$ 1.6 million *Programme National de Valorisation Energétique de la Plante Pourghère* (PNVEP) to promote the use of jatropha for rural electrification, conversion of vehicles to biofuels, and poverty reduction amongst rural women.[5] At the same time, development agencies have implemented jatropha projects since the 1990s. GTZ began a jatropha scheme in five sites in 1993 (Henning, 1996) and the Mali Folkecenter Nyetaa (MFC Nyetaa) more recently helped communities to set up local biofuels systems in four localities (see Map 1 below). In the village of Tiécourabougou, for instance, MFC Nyetaa coordinates a project cultivating 20 ha of jatropha that supply the energy needs of villages within a 20 km radius. The second stage of the project (begun in 2006) involves planting 1,000 ha of jatropha and aims to provide electricity to 10,000 rural dwellers (UN-Energy, 2007:8).

Map 1. Jatropha projects in southern Mali associated with MFC Nyetaa



Source: Mali Folke Center website (http://www.malifolkecenter.org/lowersection/Dep3_NRM/jatropha/jatropha_plantation_map.html#)

Access to land for biofuels production is based on agreements with local villagers. Villagers collectively agreed to allocate communal lands to jatropha cultivation

[5] http://www.anpe-mali.org/news/vulgarisation-de-la-plante-pourghere

because of the opportunities for improved access to energy. Before the project intervention, villagers had to go 50 to 60 kilometres to buy diesel, and the cost of diesel accounted for about 50% of household expenditure. These energy needs are currently being met by the use of jatropha generators. In addition, rental agreements have been established with local farmers, who rent out part of their land to the project (personal communication from staff involved in the project).

Similarly, in Mozambique, farmers and local non-governmental organisations have collaborated on small-scale biofuels projects, though they have only planted about 150 ha of jatropha for rural energy generation since mid 2005 (De Jongh, 2006). In West Africa, five countries (Burkina Faso, Ghana, Guinea, Mali and Senegal) are part of a UNDP *Plates-formes Multifonctionnelles* (Multipurpose platforms) project that tackles lack of access to electricity and rural women's poverty through the provision of simple multipurpose diesel engines able to run on jatropha oil.[6]

3.2 Large-scale biofuels projects

Land access implications are quite different in the case of large-scale commercial projects. Recent government allocations of large areas of land for biofuel production in countries as diverse as Mozambique, Tanzania, India and Colombia have raised significant concerns and criticism concerning the impacts on land access for more vulnerable groups.

The Mozambican government has pursued policies to attract large-scale investment in biofuels. Recent signing of a contract between the government and the London-based Central African Mining and Exploration Company (CAMEC) for a large bioethanol project, called Procana, illustrates this. Procana involves the allocation of 30,000 ha of land in Massingir district, in the Southern province of Gaza, for a sugar cane plantation and a factory to produce 120 million litres of ethanol a year. The land was allocated on a provisional basis for two years, within which the investor must initiate project implementation (Agencia de Informacao de Mocambique, 2007)).

Concerns have already been raised with regards to the effects of Procana on access to both land and water for local groups. The plantation will abstract water from a dam, fed by a tributary of the Limpopo River, which also supports irrigated smallholder agriculture. Farmers downstream have expressed concerns that the Procana project will absorb the bulk of available water, leaving little for local farmers.[7] Government officials have disputed these calculations, arguing that the dam has enough capacity to meet the water demand of both Procana and local irrigation schemes (Agencia de Informacao de Mocambique, 2007).

As for land, the Procana project attracted criticism from representatives of international donors and local communities on the grounds that the land allocated to the project had already been promised to four local communities displaced from their

[6] http://www.ptfm.net/spip.php?rubrique1, 15 February 2008

[7] Local farmer groups published calculations in the national weekly "Savana", highlighting that while the reservoir can hold up to 2500 million cubic metres of water, it presently holds only 1625 million cubic metres, 950 of which would go to Procana; http://allafrica.com/stories/printable/200710100997.html. See also http://www.irinnews.org/PrintReport.aspx?ReportId=75382.

land by the creation of the Limpopo Transfrontier Park, a joint conservation initiative among Mozambique, South Africa and Zimbabwe (IRIN, 2007).

The displaced communities, numbering over 1,000 families, were promised housing, electricity, running water and grazing at the new site after a protracted three year battle with the government, in which they were supported by a local human rights organisation ORAM (*Organizacao Rural de Ajuda Mutua*, Rural Organisation for Mutual Help). However, according to press reports, the date of the planned relocation has been postponed several times and has not yet occurred as the same tract of land has been granted to the Procana bioethanol project. Community leaders have been told that there is sufficient land in the site for both the new villages and the biofuel plantations, but they have yet to see any construction work begin (Howden, 2008).

In Benin, industrial groups from Malaysia and South Africa have proposed the conversion of 300,000-400,000 ha in the wetlands of Southern Benin for the production of palm oil, while the agricultural modernisation strategy implemented by the government of Benin is reported to involve large increases in land under cultivation, for both food crops and biofuels (ABN, 2007).

In Tanzania, the prime minister is fast-tracking agrofuels to accommodate a Swedish investor looking for 400,000 ha in the Wami Basin, one of the country’s major wetlands, to plant sugar cane for ethanol (GRAIN, 2007; ABN, 2007). Various other proposed or ongoing land allocations for jatropha and oil palm cultivation, including various combinations of plantations and outgrowers, have been reported from different parts of the country, involving investors from Sweden, the United Kingdom, Germany, Malaysia and other countries (ABN, 2007). Large-scale jatropha cultivation may be associated with significant negative impacts on land access for local groups. For example, a multimillion dollar jatropha spared by a British firm in the Kisarawe district of Tanzania has been reported to involve acquiring 9,000 ha of land and the clearing of 11 villages which, according to the 2002 population census, are home to 11,277 people. Some US$ 632,400 have been set aside to compensate a total of 2840 households (African Press Agency, 2007).

In South Africa, farmers’ organisations and rural communities are opposing plans by the Eastern Cape government to plant 500,000 ha of communal land in the Transkei region with rapeseed for biofuel production. The land is currently used for communal grazing and vegetable gardens, but would be fenced off under the plans. A biofuel plant would also be constructed in the near by East London industrial development zone. It is reported that the first stage of the project, a 70,000 ha rapeseed plantation in the Umzimvubu valley, will be planted in 2008 (African Centre for Biosafety, 2007).

3.3 Land concentration

In Brazil, the rapid expansion of sugar cane has been accompanied by increased land concentration (Peskett et al, 2007). Here, 70 % of land under sugarcane cultivation is owned by 340 industrial-scale mills, with average holdings of 30,000 ha; the remaining 30% is owned by 60,000 smaller scale landowners, with average holdings of 27.5 ha (Rothkopf, 2007:521), though many of these do not farm the land themselves but simply rent it to the large-scale sugar estates (Abramovay and Bailey, personal communication). Friends of the Earth and other groups have documented the