HLPE REPORT 5

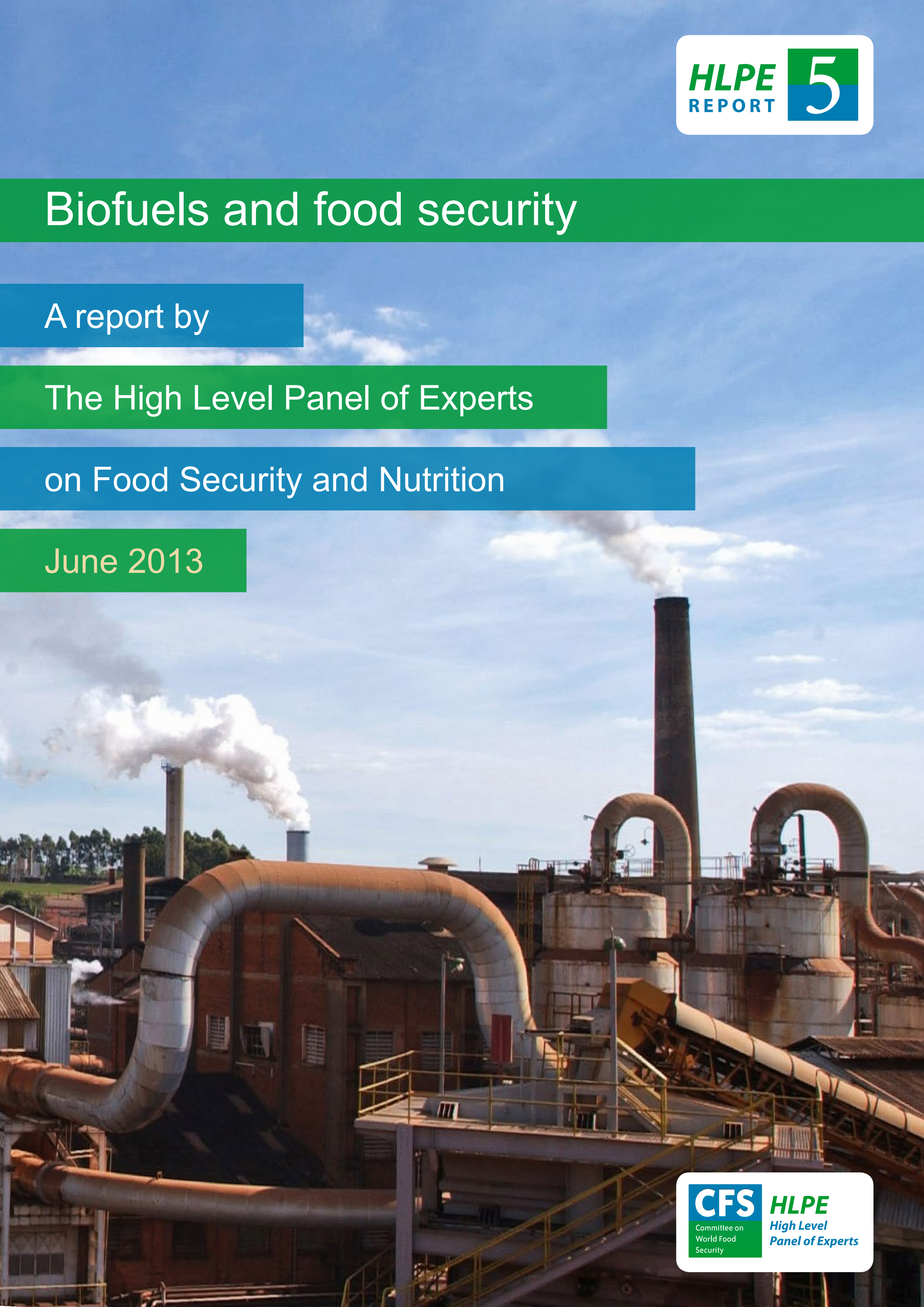
Biofuels and food security

A report by

The High Level Panel of Experts

on Food Security and Nutrition

June 2013



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Niracha Wongchinda

HLPE Project Team members

John Wilkinson (Team Leader)
Suraya Afiff
Miguel Carriquiry
Charles Jumbe
Timothy Searchinger

Coordinator of the HLPE

Vincent Gitz

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FOREWORD

Feeding and fuelling the future: harmonizing food and energy security

The High Level Panel of Experts on Food Security and Nutrition (HLPE), which I have the privilege to chair, is the science–policy interface of the UN Committee on World Food Security (CFS). It was established in 2010 to provide the CFS with credible scientific and knowledge-based advice to underpin policy formulation. The HLPE provides a collective, evidence-based response of science and technology, directly from the knowledge holders to policy-makers on a demand-driven basis.

The HLPE works at the request of CFS to provide policy-oriented analysis and recommendations to serve as a common basis for starting policy discussion. Since its establishment in 2010, the HLPE has presented the following four reports for the consideration of CFS at its annual sessions in Rome in October, in 2011 *"Price volatility and food security"* and *"Land tenure and international investments in agriculture"*; in 2012 *"Food security and climate change"* and *"Social protection for food security"*. In 2013, our following two reports will nourish the CFS debate: *"Investing in smallholder agriculture for food security"* and *"Biofuels and food security"*.

All six reports were prepared at the specific request of CFS and were therefore demand-driven. The tenure of the present Steering Committee comes to an end in October 2013. The CFS Bureau is currently finalizing the composition of the next Steering Committee, which will start functioning in October 2013. The CFS had chosen the following two topics for discussion in its October 2014 session: *"The role of sustainable fisheries and aquaculture for food security and nutrition"* and *"Food losses and waste in the context of sustainable food systems"*.

We have taken the preliminary steps essential for the incoming Steering Committee to complete the reports on time for the October 2014 meeting.

It is a tribute to CFS that it does not shy away from difficult, controversial and challenging topics. The HLPE is aware that there is wide variability on our planet with reference to socio-political, socio-economic and agro-ecological conditions. Hence, we avoid generalizations and present policy options, the bottom line always being sustainable food and nutrition security.

The topics on which CFS requests us to work are always challenging. Analysis of impacts on food security involves a multidisciplinary and pan-global approach. This is all the more important because our reports are demand-driven – which means that they have to meet the needs of CFS, taking into account the diversity of its membership and participants, of their concerns and expectations. And it is all the more necessary because HLPE reports are meant to inform and advise CFS, its members, participants and observers to discuss and prepare political decisions.

An international, intergovernmental and multistakeholder discussion on biofuels and food security could well start based on a jungle of more than 1 000 documents and reports. That

would not be very useful and would leave to each policy-maker the difficult task of selecting suitable and relevant documents, making his/her own synthesis, necessarily partial, reading the arguments of all the other parties, trying to understand them, and trying to make his/her point in the debate by articulating his/her view to all the others.

This is why the discussion on biofuels and food security in CFS starts rather on the basis of one single document to serve as a starting point for debates, providing a policy-oriented and policy-relevant window to all the other sources, including experiences from the ground, gathering the various scientific narratives, from which robust conclusions could emerge, given the state of knowledge, uncertainty and controversies. This is what the international community requested in CFS from the HLPE.

The reports of the HLPE have to serve as a starting point for discussions between stakeholders having different points of view. They have to set the stage by making comprehensive assessments, encompassing all approaches and streams of narratives. They have to make it easier for each and everyone in the policy debate to understand the various points of view and logics. To say it short: our ambition is to help debates move forward by helping people understand why they, sometimes, disagree and how to move forward in achieving sustainable food security and the eradication of hunger and malnutrition.

HLPE reports are thus very special reports. The HLPE does not carry out new research, but undertakes original analysis. Our reports have to show and explain the various perspectives, to uncover the scientific controversies and different approaches, which often underpin diverse points of views. They aim to facilitate a common understanding of issues and to build consensus among nations with different needs and opportunities.

The HLPE is directed by a Steering Committee, appointed in July 2010, which I have the privilege to chair. I would like here to underline one very specific feature of our work that makes it both scientifically challenging and intellectually rewarding. Stakeholders in CFS are asking for knowledge and scientific advice. And at the same time, most of them are also knowledge-holders. This is why we integrate in the elaboration process of our reports two public consultations, at early stages of their preparation. They serve both to better understand what the concerns are and to gather additional knowledge and evidence.

In less than one decade, world biofuel production has increased five times, from less than 20 billion litres/year in 2001 to over 100 billion litres/year in 2011. In October 2011, the CFS recommended a "*review of biofuels policies – where applicable and if necessary – according to balanced science-based assessments of the opportunities and challenges that they may represent for food security so that biofuels can be produced where it is socially, economically and environmentally feasible to do so*". In line with this, the CFS requested the HLPE to "*conduct a science-based comparative literature analysis taking into consideration the work produced by the FAO and Global Bioenergy Partnership (GBEP) of the positive and negative effects of biofuels on food security*".

To prepare a report on biofuels and food security is especially challenging. It is at the intersection of some major global issues: energy, food, land and water use, and development. There are a many publications on biofuels, but only very few deal with their impact on food security.

This report covers very different perspectives and methodological approaches, from technology to economics, at macro and micro levels, together with social and political issues. Technological developments include a focus on next generation biofuels. It also replaces the issue in the broader perspective of the mobilization of biomass for energy, including biogas.

The report contains the analysis and recommendations of the HLPE as approved by its Steering Committee at its meeting in Beijing, 13–15 May 2013, and is now being presented to the CFS.

The HLPE operates with very specific rules,[1] agreed by the CFS, which ensure the scientific legitimacy and credibility of the process, as well as its transparency and openness to all forms of knowledge. The Steering Committee of the HLPE attaches great importance to sound methodology and follows a rigorous analytical procedure. This report has been produced by a Project Team appointed by the Steering Committee and under its oversight. The process is also open and transparent, and gives opportunities for a diversity of views, suggestions and criticism: the terms of reference as well as the first draft (V0) prepared by the Project Team have been submitted to open electronic consultations. Final versions of the report have been reviewed by several independent eminent experts, on the basis of which it has been finalized by the Project Team and submitted to the Steering Committee for approval before being forwarded to the CFS.

I wish to pay my tribute to the very large number of experts who have helped us to prepare, under tremendous time pressure, these two reports. Let me first thank the Vice-Chair Madam Maryam Rahmanian and all my colleagues in the Steering Committee for the hard work done in the guidance and oversight of the studies until their approval by the Steering Committee in May 2013. They have given their time and knowledge free for this work. As per our rules of procedures given by the CFS, the Project Teams work “under the Steering Committee’s oversight”. Therefore for each report, we had requested a few Steering Committee members to voluntarily devote more time and effort to provide guidance to the Project Teams. My special thanks go to Prof. Igor Tikhonovich, who convened the Steering Committee’s oversight for this report. My gratitude goes to the Project Team Leader, John Wilkinson (Brazil/UK), and to the Project Team members Suraya Afiff (Indonesia), Miguel Carriquiry (Uruguay), Charles Jumbe (Malawi) and Timothy Searchinger (USA). Our gratitude also goes to the external reviewers and to the large number of experts who commented both on the terms of reference and the first draft of the report. Also, my sincere thanks go to Vincent Gitz, Coordinator of the HLPE, for his monumental contributions to the preparation of the HLPE reports, characterized by scientific credibility and professional authority. Much of the credit for our being able to prepare these reports on time goes to him.

Let me also express my gratitude to the donors that have funded this exercise. The HLPE is financed through extra-budgetary resources and we are impressed with the spontaneous support the mission and rationale of HLPE has generated.

[1] The procedure is described in more detail in Appendix 4.

It is our hope that this report will help to nourish the policy debate at the next meeting of the CFS in October 2013. I wish to record my sincere appreciation to the Chairman and Members of the CFS and to the CFS Bureau and CFS Advisory Group for their encouragement.

I hope our report will help nations to develop and implement an integrated **Feeding and Fuelling the Future** Programme, which can ensure both sustainable food and energy security. For this purpose, it would be useful to assess the impact and viability of biofuel policies based on the following guidelines:

- the prior existence of technical, social and environmental zoning to delimit “available land” and accompanying resources;
- the prior existence of “responsible land investment” practices;
- the prior existence of mechanisms to ensure the capacity to react quickly to food price spikes and problems of food availability (price triggers, waivers, “minimum” levels of food stocks);
- the prior evaluation of the implications for the origin of feedstock provision (domestic/imported); and for trade
- a prior evaluation of the implications of the policy for domestic and international food security.

Such an impact analysis will help countries to arrive at a policy-mix based on a win–win situation for meeting their food and fuel needs.

M. S. Swaminathan

Chair, Steering Committee of the HLPE, 12 June 2013

SUMMARY AND RECOMMENDATIONS

In October 2011, the UN Committee on World Food Security (CFS) recommended a "*review of biofuels policies – where applicable and if necessary – according to balanced science-based assessments of the opportunities and challenges that they may represent for food security so that biofuels can be produced where it is socially, economically and environmentally feasible to do so*". In line with this, the CFS requested the HLPE to "*conduct a science-based comparative literature analysis taking into consideration the work produced by the FAO and Global Bioenergy Partnership (GBEP) of the positive and negative effects of biofuels on food security*".

Analysing the relationships between biofuels and food security is especially challenging. It is at the intersection of some major global issues: energy, food, land use, and development. Biofuel production and the policies used to support its development can relate both positively and negatively with each of the four dimensions of food security – availability, access, utilization (nutrition) and stability. An appreciation of the relationships and causal impact and feedback links between biofuels and food security requires assessments at both global and local levels. It must also be situated within a dynamic perspective, given the fast changing developments, the complex and not necessarily instantaneous relationship between the drivers of biofuels' rise and the (positive and negative) impacts on food security, and the need for projections of the future. Such an approach requires making assumptions on various parameters, ranging from the role of bioenergy, to the evolution of techniques, and to potential impacts at global and local levels.

Summary

Biofuel policies

1. Public policies have played a central role in the rise of biofuel production, with two major implications. First, biofuels have assumed quite different profiles in each country or region, given the diversity in institutions and natural endowments, which in turn has given rise to varied national biofuel plans and policy toolkits. Second, as a consequence of the national determination of biofuel policies, countries have often been inclined to regulate imports of biofuels, for example by applying tariffs and barriers, in order to protect their internal market. Exports have also been similarly subject to policy stimuli.

2. Policy tools that can be mobilized are quite diverse.

    - They can act on the demand and market creation side: tax exemptions or mandates for the incorporation of biofuels into petroleum fuels (obligations for fuel distributors or filling stations), public procurement (fuel or vehicles), user incentives such as car fleet subsidies among others. They may also act on the side of support for production and distribution: blending or transformation subsidies to compensate for the additional cost over petroleum fuels, agricultural subsidies for biofuel crops, public bank support to investors in the biofuel production chain, in installation and infrastructure, public support for research and development (R&D), energy crop production zoning (e.g. in Europe, the possibility of using set-aside lands where these existed).

    - In addition, some tools are trade-related regulation measures, either shielding domestic markets (e.g. import tariffs, eligibility requirements, quotas) or preventing exports (export tariffs, quotas).

    - A final set of tools is related to environmental and technical criteria, such as blending walls, fuel quality regulations and fuel certification tools.

3. Modern biofuel markets emerged in response to the two oil price hikes in the 1970s. Various countries responded with proposals for alternative fuels policies, but the two countries that created a biofuels ethanol market and a biofuels production sector in this period were Brazil and the United States of America (US), the former using sugar cane and the latter corn/maize. In both cases, this was done taking advantage of existing agricultural production capacities when low commodity prices encouraged the search for alternative outlets. Broader strategic goals were also central, such as reducing levels of dependence on energy imports and, especially in the case of Brazil, improving the balance of payments at a time of high oil import bills.

4. These biofuel policies went beyond issues of regulation and involved the creation of markets via obligatory or highly stimulated blending targets/mandates coupled with a range of tax exemptions, subsidies and favourable credit.

5. In Brazil, the sugar-cane sector responded well to the PROALCOOL Program launched in 1975: the programme addressed both supply and demand, with a mix of R&D support, supply or investment subsidies, mandatory installment of ethanol pumps, taxation of gasoline and regulatory policies. Production rose rapidly, reaching 12 billion litres/year within a decade.

6. In the US, interest for alternatives to petroleum fuels peaked during crisis situations, such as the First and Second World Wars, and the energy crisis in the 1970s. Ethanol production, however, only rose substantially in the 1980s in the wake of the Energy Tax Act of 1978, which introduced a subsidy for blending ethanol into gasoline, and the 1980 Energy Security Act, which offered insured loans for small ethanol producers, price guarantees and federal purchase agreements, and established a tariff on foreign ethanol. Biofuels were initially promoted in the corn-producing regions where ethanol was a co-product of corn syrup.

7. When a new surge in biofuel promotion took off in the early years of 2000, the policies of these two countries had already consolidated a biofuels demand, a biofuels market and a biofuels industry. In the course of the first decade of this century, the Brazilian sugar/ethanol sector was now able to operate without direct controls and in response to movements in relative prices, and analysis has suggested that US ethanol production, given continuing high oil prices and the ban on the methyl tertiary butyl ether (MTBE) oxygenate (since 2003), could also survive without mandates.

8. In the European Union (EU), given that half the light vehicle fleet and in some countries well over half of all new car sales are equipped with diesel engines, biodiesel is more central to biofuel policy. From a feedstock perspective, this has involved giving greater weight to oil crops (over cereals and sugar beet) for the production of biofuels. EU targets cannot be fully met using only EU domestic biomass. The EU biofuel policy, therefore, has triggered the creation of an increasingly globalized biofuels and biofuels feedstock market, involving a key role for developing country agriculture. Currently, Latin America and Asia dominate these flows. At the same time, such production must conform to the "sustainability" criteria (e.g. the Fuel Quality Directive and the Round Table on Sustainable Biofuels – RTSB, among others) that underpin this market.

9. Biofuel policies in the US and EU are now at a turning point, with similar proposals to put a ceiling on food-based biofuels at around their existing levels.

10. Many more countries (over 50 at the time of writing) have now adopted biofuels policies, and the combined automobile fleets of China and India are now approaching that of the US with much faster growth rates and a concomitant preoccupation with greenhouse gas (GHG) emissions and urban pollution. In the biofuel policies of these emerging countries, food security has quickly become a central conditioning criterion for biofuels promotion, with explicit policies in China, India and South Africa not to base biofuels on food crops or on lands used for food. Hopes were based in the former two cases on the eminently non-food crop jatropha (the poison nut), which, in addition, was considered to thrive on marginal lands. South Africa, for its part, relied on the

untapped resources of the homelands, marginalized during the apartheid regime. However, in all three cases, the potential of the chosen crop and of the marginal lands to grow biofuel feedstock efficiently has to date proven to be illusory.

Biofuels and the technology frontier

11. The degree to which the promotion of biofuels enters into competition with food production, raising questions of food security, depends on a variety of factors:
    - choice of feedstock;
    - natural resources (especially land and water) involved;
    - relative efficiencies (GHG emissions, yields, costs) of different feedstocks;
    - processing technologies adopted.

    Concern over competition between biofuels and food production has been particularly acute given the overwhelming use of food- and feedcrops for both ethanol and biodiesel.
12. The choice of preferred feedstock and technology determines much of the impact of biofuel production and policies on food security. It determines the form of competition for food, feed and land, with diverse land needs depending on the feedstock.

13. While the timeline for the deployment of 2nd generation biofuels has proved overly optimistic, as reflected in particular in the Renewable Fuels Standard of the US, the first commercial-scale plants to produce cellulosic biofuels are now coming online. Multiple pathways for the conversion of different biofuel feedstocks are being developed and deployed. In the next couple of years, we can expect to see long-awaited data on the costs of these technologies operating at commercial scale and their relative performance. Based on that information and relative performance, the number of pathways can be expected to narrow. Learning-by-doing can lower the costs of the industrial process, which is a major component of the costs of producing advanced biofuels, and these industrial advances can occur more quickly than the agronomic advances needed to lower feedstock costs of both conventional and advanced biofuels.

14. The experiences with jatropha have shown that any new biomass production for biofuels will induce some form of competition for land and water, which could have an impact on food security.

Biofuels, food prices, hunger and poverty

15. In less than one decade, world biofuel production has increased five times, from less than 20 billion litres/year in 2001 to over 100 billion litres/year in 2011. The steepest rise in biofuel production occurred in 2007/2008, concomitantly with a sharp rise in food commodity prices (HLPE, 2011a), quickly accompanied by food riots in the cities of many developing countries. In comparison with average food prices between 2002 and 2004, globally traded prices of cereals, oils and fats have been on average from 2 to 2.5 times higher in 2008 and 2011–12, and sugar prices have had annual averages of from 80 percent to 340 percent above their 2000–04 prices. These price increases were accompanied by price volatility and price spikes to an extent unprecedented since the 1970s.

16. Though a range of other factors have been adduced in the enormous amount of studies that have since been dedicated to the issue of rising food prices (HLPE, 2011a), the steeply rising demand for the production of biofuels was identified as an important factor by many observers and a wide range of organizations, from civil society organizations (CSOs) to the World Bank.

17. The biofuel and food price debate is a long-standing, controversial one in the literature, with wide-ranging views. This is due to the number of impacts and feedback loops involved that can positively or negatively affect the price system. The relative strengths of these positive and negative impacts are furthermore different in the short and long terms, involving delayed effects

that substantially increase the complexity of the analysis. The expert debates are also blurred by the use of different economic models and competing forms of statistical analysis, and to draw robust conclusions it is impossible to avoid at least some of their complexities.

18. Many factors do influence, concomitantly with biofuels, the world supply and demand for food. What matters most for the present report and analysis is not the net overall effect of all factors on the net food price -– this has been dealt with, for example, in HLPE (2011a) – but the isolated effect of biofuels on food prices, *everything else being equal*. A central challenge here is to disentangle and separate the impact of biofuels from all the other factors so that it can be analysed from the standpoint of its *additional* impact, which leads to *additional* price effects.

19. When crops are used for biofuels, the first direct impact is to reduce food and feed availability. This induces an increase in prices and a reduction of food demand by the poor. It also encourages farmers to produce more. There is also a substitution effect, at consumption level and at production level, which is one of the reasons price increases spread to other crops.

20. The following robust pattern emerges from the observations and analysis and the results of the different bodies of literature:

    (i) Everything else being equal, the introduction of a rigid biofuel demand does affect food commodity prices. This observation holds in each context, even in the context of prices going down for other reasons than biofuels.

    (ii) In the last few years (since 2004) of short-term commodity food price increase, biofuels did play an important role. The fact that biofuels have been the most important contributor is still disputed. The important role of biofuels is mainly due to:
    - the difficulty of the recent growth in total supply in keeping up with the growth in total demand, including the biofuel component (MTBE ban, other mandatory biofuels policies);
    - the rise in oil prices being transmitted to food prices via biofuel production capacities, as biofuels created an opportunity gain for key foodcrops (corn, oilseeds, sugar).

    (iii) Different biofuels have different impacts, although impacts can translate from one crop to another as far as substitutions between those crops can be made in the field or at demand level. Situations in different markets can vary. Ethanol markets and biodiesel markets do not evolve in the same way. Within the ethanol market, an increase in demand has different effects if met by an increase in corn-based ethanol production or by an increase in sugar-cane ethanol production.

    (iv) Biofuels provide a link between the food and energy markets. The existence of such linkages, as well as the induced correlation between prices, is widely recognized. However, the strength of the correlation is disputed. In addition, short-term (effects on volatility) and long-term correlations are shown to be quite different, as well as very dependent on the different biofuel feedstocks and pathways.

These findings substantially confirm the results of HLPE (2011a), while refining them in important ways.

21. In the present context, oil prices can play a central role. With a continued trend of rising oil prices, corn- and sugar-cane ethanol will be increasingly competitive with respect to fossil gasoline, even without incentives or tariff protection (for example, the US eliminated the tax credit for first-generation (corn), ethanol at the end of 2011). In theory, this could open up an almost infinite market worldwide for corn- and sugar-cane ethanol (HLPE, 2011a). In practice, given the current regulatory frameworks in the US and the EU and level of development of biofuel markets, mandates and targets can become transformed into technical or political ceilings, as in the case of the blending wall in the US or the global limits established by both the US and the EU, which constitute substantial barriers to the expansion of US ethanol. As biodiesel competes economically only in situations of very high oil prices, it will remain driven by government policies,

in the absence of major technological advances, and any change in such policies could eliminate its growth.

22. If foreign markets are willing to absorb excess biofuel production, and so long as other obstacles, such as blending requirements or target ceilings do not limit the domestic uses of biofuels, the growth in biofuel demand could continue *so long as oil prices remain higher than the cost of biofuel production*. This leads to oil prices ultimately defining an "opportunity floor" on crop prices, and opens a space for transmission of volatility and speculative behaviour from the petroleum market to food markets.

Biofuels and land

23. Except when relying on crop residues and waste, biofuel production requires land. It thus competes for land with other agricultural activities, including production of other forms of bioenergy, other economic activities, urbanization and, increasingly, with land protection for environmental objectives, especially biodiversity and carbon sequestration. This last point is of particular relevance concerning biofuel production as one of its aims is to mitigate climate change; which implies that, when entering into competition with carbon sequestration, both activities should be assessed with regard to their comparative mitigation potential. To what extent is land availability a constraint to biofuel development and to ensuring world food security?

24. The debate is very much oriented by prospective considerations on what is/would be the land needed to produce a certain quantity of biofuels versus what is/would be the land "available" globally, given the need to increase food production to satisfy a growing demand. Answers to these questions are driven by the assumptions made in terms of yield (crop yield, biofuel yield) and by the information on land availability (including quantities and definition).

25. Much of the literature on land availability is devoted to calculations on the amount of agronomically "suitable" and available land, with high and low suitability parameters. Major assessments suggest that ample amounts of land can be mobilized to confront future food demand on the condition that good management practices are adopted, and the same arguments are developed when discussing biofuels. The argument has also been advanced that some biofuel feedstocks would not compete with food even via land use as they could be grown on areas not suitable for foodcrops.

26. The debate on the global amounts of land available from an agronomic point of view often hides other dimensions of "land availability". Many authors point to the need for a clearer picture of what "available land" means, some preferring to use "underutilized" land, while others contest the very notion, arguing that most, if not all, land is already used, in various ways (HLPE, 2011b). Some critical analyses on land availability argue that land that is apparently idle or underutilized is in fact generally integrated into traditional forms of land use, ranging from itinerant pasturing, to fallow lands, to land used for energy, complementary foods and raw material for a variety of non-food activities.

27. In particular many have questioned the role of biofuels as a driver of domestic and foreign large-scale investments in land, often called "land grabbing". In the initial accounts, and in the literature that has emerged as from 2008 focusing particularly on sub-Saharan Africa (SSA) countries, biofuels were identified as a central, if not the leading, motive behind these investments. Subsequent analysis has reduced the weight originally attributed to biofuels, identifying a wider concern with: (i) food security by capital-rich and resource-poor emerging countries; (ii) speculative interests in securing scarce resources in the wake of the financial meltdown of 2008; and (iii) an increasing convergence of food and bioenergy markets through the use of common feedstocks (sometimes called "flex crops"), which can be directed equally at fuel or food markets depending on price advantages. Nevertheless, there is ample documentation that large-

scale biofuel investments are playing an important role in transforming land use in many developing countries.

Biofuels and bioenergy: socio-economic impacts and development perspectives

28. For many, biofuels provide important new opportunities for income and employment generation, in addition to bringing much needed capital, technology and knowledge to developing country agriculture. Other analyses have identified negative impacts of biofuels on poor farmers and their communities, either directly in the form of land expropriations or indirectly through the concentration of resources on large-scale farming operations.

29. Developing countries are still in the process of putting policies together on biofuels, with many investments and initiatives still in various stages of implementation. An appreciation of impacts over time and on a macro or regional scale is, therefore, still largely speculative.

30. An exception here is the Brazilian case, which in terms of sugar-cane ethanol has now a 40-year history, and a decade if we consider its ambitious biodiesel programme. Although the evidence is mixed, in the case of ethanol in the State of São Paulo, a number of studies point to the relatively favourable effects of ethanol investments at municipal level when compared with the other municipalities, particularly those dominated by cattle ranching. The Brazilian biodiesel programme was designed with the objective of rural development based on the family-farming sector and its typical regional oil crops. Huge resources and ingenuity have been invested, but after ten years it is soybeans and the already best-organized sections of family farmers who have benefitted most. On the other hand, the programme confirms that if small farmers have inadequate access to basic resources of land and water, little can be done to consolidate their income on a productive basis.

31. Sub-Saharan Africa has been a specific focus of impact analysis with the use of computable general equilibrium (CGE) models in Mozambique and the United Republic of Tanzania (this latter as part of the bioenergy and food security [BEFS] studies). The countries are equally poor but quite different in energy and food dependences. Transmission of high food and fuel prices was direct in Mozambique leading to a sharp decline in the welfare index (5 percent) and even more in household consumption (7 percent). On the other hand, simulation showed that implanting large-scale biofuels for export would produce positive results with an overall increase of 0.65 percent in overall GDP, rising to 2.4 percent in the case of agriculture and 1.5 percent for industry. The Tanzanian study, conducted in partnership with the FAO BEFS programme, also shows positive welfare results with the expansion of ethanol replacing other export crops rather than foodstuffs.

32. The BEFS project has developed a detailed toolkit for country analysis that includes a long-term analysis of agriculture within an international perspective, a survey of natural resources, detailed feasibility studies of individual projects and a socio-economic analysis of likely impacts. Peru, the United Republic of Tanzania and Thailand have been analysed, covering each of the developing world continents.

33. A growing number of studies have tried to bring to the attention of policy-makers the importance of taking gender into account in biofuels development. These studies highlight the issues of the security of access to and ownership of land as key factors determining whether the expansion of biofuel feedstocks could potentially benefit the rural poor, women in particular.

34. The most positive use of biofuels in highly rural developing countries where transport fuels are less important and where the majority of the rural poor live without access to energy is in the development of bioenergy initiatives for cooking, heating and local power generation. Hundreds of initiatives in this direction are currently being supported in developing countries and there is an urgent need to benchmark the most successful of these experiences for funding and diffusion.

35. A number of scholars have produced typologies to identify both the conditions under which biofuel/bioenergy policies should be adopted in developing countries and the specific focus that these policies should have in each country, given an appreciation of key variables in terms of country endowments and levels of economic development and urbanization. Similarly, farm-level typologies are being adopted to assess relative income and employment implications. Such typologies can be important instruments in guiding the formulation of country and local biofuel policies.

Recommendations

Food security policies and biofuel policies cannot be separated because they mutually interact. Food security and the right to food should be priority concerns in the design of any biofuel policy.

Governments should adopt the principle: biofuels shall not compromise food security and therefore should be managed so that food access or the resources necessary for the production of food, principally land, biodiversity, water and labour are not put at risk. The CFS should undertake action to ensure that this principle is operable in the very varied contexts in which all countries find themselves.

Given the trend to the emergence of a global biofuels market, and a context moving from policy-driven to market-driven biofuels, there is an urgent need for close and pro-active coordination of food security, biofuel/bioenergy policies and energy policies, at national and international levels, as well as rapid response mechanisms in case of crisis.

There is also an urgent need to create an enabling, responsible climate for food and non-food investments compatible with food security.

The HLPE recommends that governments adopt a coordinated food security and energy security strategy, which would require articulation around the following five axes/dimensions.

1. **Adapt to the change to global, market-driven dynamics**

   a. Governments must adjust biofuel policies and devise mechanisms to prevent (market-driven) biofuel demands posing a threat to food security from price rises and diminishing access to land and associated resources for food.

   b. Governments and concerned stakeholders should promote the international coordination of such policies and mechanisms in an appropriate forum, which could address also short-term, coordinated responses in times of crisis.

   c. The CFS could invite the Global Bioenergy Partnership (GBEP), the Committee on Commodity Problems and its Intergovernmental Group on Grains to make a proposal on possible response mechanisms, based on a state-of-the-art review and evaluation of options.

   d. The CFS may recommend/request that governments regularly communicate their biofuels policies and targets to the Agricultural Market Information System (AMIS), with the aim of setting up a comprehensive database.

2. **Address the land, water and resource implications of biofuel policies**

   a. Governments should ensure that the principles for responsible investment in agriculture, currently being elaborated by the CFS, will be effectively implemented and monitored, especially in the case of investments for biofuel production.

   b. The principles of free, prior and informed consent and full participation of all concerned in land-use investment should be used, as preconditions for any land investments.

   c. Measures taken to implement the *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security* should ensure that biofuel investments should not undermine tenure rights, and ensure that women participate fully in land negotiations and that their land tenure rights are recognized.

d. Policies must integrate land and water impact assessment so that land concessions cannot be made without an evaluation of the impacts of land use on water resources.

e. All crops compete for the same land or water, labour, capital, inputs and investment and there are no current magic non-food crops that can ensure more harmonious biofuel production on marginal lands. Therefore, non-food/feedcrops should be assessed with the same rigour as food/feedcrops for their direct and indirect food security impacts.

3. <u>Foster the transition from biofuels to comprehensive food-energy policies</u>

a. Governments should adopt a comprehensive bioenergy policy approach, wider than simply biofuels, promoting the development of a modern biomass-based sector, which, in many developing countries, can be an effective development strategy to provide high-value products, electricity and alternative power for cooking, power for water management and local productive facilities, in addition to transport fuel.

b. Governments should support smallholder participation in biofuels and bioenergy value chains on the basis of fair and equitable conditions of market access and contractual arrangements.

c. As a key part of a coordinated food security and energy security strategy, governments need to explore alternative policy measures (such as improvements in fuel efficiency and a transition to collective transport, and the development of alternative renewable fuels) in order to reduce fossil-energy-based transport and associated GHG emissions according to the specificities of both developing and developed countries.

4. <u>Promote Research and Development</u>

a. Research and development (R&D) have an important role to play in improving the efficiency of the technologies used for biofuels both as regards resources and processes. Research partners should devise solutions adapted to the needs of the least developed countries and of smallholders who are most in need of access to energy. The public sector has here an important role to play, in partnership with the private sector, to upgrade and finance related R&D systems.

b. Research should examine if and how both first- and second-generation biofuels could contribute to restoring degraded land and to the better management of watersheds. Such research could be developed in collaboration with the Global Soil and the Global Water Partnerships.

c. Given the relative energy inefficiencies of current biofuel technologies and those in the pipeline, R&D resources should be dedicated to accelerating the commercial feasibility of more advanced renewable energy pathways.

d. In order to better inform decision-making, governments, FAO, research and associated institutions should promote and facilitate exchange of information and cooperation for food security and biofuels assessments and projections, including by providing transparent information on assumptions, methods, tools and data used.

5. Develop methods and guidelines for coordinated food, biofuels, bio-energy policies at national and international levels

a. The CFS could encourage FAO and relevant stakeholders to elaborate methodologies, including typologies, for assessing national biofuel potential based on land and water availability, population density, food and energy needs, agricultural production, per capita income and other relevant variables to provide a preliminary orientation on the incorporation of biofuel/bioenergy policies within a national food security and energy security plan.

b. The CFS could invite GBEP to launch an inclusive process to ensure that only certification schemes that are multistakeholder, fully participative and transparent be recognized for access to the biofuels market. These schemes should also limit transaction costs to avoid excluding smallholders.

c. While it might be difficult to request all agricultural production to be subject to sustainability criteria ratified by recognized certification schemes, the question should be raised of how to improve the overall sustainability of agriculture at the macro-aggregate level. The CFS could invite the Committee on Agriculture (COAG) to prepare proposals for the development of sustainability criteria, testified by certification schemes, for farming activities and products.

d. The CFS could launch, with support of FAO and GBEP, the development of guidelines to be adopted by countries and used to evaluate the impact and viability of biofuels policies. These guidelines should include:

   i. the prior existence of technical, social and environmental zoning to delimit “available land” and accompanying resources;

   ii. the prior existence of “responsible land investment” practices;

   iii. the prior existence of mechanisms to ensure the capacity to react quickly to food price spikes and problems of food availability (price triggers, waivers, “minimum” levels of food stocks);

   iv. the prior evaluation of the implications for the origin of feedstock provision (domestic/imported); and for trade;

   v. a prior evaluation of the implications of the policy for domestic and international food security.

INTRODUCTION

In October 2011, the UN Committee on World Food Security (CFS) recommended a "*review of biofuels policies – where applicable and if necessary – according to balanced science-based assessments of the opportunities and challenges that they may represent for food security so that biofuels can be produced where it is socially, economically and environmentally feasible to do so*". In line with this, the CFS requested the HLPE to "*conduct a science-based comparative literature analysis taking into consideration the work produced by the FAO and Global Bioenergy Partnership (GBEP) of the positive and negative effects of biofuels on food security*".

To prepare a report on biofuels and food security is especially challenging. It is at the intersection of some major global issues, energy, food, land use and development. Bioenergy and biofuels can be important components within a country's energy portfolio. While there are numerous renewable energy options for heat and electricity generation, biofuels are currently the only means of displacing liquid fossil fuels such as gasoline, diesel and aviation fuels (IEA, 2013).

Biofuel production and the policies used to support its development can relate both positively and negatively with each of the four dimensions of food security[2] – availability, access, utilization (nutrition) and stability. Assessing relationships and causal impact and feedback links between biofuels and food security requires assessments at both global and local levels. It must also be situated within a dynamic perspective, given the fast changing developments, the complex and not necessarily instantaneous relationship between the drivers of biofuels' rise and the (positive and negative) impacts on food security, and the need for projections of the future. And this requires making assumptions on various parameters, ranging from the role of bioenergy, to the evolution of techniques, and to potential impacts at global and local levels.

The report must cover very different perspectives and methodological approaches, from technology to economics, at macro- and micro levels, including social and political issues. It has to tackle these issues despite the existence of sometimes huge data gaps, especially as the development of biofuels is still recent and ongoing. In such an enterprise, there is therefore always a risk of focusing on what is the most familiar (including in terms of methodological approaches to assess policies and impacts), or on what is better known; there is a risk of having one level or dimension overshadowing the others, a risk of wishful thinking, with a belief in science or in safeguards without sufficient proper evidence in the field to back them up.

The scientific endeavour is made more complex by the fact that the topic is also a very sensitive, even emotional, one, as expressed in the provocative "food or fuel" slogan, or in the image contrasting the use of corn (maize) for the Mexican tortilla with its use as ethanol to fuel the cars of the well-to-do.

Biofuel policies have created and provided support for a new demand for traditional foodcrops. The development of biofuels triggers a cascade of impacts on food, agriculture and energy systems (see Figure 1). It results in increased competition in existing markets and new market opportunities. Depending on one´s starting point, either the former or the latter tends to be emphasized, turning the "biofuels and food security" debate into a "sea of controversies":

1. The contribution of biofuels to higher overall demand leads to a first level of controversy over how much of this causes a direct net diversion from human consumption, or indirect when used as feed for livestock ("given what would otherwise be the case").

[2] "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". (World Food Summit, 1996) This widely accepted definition points to the following dimensions of food security:

- Food availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports.
- Food access: Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet.
- Utilization: Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.
- Stability: To be food secure, a population, household or individual must have access to adequate food at all times.

2. The extent of the contribution of biofuels to higher food prices and its magnitude are the source of many debates, which are only relevant in this report to the extent that they feed into a second controversy: the impact of high prices on food security (HLPE, 2011a). Higher prices make food less accessible to poor and hungry people. On the other hand, higher prices will increase income and food security of farmers able to benefit from them: those who are net sellers can store and invest to benefit from increased demand (HLPE, 2013). Higher prices and higher demand are also incentives to increase production.

3. Biofuel production also creates new jobs in the transformation process. These could further trigger new economic activities, responding to the demand of new and more well-to-do consumers. The categories that benefit from such an increased income will see their access to food facilitated. The essential question then is: are these results better (more jobs, more income, more rural development) than would have happened without biofuels, or by adopting other forms of support for agricultural development?

4. Biofuel production generates important amounts of co-products, often particularly valuable as feed for livestock (FAO, 2013). This can offset part of the competition for feedstock between fuel and livestock. It could even lead to an increase in feedstock production, reducing the cost of this particular source of feed, with positive impacts on livestock production (and efficiency), thereby contributing to food security.

5. The development of biofuel production can induce additional competition for land and water, which could further limit access to the natural resources on which smallholders and indigenous people rely.

6. Biofuel development can lead to new land use, reducing access to the biomass on which smallholder populations rely for their cooking. On the other hand, and particularly in energy-poor countries or in remote areas that are difficult to link to the energy grid, bioenergy and biofuels could provide easier and cleaner forms of energy than traditional biomass use and play an important role in rural development.

Not only are these impacts and feedbacks very diverse by nature, they are also experienced differently at global and local levels, and depend very much on local conditions.

The issue of land availability for the joint development and increase of energy and food production is a pivotal point in the debate.

First of all, the question "*Is land available?"* needs to take into account the multiple dimensions of the notion of availability: from physical availability, to land´s agronomic, legal, environmental and social dimensions. The places "available" for biofuels depend on the proper accounting of all these dimensions and the way priorities are established among them.

Second, each of the dimensions above contains its own debates. For example, the physical availability question is debated from "Malthusian" and more "optimistic" positions on the hectares of productive land available, which in fact mirrors the debate between "pessimistic" versus "optimistic" beliefs regarding the global improvement of yields, from marginal up to top prime lands. Another example would be the environmental dimension, which reflects the debates between those who argue that multiple objectives have to be reached within each land use (the "multifunctionality" of agriculture, including the provision of energy as one of these functions), and those who adopt the "specialization" conception, by which trade-offs between different, specialized land uses associated with particular objectives (food land, energy land, environmental reserves, land for smallholders and development) would take place on a broader, even global, level.

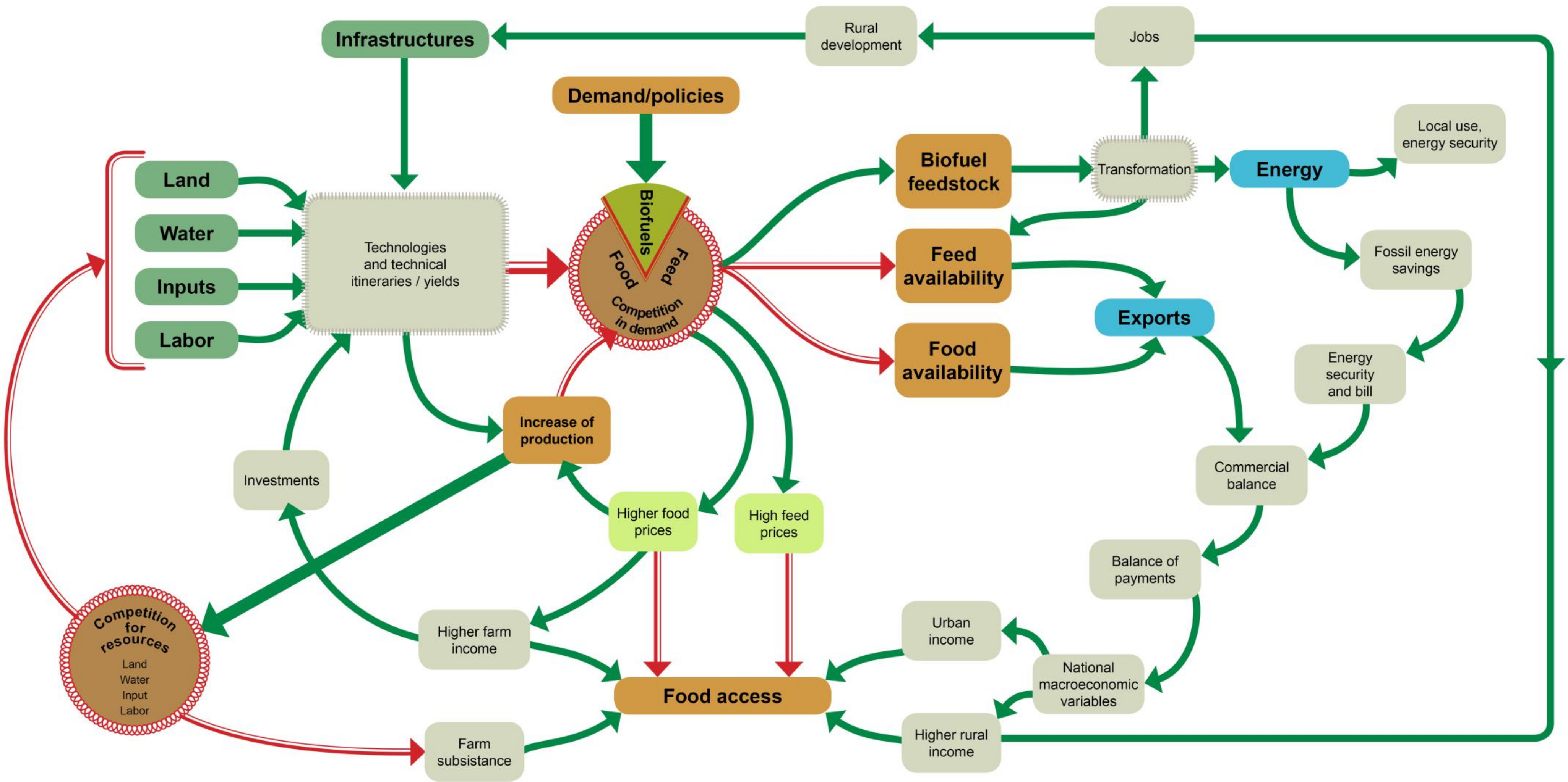


Figure 1 Representation of main impacts and feedbacks in the food, agriculture and energy systems following the introduction of a biofuel demand

Green/plain arrow between A and B shows "positive" impacts (effect A acts to increase effect B). Red/hemstitched arrow shows "negative" impacts (effect A acts to lower/reduce effect B). It starts by biofuel demand/policies, which trigger increased competition for products, which then translates into effects (i) on the production system, including increased competition for resources (bottom/left of the figure), (ii) in households, including farm and non-farm (bottom of the figure), (iii) more broadly on the rural development and national economies (right side of the figure). No distinction is made here on the strength of each impact and feedback loops, nor between long-term or short-term impacts.

The existence of potentially differing impacts at different time scales makes the discussion of biofuels even trickier. The very speed with which the development of biofuels has occurred has induced major changes to the agricultural and agro-industry production systems, posing varied challenges for food security

1. Following the introduction of biofuels triggered in response to policy measures, competition with food generally occurs *before* an eventual induced increase in food production.

2. Overall, it is mostly the global impact of growing demand[3] that is felt first and is mostly negative for the poor and hungry (HLPE 2011a). Positive impacts, whether global through the stimulus of high prices on investment or local on incomes, wages and development, take longer to appear.

3. The delay of some years between the act of buying land for biofuels and the eventual generation of production (as captured in statistics) makes any estimation of the current link between biofuels and "land grabbing" difficult to ground on solid evidence. More positive "spillover" effects on development will also take some years to be documented. Apart from Brazil, which deserves a special consideration, most of the projects in developing countries are relatively new, and so we very often lack evidence on their impacts, whether positive or not.

4. Some of the controversies surrounding biofuels is also grounded in the struggle between two competing narratives according to which their negative effects will necessarily either *increase* or *decrease* through time. The first narrative mainly focuses on perceived negative global effects and expects them to be amplified with biofuel development. The second expects that there will be other positive effects, or that technological progress will radically mitigate the initial negative effects and with time change the terms of the competition.

Finally, perhaps the most important reason for polarization is the understanding that this new demand has been artificially created by policies, which makes it both "unnatural" and, at the same time, easily reversible. To a certain extent, in the US, EU and Brazil, biofuels show an emblematic example of "policies having succeeded to trigger change" in having reached their goals of building an agro-industrial complex, understandably also a reason for national pride. This is, without doubt, why those pro-biofuels and those anti-biofuels are so active in the policy debate: this is an area where policies have made, and can make, the difference, at least up to a certain point, and up to a certain price for oil.

The question therefore goes beyond the impacts of biofuel production to the sometimes different impacts of biofuel *policies* (mandates, tax exemption, prioritization of resources among different uses). Of course they are linked: the development of biofuel production is the result of concerted policies, but the way these policies are conducted and how they evolve have their own impacts.

For example, supporting production increases through investments in research and development has a different type of impact than directly supporting demand. Here again a key question is what would have happened without such policies, or if efforts had been directed instead at other policies for agricultural development?

As a key policy tool, mandates (as an element of the overall demand) seem to be more respectful of market principles than subsidies, for instance. They still distort the market, however, by creating rigidity on the demand side. This new demand affects the price system in two ways: first, everything else being equal, it is an additional demand, and second, the permanence of biofuel demand will modify, and possibly amplify, impacts on the prices of other factors (involving production shocks, speculation and the levels of stocks, etc.).

If the rigidity of the mandates is a problem, could introducing flexibility be an advantage? Devised at a moment when EU and the US were experiencing "excess" agricultural production, mandates provided a protection for farmers against sharp price decreases, thereby serving as a buffer. Could they not also play this buffer role, in a now very different context, to protect markets, farmers and hungry people at times when stocks are short, and when price volatility is exacerbated by risks of various kinds? Instead of supporting the increase of demand, could not mandates, in times of food security crisis, be used in a flexible, reversible way to support a temporary reduction of biofuel demand?

[3] Except for cases where, like sugar-cane ethanol in Brazil, sugar production can grow at the same pace as ethanol demand with little effect on export capacity or competition with its use as food.

Given the complexity of the issues as outlined above, this report does not aim to provide a general account of biofuels nor a comprehensive consideration of food security. Its aim is more specific, that of identifying the implications for food security of biofuel policies and the development of biofuel markets.

Our report analyses the relationship between biofuels and food security from the perspectives of biofuel policies, technology trajectories, prices and land. Each of these themes is discussed through a critical reflection on the relevant recent literature including policy documents, the conclusions of major research institutions and networks, individual academic contributions, specialist journals and business studies, in addition to civil society sources, particularly as regards databanks on biofuel investments and case studies. With regards to the most recent developments in policies and technologies, appropriate information can be found almost exclusively in non peer-reviewed sources. We retained them as far as they appeared to be sufficiently credible (reports commissioned by recognized intitutions, specialist journals, major corporation's reports etc).

While biofuels as substitutes for fossil-based transport fuels are the central element of biofuel policies, our report also considers the related use of biomass for the production of bioenergy. This broader notion is present in the adoption of biogas (which can be simultaneously used for heating and power and for transport) as a strategy for achieving renewable energy targets. As we move to developing countries and particularly those with predominantly rural populations, the bioenergy component of these policies assumes greater importance, since questions of electricity, power generation and heating are often more pressing than transport fuel.

As mentioned above, we take as our point of departure the now commonly accepted understanding of the multiple dimensions of food security – access, availability, use and stability – that are influenced by prices, the availability of the means to produce food, and the extent to which food can be adequately appropriated, particularly relevant here being access to energy and to clean water. Food security depends finally on the degree to which these factors are guaranteed and predictable. Each chapter addresses one or more of these dimensions.

Chapter 1 analyses biofuel policies in developed and developing countries showing that energy security, alternative agricultural outlets or climate change considerations have been dominant in the three leading producer countries/regions. As major emerging countries in Asia adopt biofuels, however, the issue of food security quickly becomes central both in the decision to use non-food crops and in the principle of no land competition with food production. SSA countries may have been initially motivated by the opportunities of new agricultural markets, foreign investments and concerns with energy security, but they too increasingly place food security to the fore. In this chapter, we also discuss the way biofuel markets were created by biofuel policies but may, in some cases, now be reaching the stage where market price signals are the dominant stimulus.

Chapter 2 focuses on the different types of feedstocks and industrial biofuel processes, drawing out their different implications for questions of food security. In the EU and the US, the use of food crops as feedstock is being questioned, and in Asia and Africa the performance of jatropha, on which high hopes had rested for a non-competitive feedstock, has not lived up to initial expectations. While second-generation biofuels have not come on stream as initially hoped, there are now signs that commercial production may be ready to take off, although many feedstocks and technology routes are still in competition. The heterogeneity of biofuels, both in terms of feedstocks and industrial processes, is taken into account throughout the report.

Chapter 3 deals, particularly, with the effects of biofuels on food price levels and volatility, central to the access and stability dimensions of food security. It reviews the literature and discusses the variety of explanatory factors offered. The central concern is to identify the incremental role of biofuels in the sharp rises in agricultural commodity prices. The different models used for agricultural commodity price analyses are briefly reviewed and their difficulty in capturing sharp and rapid shifts in prices highlighted.

Chapter 4 considers the impact of biofuels on land use for food. It also discusses how biofuel investments are influencing access to and rights over land. The issue here, therefore, is the notion of availability and, once again, the degree to which this is assured. Our discussion of water in this chapter captures its centrality for ensuring both the availability and the use aspects of food security. The recent surge in foreign land acquisitions, often characterized as "land grabs", and its association with biofuel investments, is examined first in terms of the empirical evidence and the nature of the data sources and then in the light of differing interpretations of this phenomenon. It is argued that biofuel debates reproduce broader debates on the most appropriate model of agricultural development.

The widespread conflicts that have accompanied these investments have led to further reflection on the notion of land availability, communal rights and the need for a governance framework for land investments including measures for the regulation of land rights, agro-ecological zoning and certification schemes.

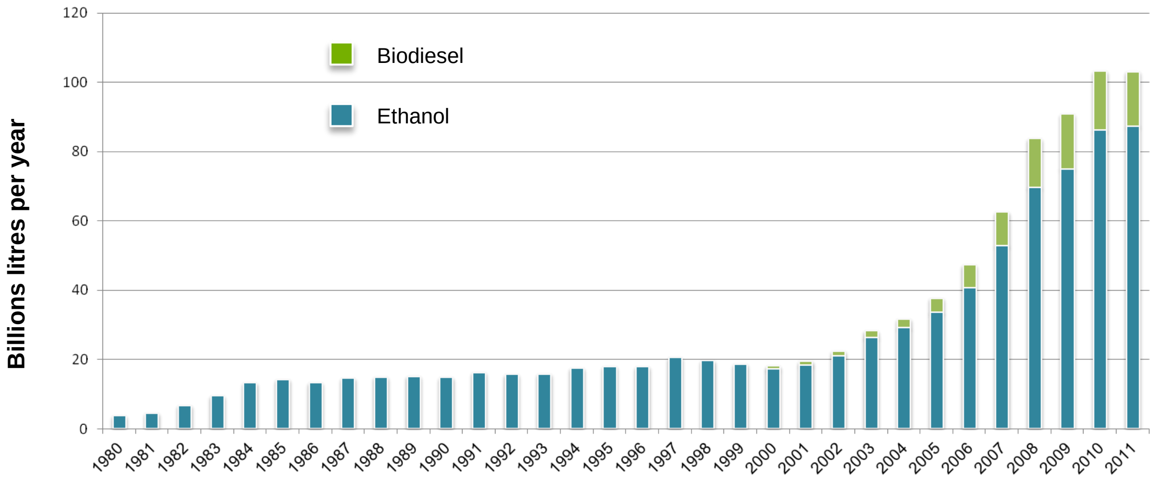
Chapter 5 discusses the positive and negative socio-economic impacts of biofuel investments, particularly on income and employment in developing countries. It examines the Brazilian experience, which, given its long history, is most susceptible to an analysis of socio-economic impacts. It then discusses the results of the leading research networks that are currently evaluating these questions, both those using computable general equilibrium (CGE) models and those basing themselves on household survey techniques. Particular attention is given to gender and biofuels, given the centrality of women in agricultural and household activities. We also consider the development of biofuels/bioenergy for the promotion of energy security (heating, electricity and local power generation), which in turn is a major condition of food security. The chapter concludes with a consideration of the literature dedicated to the development of tools to assess the impacts of biofuel production at country, local and farm levels, which we see as an important instrument for policy formulation.

1 BIOFUEL POLICIES

One of the essential features of the rise in biofuel production, since the 1970s in some key countries, and also of its recent massive increase, has been the central role of public policies. In 2008, about 15 percent of global corn production (mosty in the US) equivalent to about 5.7 percent of total global corn and coarse grain production was used for ethanol production, about 10 percent of global vegetable oil production (mostly in the EU) went to make biodiesel, and 18 percent of sugar cane (mostly in Brazil) went to make ethanol fuel (Daynard and Daynard, 2011; and see Figure 2).

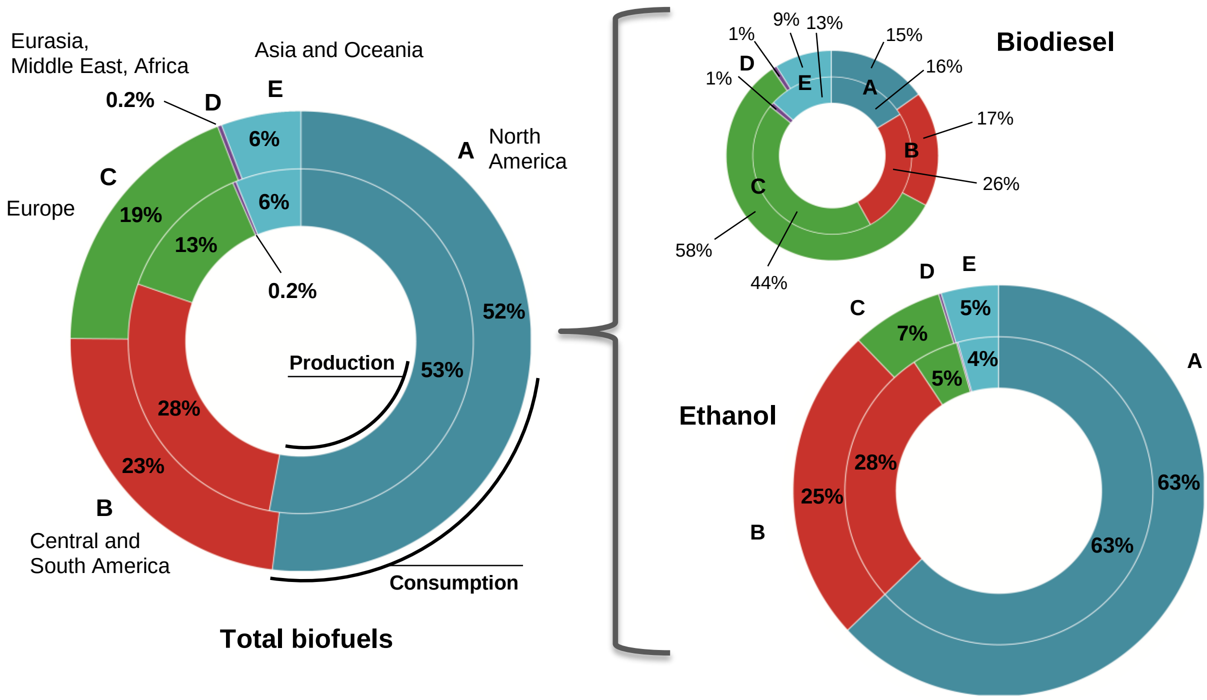
Producer decisions (from the field, to the biofuel plant, and on to the biofuel distribution channels) and consumer demand have mostly been determined by sets of policies and incentives, which in turn have been integrated into broader existing policies and regulations, such as agricultural, energy and bioenergy policies.

Figure 2 Biofuel production, 1980–2011



Source: HLPE, 2012a.

Figure 3 Regional production and consumption of biofuels, ethanol and biodiesel in 2011



2011 Biofuel production (inner circles) and consumption (outer circles) by main region, in percent of world totals. **A** = North America; **B** = Central and South America; **C** = Europe; **D** = Eurasia, Middle East, Africa; **E** = Asia and Oceania. In 2011, biodiesel reprented 21.3% of total biofuel production.
Source: EIA / International Energy Statistics, available at http://www.eia.gov/.

This has had two major implications. In the first place, biofuels have assumed quite different profiles in each country or region, given the diversity in institutions and natural endowments, which in turn has given rise to varied national biofuel plans and policy toolkits (Harvey and Pilgrim, 2011). Second, as a consequence of the national determination of biofuel policies, countries have often been inclined to regulate imports of biofuels, for example by applying tariffs and barriers, in order to protect their internal market. Exports have also been similarly subject to policy stimuli.

The policy toolkit that can be mobilized is quite diverse (Pelkmans, Govaerts and Kessels, 2008), with the main options including:

- on the demand and market creation side: tax exemptions or mandates for the incorporation of biofuels into petroleum fuels (obligations for fuel distributors or filling stations), public procurement (fuel or vehicles), user incentives such as car fleet subsidies, etc.;
- on the side of support for production and distribution: blending or transformation subsidies to compensate for the additional cost over petroleum fuels, agricultural subsidies for biofuel crops, public bank support to investors in the biofuel production chain, in installation and infrastructure, public support for R&D, energy crop production zoning (e.g. in Europe, the possibility of using set-aside lands where these were mandatory), etc.

In addition, some tools are trade-related regulation measures, either shielding domestic markets (e.g. import tariffs, eligibility requirements, quotas) or preventing exports (export tariffs, quotas).

A final set of tools is related to environmental and technical criteria, such as blending walls, fuel quality regulations, fuel certification tools, and sustainability criteria.

This chapter describes the principal features of policy regimes in the leading biofuel markets (Brazil, US, EU) as well as those of the major emerging regions in the biofuels landscape. We look both at the production and demand aspects of these policies since each is equally pertinent in a report that focuses on biofuels and food security. On the production side, biofuel policies are often closely interlinked with agricultural and land-use policies, while demand creation components in addition to tools linking biofuels to the petroleum sector (blending targets, etc.) have created linkages between food and fuel markets, with possible effects on food prices, discussed in Chapter 3.

1.1 The emergence of policy-based biofuel markets – ethanol in Brazil and the US

Modern biofuel markets emerged in response to the two oil price hikes in the 1970s. Various countries responded with proposals for alternative fuel policies but the two countries that created a biofuels ethanol market and a biofuels production sector in this period were Brazil and the US, the former using sugar cane and the latter corn. In both cases, this was done taking advantage of existing agricultural production capacities when low commodity prices encouraged the search for alternative outlets. Broader strategic goals were also central, such as reducing levels of dependence on energy imports, and, especially in the case of Brazil, improving the balance of payments at a time of high oil import bills.

Biofuel policies went beyond issues of regulation and involved the creation of markets via obligatory or highly stimulated blending targets/mandates coupled with a range of tax exemptions, subsidies and favourable credit.

In Brazil, the sugar-cane sector responded well to the PROALCOOL Program launched in 1975: the Program (see Box 1) addressed both supply and demand, with a mix of R&D support, supply or investment subsidies, mandatory instalment of ethanol pumps, taxation of gasoline and regulatory policies. Production rose rapidly, from less than 1 billion litres/year in 1975 to an average of around 12 billion litres/year by 1984. In addition to the demand created by the setting up of a 20 percent blending level for ethanol in standard gasoline, dedicated ethanol-fuelled car production was successfully promoted, using 100 percent (hydrous) ethanol fuel and, by the early 1980s, up to 90 percent of new car sales were of alcohol-only engines (Wilkinson and Herrera, 2010).

Box 1 The PROALCOOL Program in Brazil and subsequent phases of Brazilian ethanol policy

The PROALCOOL Program consisted of two phases.

- Phase 1 (1975–1979) targeted the subsidized expansion of sugar-cane distilleries and an increase in the ethanol content of gasoline, which remained flexible up to 22 percent. There was no commitment to a fixed supply of ethanol and the proportion of ethanol in the transport fuel system could vary according to relative prices (especially of sugar), since plants were versatile and could produce either sugar or ethanol from the same sugar-cane input.
- Phase 2, starting in 1980, saw the introduction of dedicated ethanol-fuelled cars. The technology for these cars was primarily developed at public research centres in the 1970s and then passed on to the private sector (Pelkmans, Govaerts and Kessels, 2008). Expansion in the sugar-cane industry capacity continued to be subsidized for ethanol-only processing plants and ethanol powered cars reached 94.4 percent of total automobile sales by 1986.

Lebre La Rovere, Pereira and Simões (2011) mention third, fourth, and fifth phases in Brazilian alcohol policy, following on from the PROALCOOL Program:

- Phase 3 (1986 to 1989): Ethanol production stopped increasing in 1986 and a major supply crisis in 1989 reduced the share of ethanol-fuelled cars to only 1.02 percent of new cars sold.
- Phase 4 (1989 to 2003): Ethanol is mixed up to 24 percent with gasoline. Local environmental benefits (reduced air pollution in large cities) and employment generation in rural areas become important justifications for ethanol. As from 1999, market forces become the main drivers.
- Phase 5 (from 2003 on): New and huge investment cycle. High oil prices, energy security and climate change concerns stimulate world demand, increasing export opportunities. Domestic demand grows thanks to flex-fuel cars.

A complete account of ethanol in Brazil would have to include further phases covering its recognition by the US as an "advanced" fuel, the 2008 crisis, subsequent recovery in the context of an internationalization of the Brazilian ethanol sector, and the beginnings of corn ethanol production.

In the US, interest for alternatives to petroleum fuels peaked during crisis situations, such as the First and Second World Wars, and the energy crisis in the 1970s. Ethanol production, however, only rose substantially in the 1980s in the wake of the Energy Tax Act of 1978, which introduced a subsidy for blending ethanol into gasoline, and the 1980 Energy Security Act, which offered insured loans for small ethanol producers, price guarantees and federal purchase agreements, and established a tariff on foreign ethanol. Biofuels were initially promoted in the corn-producing regions where ethanol was a co-product of corn syrup. The production of flex-fuel vehicles (FFV) was also encouraged by the Corporate Average Fuel Economy (CAFE) benefits provided to automobile makers, and, by the late 1990s, this led to the production of the E85, the adoption of which, however, even today is quite limited. Tax breaks were tied to E10 blending targets and domestic ethanol was protected from imports by a US 54 cent to the gallon tariff (Glozer, 2011).

Following these early developments (1975–1985), both countries saw an interruption in the growth of their ethanol markets in the 1990s, in a context of lower oil prices. In Brazil, several factors, among which was the increase in international sugar prices, resulted in a larger share of Brazil's sugar cane being used for sugar production, leading to severe ethanol shortages. The alcohol car virtually disappeared and the ethanol market was maintained at more modest levels only through compulsory blending in regular gasoline.

In the US, the dampening effect of lower oil prices was offset by the tax incentives and ethanol production increased from 1.0 billion litres in 1992 to 1.7 billion in 2001 (Glozer, 2011). The Federal Clean Air Act, particularly the 1990 amendments, led first to the use of methyl tertiary butyl ether (MBTE) in substitution for lead as a gasoline octane enhancer. This was soon to provide a decisive opening for ethanol, when MBTE became identified as a contaminant of water sources, leading to its progressive banning in successive States as from the early 2000s and to its substitution by ethanol.

When the surge in biofuel promotion took off in the early years of 2000, the policies of these two countries had already consolidated a biofuels demand, a biofuels market and a biofuels industry. In the course of the first decade of this century, the Brazilian sugar/ethanol sector was now able to operate without direct controls and in response to movements in relative prices, and analysis has suggested that US ethanol production, given continuing high oil prices and the ban on the MBTE oxygenate, could also survive without mandates (Babcock, 2011).

1.2 The entry of the EU and the rise of biodiesel

In the EU, given restrictions in relation to other alternative fuels, biofuels assumed increasing importance within the category of renewable sources of energy, and transport became a central focus. Transport was responsible in 2008 for 32 percent of final energy consumption and 24 percent of total GHG emissions, with road transport accounting for 70 percent of these (European Commission, 2012).

In the first decade of this century EU biofuel policies introduced three new elements: the emergence of environmental concerns, the use of oilseed crops as feedstock, and the first steps towards a globalization of the biofuels market.

1. Differently from Brazil and the US, an extra initial driver in the EU (in addition to the diversification of energy supplies, and the search for new outlets for the agricultural sector) was the goal of combating climate change, arising from the Kyoto commitments (European Biofuels Directive, 2003). This has made EU policy, and biofuels more globally, highly sensitive to environmental concerns, which were also reflected by positions of civil society (Harvey and Pilgrim, 2011).
2. In the EU, given that half the light vehicle fleet and in some countries well over half of all new car sales are equipped with diesel engines, biodiesel is more central to biofuel policy. From a feedstock perspective, this has involved giving greater weight to oilcrops (over cereals and sugar beet) for the production of biofuels. This promotion of oilcrop expansion has involved some direct land-use change (DLUC).
3. Given its traditional dependence on imports of oilcrops and the rapidly expanding mandates, the EU has become dependent on imports, either of biofuels or of feedstock, to meet its targets. In the case of ethanol, imported first from Brazil and later from the US, cost competitiveness appears to be the principal driver. For biodiesel, the scale of the targets leads to a large share of the feedstock being currently imported, variously from Latin America, Africa, Asia or Central and Eastern Europe. According to Bowyer (2010) and German and Schoneveld (2011), by 2020, on the basis of its current targets, the EU would be importing annually the equivalent of some 15.9 billion litres of biodiesel.

The EU biofuel policy, therefore, has triggered the creation of an increasingly globalized biofuels and biofuels feedstock market, involving a key role for developing country agriculture. Currently, Latin America and Asia dominate these flows but Africa, that has become a dominant focus of biofuel investments: if these projects mature, Africa might play an increasing role in future biofuels trade, in the context of the EU-Africa Energy Partnership (EFMN, 2008), one of the eight partnerships of the Africa-EU Joint Strategy adopted by African and European Heads of State and Government in Lisbon in December 2007. The relative weight of Europe´s current dependence on energy feedstocks, and the central role of Asia in biodiesel imports to the EU, is captured in Figure 4 (which also includes wood pellets that have recently become a key feedstock option for power plants in Europe).

The need for major changes in energy sources and transport fuels was widely discussed in Europe in the 1990s. These concerns were consolidated in the European Commission (EC) 2000 Green Paper, *Towards a European strategy for the security of energy supply*,[4] and in the 2001 White Paper, *European transport policy*.[5] Concerns ranged from energy dependence to Kyoto commitments to agricultural development considerations. The overall goal was for the replacement of 20 percent of conventional with "substitute" fuels by 2020.

In the 2003 *Directive on the promotion of the use of biofuels and other renewable fuels for transport,* the first EU-level policy on biofuels, indicative targets of 2 percent and 5.75 percent, respectively, were set for renewables for 2005 and 2010. This Directive also called for biannual evaluations to assess the development and impacts of the programme (EU, 2003).

In 2009, the EU Climate and Energy Package, the Fuel Quality Directive, and the EU/Renewable Energy Directive, were adopted by the European Council, establishing a 10 percent target for renewable transport fuels by 2020. Each Member State would decide its own renewable energy mix and the means to reach this target. The 2009 revision of the EU Fuel Quality Directive also set compulsory targets for the reduction of the life-cycle GHG emissions of fuels, and introduced sustainability criteria for biofuels in order to count towards those targets.

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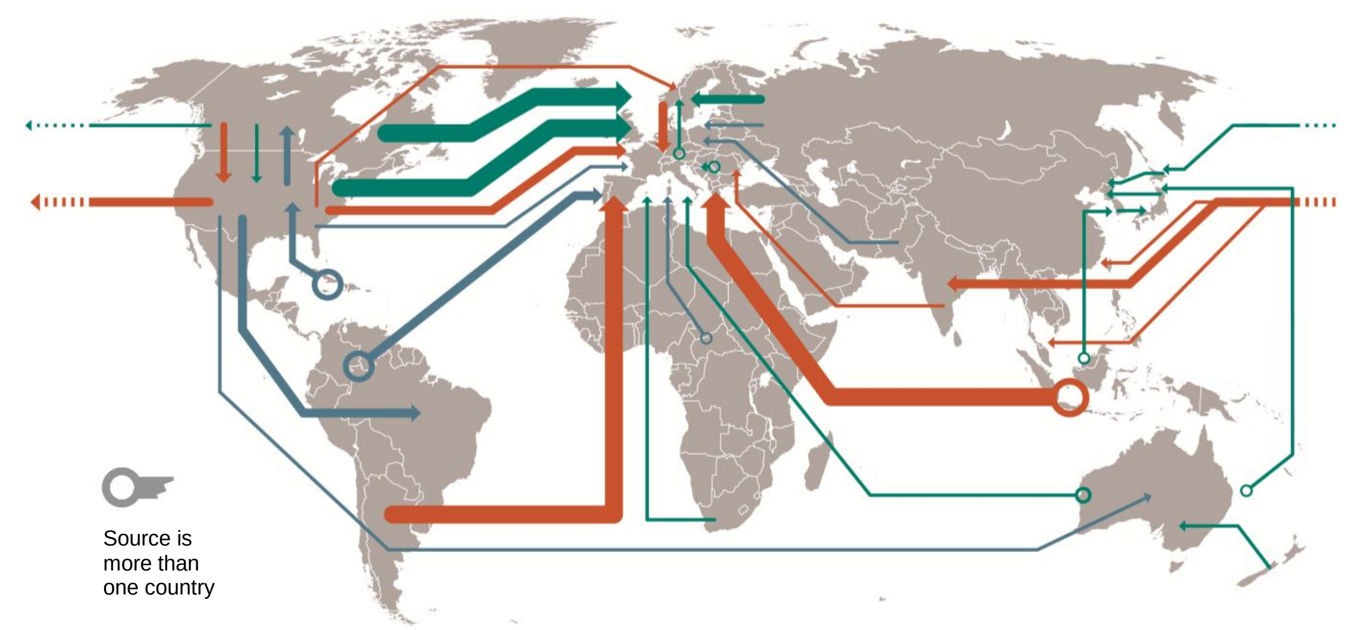
[4] Document COM final (2000) number 769, available at http://eur-lex.europa.eu

[5] Available at http://ec.europa.eu/transport/themes/strategies/2001_white_paper_en.htm

Figure 4 Net trade streams of wood pellets, biodiesel and ethanol, 2011



Bioethanol	Biodiesel	Pellets	Energy content
> 1 000 Ml/yr	> 600 Ml/yr	> 1 000 kt/yr	> 20 PJ/yr
501-1 000 Ml/yr	301-600 Ml/yr	501-1 000 kt/yr	10-20 PJ/yr
101-500 Ml/yr	61-300 Ml/yr	101-500 kt/yr	2-10 PJ/yr
10-100 Ml/yr	6-60 Ml/yr	10-100 kt/yr	0.2-2 PJ/yr

Source: Adapted from REN21, 2012.
Ml = Million litres; kt =Thousand tonnes; PJ = Peta joules (1 Exa joule = 1 000 Peta joules).

Biofuel policy in the EU has been heavily influenced by the dispositions of the Common Agricultural Policy (CAP). In 1992, the establishment of compulsory set-aside lands to counter overproduction in food markets allowed later for the production of non-food crops, providing an initial stimulus for biofuels. In 2004, an energy crop support of 45€ per hectare was introduced for production on non-set-aside lands. In 2009, both compulsory set-aside lands and the 45€ premium for energy crops were abolished.

1.3 A new impulse to biofuels in the US and Brazil

The first decade of this century also saw a leap forward in biofuels in both the US and Brazil. Biofuels in the latter country experienced a remarkable comeback with the launching and rapid diffusion of the flex-fuel car, where the choice of fuel (gasoline or ethanol) can now be made at the pump according to relative prices and not, more irrevocably, at the moment of vehicle purchase. The elimination of price controls for sugar and ethanol, together with the elimination of controls over exports that began at the beginning of the 1990s but were only implemented in 1999, meant that ethanol in Brazil became largely market-driven, with primacy for the rapidly growing domestic market of flex fuel vehicles (FFV), although variable compulsory blending (18–25 percent) with gasoline continued (Jank, 2010).

In addition, and in counterpart to the large-scale monoculture model of sugar-cane ethanol production associated also with harsh labour conditions, the Brazilian Government launched a biodiesel programme[6] in 2003 justified in terms of social inclusion and rural development, (Rodrigues and Accarini, 2007). The idea was to base the programme on family-farm production of biodiesel feedstock using regionally appropriate oilcrops that could be integrated into existing farming systems. Blending targets were originally fixed at 2 percent (B2) but rapidly evolved to 5 percent (B5) by the end of the decade. Although the product of a sophisticated policy of market construction envisaged to ensure

6 http://dc.itamaraty.gov.br/imagens-e-textos/Biocombustiveis-09ing-programabrasileirobiodiesel.pdf

predominantly family-farm participation on the basis of varied feedstock supplies, Brazilian biodiesel is currently overwhelmingly dependent on soybeans, with animal fats making up most of the rest (Wilkinson and Herrera, 2010).

In the US, the first decade of this century also saw a dramatic surge in biofuels, especially following the 2003 Renewable Fuel Standard (RFS) legislation, which called for a phasing out of the MTBE for which ethanol was the only practical substitute. The ban on MTBE created a 3.5 billion gallon (13.2 billion litres) market for ethanol (Keeney, 2009). The 2005 Energy Policy Act required 7.5 billion gallons of ethanol (28.4 billion litres) to be incorporated into transport fuels by 2012, putting in place at the same time a system for trading ethanol credits. Government support for biofuels was also justified in terms of job creation and there was concern for the inclusion of small-scale producers and agricultural cooperatives into the programme, in line with dispositions contained in the 2004 American Job Creation Act and in the 2005 Energy Policy Act.

In 2007, the RFS was expanded by the Energy Security and Independence Act, with the figure for corn ethanol set at 15 billion gallons (56.8 billion litres) by 2015, and a total biofuels target now set at 36 billion gallons (136 billion litres) in 2022, of which 21 billion gallons (80 billion litres) had to come from "advanced" biofuels (see Box 3, page 44) which does include Brazilian sugar-cane ethanol,[7] but not corn ethanol.

The new US targets were accompanied by a host of State and federal policy support measures, such as tax incentives, fuel quality regulations, federal or State car fleet requirements, credits for alternative fuel motors, as well as State subsidies to producers, grants and loans programmes, and tax exemptions (Schnepf and Yacobucci, 2013). As a result, ethanol production in the US shot up from 1.7 billion gallons (6.4 billion litres) in 2001 to 13.9 billion gallons (52.6 billion litres) in 2011, overtaking Brazil, whose ethanol sector only produced 20.8 billion litres in 2011, after the 2008 crisis that put a hold on new investments, driving up the price of ethanol towards potentially uncompetitive levels with gasoline, whose price, in addition, was maintained artificially low.

US biodiesel, using largely soybeans as its feedstock, was less than 1 billion gallons (3.8 billion litres) in 2012, reflecting the share of diesel in the transport matrix. In the renewable fuels legislation, 1 billion gallons (3.8 billion litres) of biodiesel are included in the advanced fuels category to the extent that they show a 50 percent reduction in GHG life-cycle emissions.

In 2012/2013, Brazil's sugar/ethanol sector emerged from the crisis with a record harvest of 653.8 million tonnes. Ethanol increased to 25.8 billion litres and sugar to 43.5 million tonnes, as against 25.8 million tonnes in 2006, a 48 percent increase in sharp contrast to the 1 percent decline in production in the rest of the world during the same period. Since the 2008 financial crisis, there has been a huge influx of international investments (USD22 billion) largely directed at land acquisitions. Some 33 percent of Brazil's production now comes from foreign-owned mills (as against 3 percent in 2006), although agricultural production remains in Brazilian hands given the restrictions imposed on foreign land purchases. Petroleum companies and traditional grain transnationals have a leading position, but important new actors include China, Indonesia and India. China is also investing in corn ethanol in Brazil.[8] These last three players are an expression of the increasing importance of Asian markets for sugar and biofuels.

1.4 The adoption of policy-promoted biofuel markets worldwide

While a number of other countries initiated biofuel policies in the 1970s along with Brazil and the US, it was only in the first decade of this century that many countries on all continents adopted such policies. Unfortunately, there is currently no international mechanism by which countries are invited to report on their policies in all their dimensions: mandates, targets, regulations, tax exemptions etc. This makes compilation and comparison between various heterogeneous sources very challenging. Based on

7 Assumptions on limited indirect land-use change effects were instrumental to this compliance, see US-EPA Proposed rulemaking for the Renewable Fuel Standard Program (RFS2), available at http://www.epa.gov/otaq/renewablefuels/rfs2_1-5.pdf, the Fact sheet on GHG life cycle analysis available http://www.epa.gov/otaq/renewablefuels/420f10006.pdf, and the Summary and analysis of comments on the proposed RFS2 at http://www.epa.gov/otaq/renewablefuels/420r10003.pdf.

8 Article by Germano Oliveira published on www.novacana.org on the basis of a Datagro www.datagro.com report and interview with Datagro President, Plinio Nastar. See http://www.novacana.com/n/industria/usinas/estrangeiros-nova-geracao-usineiros-290413.

various sources, the International Energy Agency[9] publishes overviews of biofuels targets and mandates (e.g IEA, 2011). There are also other attempts, such as the annual survey[10] of Biofuels Digest. According to this latter reference, in 2012, some 60 countries had mandates or targets in place, motivated variously by the attraction of energy security, savings in energy import bill in a context of sustained high oil prices, perspective for improved balance of payments, new sources of income, employment, agricultural and rural development, and by concerns over GHG emissions.

1.4.1 Biofuels in China

China has sustained three decades of record high economic growth and has brought some 300 million people above the poverty line. Nevertheless, given the size of its population, it still accounts for 25 percent of the world´s poor and food insecure (Sumner, 2012). As a result of the size of its economy and its high rate of economic growth, GHG emissions are increasing. Its car sales market, 18.5 million in 2011, is now the largest in the world and is expected to increase to 30 million a year by 2020 (Madslien, 2012). Current estimates put China´s automobile fleet at over 100 million with a projection of some 200 million vehicles by 2020.[11]

China is also dependent on oil imports: they accounted for 55% of oil needs in 2010,[12] a figure estimated to increase to 75 percent by 2030. China launched its renewable energy policies in 2000 and set a renewable energy target of 10 percent of total energy demand by 2010 increasing to 15 percent by 2020 (Shiyan *et al.,* 2012). For liquid biofuels, the target set for 2020[13] was 10 billion litres of ethanol and 2 billion litres of biodiesel, and five large-scale plants capable of producing 1.87 million tonnes were constructed. According to Qiu *et al*. (2012), such an ethanol target represents 14 percent of total gasoline consumption, but would use 20 percent of China´s maize/corn production, some 32 million tonnes, and 6.6 percent of all its cereal production at 2009 figures. Soil degradation through the use of cropland for biofuels was identified as the greatest threat to China´s food security (Ye *et al*., 2010).

In the light of these figures and their possible food security implications, China revised its biofuels policy and in its "Development Program for Renewable Energy" in 2006–07 decided on the use of non-cereal crops and the incorporation of marginal lands (see Chapter 4 for a discussion on marginal land). In the words of the Program: *"biofuel must not compete with grain over land, it must not compete with food that consumers demand, it must not compete with feed for livestock and it must not inflict harm on the environment"* (cited in Qui *et al.*, 2012)

Sweet sorghum, sweet potato and cassava then became the preferred crops and the ethanol targets fixed at 4 billion litres in 2010 and 10 billion litres in 2020. China has a cassava plant with a capacity for 150 million litres and, in addition to domestic supplies, imports from countries within the region, especially Thailand. It is not clear to what extent this new choice of feedstocks competes with food crops for land in China, and intercropping seems to be the guiding strategy. At the same time, China continues to produce grain ethanol from corn and wheat in four ethanol plants already in operation (GAIN, 2012) and is in negotiation for investments in corn ethanol in Brazil.[14]

Jatropha is being promoted for biodiesel through the incorporation of marginal lands. Official calculations put marginal land at 130 million hectares but one study (Wu, Huang and Deng, 2009) argues that suitable and moderately suitable land for jatropha in the three provinces – Yunnan, Sichuan and Guizhou – is insufficient to meet the proposed targets, and that only Yunnan has sufficient land for jatropha. The study suggests that the regional targeting of the jatropha policy should be reconsidered, that there is still considerable work to be done in improving varieties and production practices, and that environmental and economic impact assessments should be undertaken. The targets for biodiesel, which is little used in transport, are much more modest: 200 million litres in 2010

9 The International Energy Agency is an autonomous agency, established in November 1974. It has 28 Member states. A member country of the IEA has to be a member of the OECD.

10 http://www.biofuelsdigest.com/bdigest/2012/11/22/biofuels-mandates-around-the-world-2012/

11 www.chinadaily.com.cn/bizchina/2011-09/17

12 Data from the China National Petroleum Corp (CNPC) Research Institute of Economics and Technology. http://www.cnpc.com.cn

13 Medium- and long-term development plan for renewable energy 2007.

14 http://agro.olhardireto.com.br

and 2 billion litres in 2020. China is heavily dependent on imports for oilcrops and current biodiesel plants are small and use animal fats or waste oils (Fengxia, 2007).

Subsidies are used both for the cultivation of non-cereals and for the incorporation of marginal lands. In addition, Qui *et al.* (2012) provide evidence that China is making important advances in the genetic modification of plants for biofuels and in the development of cellulosic biofuels.

1.4.2 Biofuels in India

India imported 75 percent of its crude oil consumption in 2010 (Ahn and Graczyk, 2012). It was the third largest emitter of CO_2 after China and the US in 2009.[15] Its vehicle fleet was 90 million in 2005, increasing to 140 million in 2011. With vigorous economic growth between 6 and 8 percent/year, annual growth of the transport sector is currently around 8–10 percent/year. Some 51 percent of petroleum consumption goes to transport, as against only 4 percent for agriculture (GAIN, 2012).

Both as a response to dependence on energy imports and to the concern over growing emissions owing to a rapidly increasing transport sector, India has adopted the EU norms on emissions, which involve the promotion of clean fuel. In 2003, it decided on a 5 percent Ethanol Blending Programme, but by the end of that decade only a 2 percent blending had been achieved and biodiesel was insignificant (GAIN, 2012). India´s bioethanol comes principally from molasses although favourable harvests may permit use of the sugar-cane juice. Imports of biofuels are not permitted, although alcohol is both exported and imported.

India´s sugar-cane harvests are very cyclical, which means that bioethanol supplies are also irregular. In the light of good harvests in the middle of the last decade, India increased its target to 5 percent and later to 10 percent, although these figures have not been met. Nevertheless, a target for 20 percent for all biofuels was set for 2017 in the National Policy on Biofuels in 2009 (GAIN, 2012).

Although, for many reasons, ethanol has not advanced as planned as a transport fuel (GAIN, 2012), electricity from sugar-cane biomass is an important factor in power generation for many plants in the sector and in other industries.

The Indian policy for biodiesel, as in the case of China, has been to plant jatropha on marginal lands. In 2003, India launched an ambitious programme for reaching a 20-percent biofuel blend by 2012 through the harvest of between 11.2 and 13.4 million hectares. However by 2010, only half a million hectares had been planted, many of them with a large portion of the crop not yet at harvesting stage. It is now estimated that the target of 20-percent blending would require 18.6 million hectares of marginal land. Although 100 percent foreign direct investment (FDI) is permitted for biofuel projects oriented to the domestic market, inedible oil bearing plants would not be open to such FDI participation (GAIN, 2012).

The first four objectives of India´s National Policy on Biofuels approved in 2009 are as follows:

(i) meet energy needs of India´s vast rural population, stimulating rural development and creating employment opportunities;
(ii) address global concerns with emission reductions through environmentally friendly biofuels;
(iii) derive biofuels from non-edible feedstock on degraded soils or wastelands unsuited to food or feed, thus avoiding a possible conflict between food and fuel;
(iv) optimum development of indigenous biomass and promotion of next generation biofuels.

As in the case of China, the concern with food security in India is paramount both in terms of giving priority to non-food crops and to the use of land that does not enter into competition with food production. In both cases, however, the use of non-edible crops, in particular jatropha, and marginal land has been unsuccessful. The Indian firm Renaka is also investing in the Brazilian sugar/ethanol sector and now has four distilleries that produce 13 million tonnes of sugar and 5 million litres of ethanol.[16]

15 http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid

16 www.novacana.com, see footnote 8.

1.4.3 Biofuels in other Asian countries

Of the other major Asian countries, Japan and the Republic of Korea meet their targets through imports coming from the US, Brazil and Argentina. Indonesia and Malaysia, in spite of being responsible for nearly 90 percent of crude palm oil, are giving less importance to biofuels, either because of the availability of other cheap alternatives to biomass, in the case of Indonesia natural gas, or because palm oil for both countries has more promising markets. Major campaigns by leading non-governmental organizations (NGOs) have associated deforestation in Indonesia and Malaysia with European demand for biofuels. In practice, only small quantities of palm oil or biodiesel are exported to Europe and the deforestation can be understood better as a food-related, indirect land-use change (ILUC) effect as more palm oil is exported to be used in the food industry (Sanders, Balagtas and Gruere, 2012). Wicke *et al*. (2008a, 2008b), for their part, have focused on the DLUC effects of palm oil production in Indonesia and Malaysia, which is then used in conjunction with natural gas to fire electricity generation plants in Europe. Although they do not discuss the relative size of this market compared with the demand for palm oil for food, they argue that in principle the extra demand for land can be met by the use of degraded lands and best agricultural practices. Recent studies by Delzeit, Klepper and Lange (2011) and ICCT (2013) strengthen the view that the different vegetable oil markets are highly correlated and that palm oil from Indonesia and Malaysia substitutes for rapeseed oil used in biodiesel, confirming the relationship between the EU biodiesel targets and palm oil expansion in these countries. Indonesia has also recently made direct investments in Brazil's sugar/ethanol sector.[17]

Thailand has the most ambitious biofuels targets and has been studied by the FAO-BEFS programme (FAO, 2010d). Its 15-year (2008–2022) programme, the Alternative Energy Development Plan (AEDP) aims for alternative energy sources to make up 20.4 percent of its total energy requirement by 2022. Biofuels have an important place in this programme and are expected to increase fivefold, developing ethanol on the basis of sugar cane and cassava, and biodiesel from palm oil. The FAO-BEFS analysis concludes that the programme is feasible but only if high yield increases can be achieved together with improved agricultural practices and the expansion of irrigation. It argues, on the other hand, that food prices will increase with negative effects for urban consumers and the poorest farmers. Expansion in crop area will be at the expense of existing production, particularly rice and rubber, leading to a decline in exports. Exports of cassava are also expected to decline, although Thailand has recently become the major regional exporter of cassava to China, which has led to discussions on the need to limit these exports for food security reasons (Rosenthal, 2011).

Bioenergy, in the form of biogas from residues and waste is widely diffused in Asian agriculture. According to the Netherlands Development Organization (SNV) China had 42 million biogas plants, India 4.4 million and a further eight countries have some 430 000 domestic biogas plants. The Asian Development Bank (ADB[18]) coordinates the Energy for All programme, which aims to install a further one million biogas plants in 15 Asian countries by 2016, providing energy for five million people.[19] The FAO-BEFS analysis of Thailand included small-scale bioenergy projects and identified an important vulnerability in their continued dependence on outside technical assistance, which is generally not taken into account when promoting these projects.

1.4.4 Biofuels in South Africa

In a very different context, South Africa has also focused its biofuels programme on "underutilized land", a concern evident both in India and China, and on small producers marginalized by apartheid, which recalls the Brazilian biodiesel programme. The results have so far been very unpromising. One fundamental difference, however, was the exclusion and banning of jatropha as an exotic plant, which it was thought could become invasive in the South African context. The first moves to develop biofuels came from the established sugar and, particularly, maize growers but these were thwarted by the criteria governing the Government´s biofuels policy in 2007. It was decided that, for food security reasons, maize should not be acceptable as a feedstock until underutilized land has been fully put into production and measures put in place to guard against extreme food inflation (Department of Minerals

[17] www.novacana.com, see footnote 8.

[18] http://www.snvworld.org/

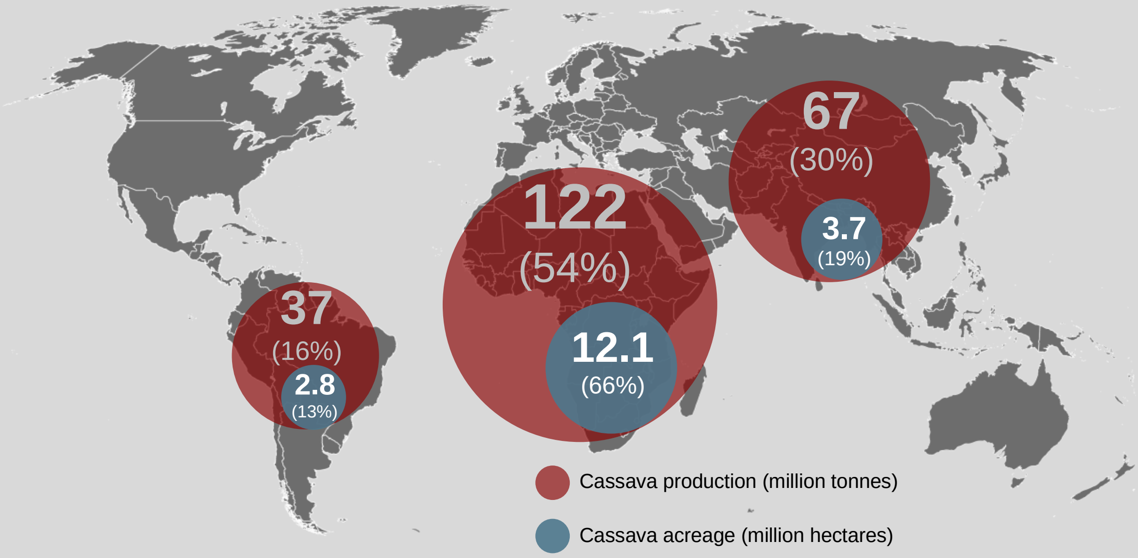
[19] www.snvworld.org

Box 2 Cassava: a "new" biofuel feedstock

There is a growing interest in using Cassava as a feedstock for ethanol-based biofuel (Jansson *et al.*, 2009). The first important use of cassava is for human food. It ranks as the fifth most important source of calories in the world (FAO, 2000). Cassava as daily food serves approximately 600 million people in the world. Cassava is a key staple food in Africa. In Sub-Saharan African regions, in particular, about one-third of the population gets more than half of its calories from foods made from cassava roots" (Manyong, 2000). Besides the root, young leaves are also used as greens. Since it is suitable to grow on marginal land, cassava is often considered as a food of the poor, with the majority of it grown by small-holders, in particular poor farmers, many of them are women (Rossi & Lambrou, 2008).

In 2006, total world production of cassava was around 226 million tonnes with Africa as the main producer region, with Nigeria, Brazil, Thailand, Indonesia, and the Democratic Republic of Congo accounting for almost 70 percent of the world´s cassava (FAO, 2000). Cassava is also used as starch for myriad food products and industrial goods, including cardboard, glue, laundry starch, textile, plywood, tapioca pudding, and alcohol (FAO, 2000; FAO, 2002). The second important use of cassava is as a feed ingredient for pork, poultry, cattle and fish farming. A number of projects have been designed to increase the production and industrialization of cassava for income generation and food security for the low-income population in rural Africa and Asia (FAO, 2001; Manyong *et al.*, 2000). Since this crop is important for food, feed, and the livelihood of people in the developing countries, there has been concern about the impact of its use for biofuel feedstock on food security (Sidhu, 2011).

Figure 5 Production and harvested areas of cassava in the world (2006)



Source: Adapted from H.Vanderschuren (ETH Zürich) and data from FAO (2008), available at http://www.pb.ethz.ch/research/cassava_projects/cassava_facts.

In terms of international trade, Thailand supplies around 80 percent of cassava on the world market (FAO, 2001). Thailand, Viet Nam, Nigeria and especially China are among the countries that are considering using cassava for bioethanol. Realizing that using food crops for biofuel can contribute to increases in food prices, from 2007 onwards the Chinese government stopped new plans for grain-based ethanol, and looked as alternatives at cassava and sweet sorghum, considered in China as non-food crops (Huang *et al.*, 2008). China´s increased imports for cassava especially from Thailand, as biofuel feedstock instead of wheat and corn, contributed to the increase in the price of cassava in 2008 (Rosenthal, 2011; Scott & Junyang, 2012; Fengxia, 2007). Raw cassava exports from Thailand, the world's largest exporter, switched from EU for feed to China for biofuel: Thailand sent nearly 98 percent of its cassava pellets exports to China in 2010, a fourfold increase over 2008 (Rosenthal, 2011; Sidhu, 2011).

and Energy, 2007). Sugar cane, sugar beet and soybean projects have been approved but the overriding condition is that feedstocks should be from crops produced in the underutilized homelands.

The objectives of the programme were neither inspired by dependence on energy imports, nor by concern with CO_2 emissions. Here again, the South African context differs from that of both China and India. Where it has closer parallels are in the objectives of using the biofuels programme to promote rural development, alleviate poverty and focus on non-cultivated lands, more specifically "new and additional lands" and/or "currently underutilized lands" (Sparks and Ortmann, 2011).

The initial target was for an overall voluntary 2 percent blend, broken down into B2 (2 percent biodiesel) and E8 (gasoline with 8 percent of ethanol) given the overwhelming dominance of diesel-driven vehicles. It was claimed this would only occupy 1.4 percent of cropland and would create over 25 000 jobs (Funcke, Strauss and Meyer, 2009). The targeted land was situated in the homelands where an estimated 14 percent of the land was underutilized (Department of Minerals and Energy, 2007). A further goal was to focus the programme on products that had been grown previously in the homelands, and on small farmers discriminated by apartheid. In this respect, the programme echoes the Brazilian biodiesel programme, which similarly has tried to base itself on the family farmers, choosing the feedstock in accordance with different regional farming practices.

To date the results in South Africa have been quite negative. Some have attributed this to lack of compulsory mandates; others to the exclusion of maize. Letete and von Blottnitz (2010) would give more importance to the ambiguity of the notion of "underutilized" land (see Chapter 4), together with the lack of experience of the farmers targeted and the lack of effective assistance given to these farmers. In South Africa, oil crops sell for three times diesel prices and the only biodiesel currently being commercialized comes from small plants recycling used vegetable oils.

1.4.5 An emerging biofuels strategy in sub-Saharan Africa

Some African countries (Malawi, Zimbabwe) have an established tradition of biofuels/bioenergy production from sugar-cane molasses. In the last decade, however, an increasing number of SSA countries have adopted biofuels/bioenergy policies, some with targets and mandates for transport fuel blending. The motives have been varied, ranging from increasing energy self-sufficiency and foreign exchange savings to rural development objectives.

Energy security on the African continent is not limited to finding substitutes to fossil fuel imports, although this is an important motive in a number of energy dependent countries. First, as we also saw in the case of India, biomass can be an important source of power generation, when there is no access to the electricity grid, as in many countries with predominantly rural populations. The burning of wood for cooking and heating and its transformation into charcoal provides the overwhelming source of energy for the majority of Africa's poor. On the other hand, an accelerating urbanization in all African countries will increase interest in the use of biofuels for transport, particularly for landlocked and petroleum-dependent countries. Bioenergy, however, in its various forms, and not simply biofuels, is a key concern both for energy and food security goals.

Climate change concerns and GHG mitigation have not been an explicit goal since these countries have no obligatory commitments under the Kyoto Protocol of the UN Framework Convention on Climate Change (UNFCCC). A common goal, however, has been that of creating a favourable institutional climate for foreign biofuels investment. A key stimulus here was the EU biofuel targets. While each EU Member State was free to decide the mix of renewable energies for achieving the 10 percent target or renewable energy in transport, it was clear that the major role would be played by first-generation food/fuel crops and that, differently from the cases of Brazil and the US, substantial imports would be required. The EU-Africa Energy Partnership was created with this in mind (EFMN, 2008). Although different agricultural models could be adopted, the common objective was to promote large-scale production for export. This would involve similarly large-scale investments that were attractive to SSA governments both for the benefits this might bring in terms of agricultural development and because it would lead to the entry of much-needed hard currency. In addition, in some cases, financial benefits via the Clean Development Mechanism are also involved (UNFCCC, 2012).

Brazil, for its part, has also committed itself to promoting biofuels in SSA and is promoting feasibility studies in various African countries. Access to the European biofuels market within the "Everything but Arms" agreement in itself provides a considerable motivation but the overriding incentive has been the desire to promote a global biofuels market. Brazil has clear advantages in research capacity and

technological know-how for the promotion of biofuels. It also has an interest in increasing the number of biofuel-producer countries.

Maltitz and Stafford (2011) document the evolution in policy formulation in their recent analysis of different African countries. In addition, they point to the emergence of a common baseline among SSA policy formulators on the need for biofuel policies to:

(i) be designed for the promotion of rural development;
(ii) be geared to the objectives of energy security;
(iii) develop the ability to attract appropriate investments;
(iv) be based on sustainable land use.

1.4.6 Biofuels in Latin America

As from the 1970s, Brazil´s PROALCOOL Program served as a stimulus to the adoption of biofuel policies in other Latin American countries. An independent impulse for Central American countries was provided by their exemption from the 54 cent import duty on ethanol to the US. This tax was primarily designed to limit the importations of Brazilian ethanol, which in turn incited Brazil to start making direct investments in ethanol production in Central America and the Caribbean as a way of accessing the US market.

Differently from Asia and Africa, Latin American countries are overwhelmingly urban and, in the resurgence of biofuels in the last decade, Dufey (2010) identifies 17 Latin American countries as having adopted biofuel policies with specific targets and mandates for transport fuels. Most of these countries have targets for both ethanol and biodiesel.

Of the 900 million hectares of land not cultivated globally but suitable for rainfed cereal cultivation as identified in the GAEZ/IIASA/FAO study (Fischler *et al*., 2011), some 320 million are located in Central and, particularly, South America. An FAO/ECLAC (2007) study concluded that "*Latin America has the potential of satisfying an important part of world demand for ethanol and biodiesel*" (p. 39).

If we limit our considerations to Brazil, the report´s conclusions find strong support. Using only some 1.5 percent of its arable land (4.5 million hectares), Brazil in 2008 was supplying half of the fuel needs of its non-diesel vehicle fleet with ethanol and was also the leading exporter of ethanol (BNDES and CGEE, 2008). In addition, Brazil has huge resources of some 170 million hectares of underused pasture land, with currently little more than one head per hectare on average. Modest improvements in productivity would in principle release sufficient land to attend future domestic demand and remain a major exporter (Leite *et al.,* 2009). Agro-ecological zoning carried out by the national agricultural research institution (Embrapa) in conjunction with other academic institutions identified some 64.7 million hectares suitable for sugar-cane production, not including the Amazon, the Pantanal and areas of rich native biodiversity (Manzatto *et al*., 2009). Paraguay has more recently made similar claims for the development of biofuels (Hira and Garceti, 2011).

The FAO/ECLAC study, however, was careful in its conclusions, pointing to potential dangers deriving from land concentration, the uncertainty surrounding net employment benefits, doubts on cost competitiveness, and concerns over the extension of the agricultural frontier with resulting pressure on ecosystems. The message was nevertheless positive and the probable shifts in income from consumer to producer and from urban to rural were seen to be consistent with rural development strategies. In a further official joint FAO/ECLAC document in the same year (2007), the conclusion on land availability and the lack of any necessary conflict between food and fuel production is even more emphatic: "*The general perception is that arable land is completely occupied and that there is little margin for expansion for new crops. The data on Latin America and the Caribbean show, on the contrary, that there is still a great potential for increasing production*" (p. 8).

In Chapter 4, we discuss the question of the technical availability of land and its actual availability in the light of investment projects. In Latin America, where land availability has been most plausibly demonstrated, conflicts associated with land investments have, nevertheless, been widespread (Jayne, Chamberlin and Muyanga, 2012; Haddock, 2012; Goldstein, 2012).

The Inter-American Development Bank (IDB) began its support for biofuels in 2007, financing Brazilian sugar mills, and then provided a line of credit to promote Brazilian ethanol exports, particularly to the UK. By 2009, the IDB was providing systematic support for the promotion of national programmes in many Latin American and Caribbean countries. Regional initiatives also became important with the establishment of the Meso-American Network involving Mexico, eight Central American countries and

Colombia. Central America was seen to be a priority given its almost total dependence on petroleum imports, its favourable climatic and agronomic conditions, and the crisis affecting its export crops.

In the wake of the price hikes in 2008–09 and the food–fuel debates, the IDB elaborated its Scorecard for Sustainable Biofuels,[20] changing the conditions under which it continued its support for biofuels. The new criteria cover: yield, previous land use, crop life-cycle/crop rotation and crop mix. Corn for ethanol was excluded and while sugar-cane and soybean projects continued to be supported, these had to be combined with development objectives. Ethanol plants in the Brazilian South were excluded but not those in the Northeast or in Central America and the Caribbean. Nevertheless, the orientation was now for non-food crops – jatropha and sorghum – or for second generation options as in its support for the development of ethanol via wood residues in Chile. By the end of 2008, the IDB was dedicating 10 percent of its USD4 billion Latin American portfolio to biofuel projects, comparable with its support for traditional energy. It has subsequently joined the Steering Board of the Global Bioenergy Partnership and the Roundtable on Sustainable Biofuels, and it finances auditing, the development of indicators and certification schemes within these frameworks.[21]

Argentina has emerged as a major player in biodiesel and, while it too now has a B7 blending target, it has transformed itself into a leading exporter to Europe, particularly in the light of civil society critiques of the impact of Asian palm oil exports on deforestation (GAIN, 2012). Argentina´s biodiesel is based on soybeans like in Brazil but, in terms of global perception, it is seen to be far from the Amazon, and therefore less problematic in terms of impact on land use and deforestation than soybeans from Brazil. Nevertheless, some analyses suggest that the expansion of soybeans in Argentina is partially at the expense of native forest land (Recalde, 2012). The two principal motives behind the promotion of biodiesel from soybeans have been to substitute diesel imports and to compensate the loss of the Chinese vegetable oil market consequent on China´s decision to crush its own oil. There is in practice a dual market with small and medium enterprises feeding into the domestic biofuel market, and large-scale global traders/crushers exporting basically to Europe (GAIN, 2012).

More recently, Argentina has moved into corn ethanol, for which it has a competitive advantage (Babcock and Carriquiry, 2012). More surprisingly perhaps, Brazil is also beginning corn-based ethanol production,[22] stimulated in part by proposed investments from China, but also related to the explosion of corn production in the savannah region in the interior of the country, which is confronted with great logistical difficulties for export. Corn ethanol may well become an important complement in the interval between sugar-cane harvests. The latest development, in this sense, has been the construction of a flexible distillery able to produce ethanol either from corn or sugar cane.[23]

Colombia has developed an aggressive biofuels policy based on mandates and it is expected that the domestic market will absorb all its production in the coming period (GAIN, 2012b). In Colombia, palm oil is being seen as the most viable alternative to coca and some accounts suggest that the results are being positive for small producers both in terms of income and in the concomitant opportunity for associated food crop production (USDA, 2011). Other studies, both with regard to Colombia and other Latin American countries, have identified biofuel expansion with encroachment on peasant lands (Borras *et al*., 2012). Here again, we see that the technical availability of adequate land identified in the FAO/ECLAC studies mentioned above does not necessarily mean that these are the lands that will be effectively occupied. We explore the issue of land availability and land investments for biofuels in more detail in Chapter 4.

1.5 EU and US: policies at a turning point?

The policy context in the US and in Europe regarding biofuels is rapidly evolving. There are several reasons behind this, the main ones in Europe being suspicions over the possible negative role of biofuels in terms of DLUC and ILUC effects at the expense of pristine ecosystems and forests, and also over biofuels' possible negative role in the competition of first-generation biofuels with food crops (See Chapter 4). In the US, the decisive issues are the approaching ceiling on corn ethanol within the

20 www.iadb.org/biofuelsscorecard/

21 See http://www.icao.int/Meetings/EnvironmentalWorkshops/Documents/2011-SUSTAF/20_Vieira.pdf

22 See http://www1.folha.uol.com.br/internacional/en/business/2012/03/1058859-corn-based-ethanol-is-feasible-in-brazil.shtml

23 See http://g1.globo.com/mato-grosso/noticia/2012/03/usina-que-produz-etanol-de-cana-comeca-gerar-combustivel-de-milho.html

current rules, and the current inability of second-generation biofuels to occupy their projected share of the market.

While such aspects will be studied in more detail in Chapter 3 (Biofuels, food demand and food price, hunger and poverty) and Chapter 4 (Biofuels and land) of this report, we draw attention here to the consequences of such recent considerations for the EU and the US biofuel policies.

In October 2012, after almost two years of discussions, the European Commission (EC) issued a proposal for a new directive proposing a radical revision of its previous dispositions, suggesting a 5 percent blending cap for food-crop based biofuels (including cereal and other starch-rich crops, sugars and oil crops), a level virtually reached for Europe as a whole and that some countries had already exceeded. While the overall target of 10 percent of renewable fuels in transport would remain unchanged, a direct consequence of this proposal would be the need to achieve this goal with non-food, second-generation biofuels or with alternative renewable fuels (e.g. electricity out of renewable sources, such as solar, wind or hydraulic sources). Some observers have pointed out that this might increase the difficultly of reaching the 10 percent renewable fuels target in EU transport by 2020, as second-generation biofuels might not be available on such a commercial scale (see Chapter 2).

Furthermore, the EC is currently carrying out an evaluation of the impacts of the EU-funded biofuel projects under development in the African, Caribbean and Pacific (ACP) countries, potentially questioning EU support for food crop biofuel investment projects aimed at exports to Europe. The EC is studying the impact of biofuel production on developing countries from the point of view of policy coherence for development, as its commissioning of a related study testifies (Diop *et al.,* 2013; see also Chapter. 5).

In the US, at the same time, uncertainties regarding the viability of mandates emerged, once it became clear that second-generation biofuels were not in a position to take over from food-crop biofuels as originally imagined in the policy mandate. Maize-based ethanol was nearing the "blending wall" (the percentage limit of ethanol to be mixed with gasoline) of E10 imposed by the EPA: as a first-generation biofuel, it was also close to the allotted share of 15 billion gallons (56.8 billion litres). It was clear, however, that second-generation biofuels[24] were still only initiating full-scale commercial operations and were not yet ready to fill the remaining 16 billion gallons (60.6 billion litres). The way was now open for Brazilian ethanol, recognized as an advanced biofuel[25] by the EPA, to occupy the 4 billion gallon (15.1 billion litres) window of advanced biofuels. The provision for E15 in the case of new (2007 and after) light vehicles, however, could allow for the continued expansion of corn ethanol, although there is widespread resistance to its adoption.

Biofuel policies in the US and EU are now at a turning point, with similar proposals to put a ceiling on food-based biofuels at around their existing levels. Regional exports of "advanced" sugar-cane ethanol from Brazil and Central America to the US will probably increase, while the US will be looking towards export markets for its "old" 1G maize ethanol, including to Brazil. The 2012 proposed change in EU-mandated targets could slow down, or change the composition of the emerging global market towards which the original 10-percent target was originally leading all actors. In the light of currently less profitable conditions for the biofuel industry given today's high grain and oilseed prices, and the lack of success to date with jatropha, many EU investment projects abroad have already been abandoned or put on hold and the EU´s proposal is likely to accelerate this process. For the biofuel policies of developing countries, this means that the much needed investment capital will be more difficult to mobilize, but it will also allow space for redefining national and regional policies, as Maltitz and Stafford (2011) have documented for the case of SSA mentioned above.

What is less clear is the impact of future demand by China, India and other major developing countries, such as Brazil, on biofuel investments in Africa, where many of these countries are active. In addition, these countries are both promoting new regional biofuel markets in Asia, and accelerating the development of a global biofuel market through their investments in Brazil. It remains to be seen, however, whether these countries will revise their biofuel targets/mandates downwards under the influence of the EU proposal to limit first-generation biofuels to their current levels.

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[24] Second-generation biofuels are those biofuels produced from cellulose, hemicellulose or lignin. Examples of second-generation biofuels are cellulosic ethanol and Fischer-Tropsch fuels (OECD/IEA, 2010).

[25] The EPA defines ''advanced biofuel'' as a renewable fuel, other than ethanol derived from corn starch, and for which lifecycle GHG emissions are at least 50 percent less than the gasoline or diesel fuel it displaces. (Federal Register / Vol. 75, No. 58 / Friday, March 26, 2010 / Rules and Regulations. Environmental Protection Agency 40 CFR Part 80 Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program).

A recent development in the EU that might provoke renewed interest in investments in the South, although for the moment supplies are largely being mobilized from temperate climate sources, is the promotion of biomass in the form of wood pellets for energy generation in power plants. Here again we see that biofuels should be situated within broader bioenergy strategies and policies.

1.6 Conclusions

As we move from the US and Brazil to the EU and then to Asian and African emerging or developing countries, the connection between biofuels and food security becomes more explicit. The US and Brazil share many similarities, with large agricultural areas, high self-sufficiency in food and raw materials, and processes of urbanization already completed. Their ability to harmonize food security and biofuel production domestically has not been seriously challenged. In the case of the US, the impact on food security is essentially through the global transmission of prices. Brazil, on the other hand, in addition to promoting its ethanol exports, is also engaged in exporting its sugar-cane bioethanol model. Few developing countries, however, dispose of the exceptional conditions (land, water, technology, accumulated expertise and R&D capacity) that have justified Brazil's biofuels strategy.

With the entry of the EU, a new dynamic is created since its targets cannot be fully met using only its domestic biomass and have led to the global promotion of biofuels and biofuel feedstocks, particularly in the developing world, to attend to an important part of its demand. At the same time, such production must conform to the "sustainability" criteria (the fuel quality directive and the RTSB) that underpin this market. Initially these were restricted to a demonstration that the required GHG emission reductions over fossil fuels had been achieved. Once land-use change issues became incorporated into the calculation, the impact on GHG was drastically modified, and it opened the door to a questioning of the impact on food crop production, and therefore on food security, even if such criteria were not part of the sustainability criteria retained in the Fuel Quality Directive.

When we turn to the biofuel policies of the major emerging countries, we see that food security quickly becomes a central issue, with clear policies in China, India and South Africa not to base biofuels on food crops or on crops in competition with food for land. Hopes were based in the former two cases on the eminently non-food crop jatropha (the poison nut), which, in addition, was considered to thrive on marginal lands. South Africa, for its part, relied on the untapped resources of the homelands, marginalized during the apartheid regime. However, in all three cases, the potential of the chosen crop and of the marginal lands to grow biofuel feedstock efficiently has to date proven to be illusory.

The need to condition biofuel policies on their compatibility with food security as a primary policy objective, together with environmental concerns and the need to demonstrate effective GHG savings, act as strong drivers for an accelerated transition to second-generation biofuels in the US and the EU. The same pressure has led to innovative regulation of land use in Brazil (the adoption of agro-ecological zoning) and to new strategies of biomass use (bio-electricity and bio-fertilizer as co-products).

In the emerging and developing countries, as we saw above, the non-use of food crops and the principle of no competition with food crops for land often have been inscribed in their policies. The proposed solutions that would make such policies viable have, however, been shown to date to be unworkable, both as regards proposed products (jatropha) and lands (marginal). As we will see in the next chapter on the technological frontier for biofuels, few of these countries have the resources to move forward to second-generation biofuels, given the often proprietary nature of this technology, the elevated capital investments required, and the high demands that second-generation technologies make on infrastructure, logistics and human capital. While many developing countries have experience with sugar-cane production and some with ethanol, few have the institutional and R&D capacities that underpin the Brazilian model. Brazilian international biofuels cooperation is designed to offset these limitations and transfer the necessary technological and human competences.

For many developing countries, particularly those that are still predominantly rural, the participation of transport fuels in total energy demand is quite limited. This also means that a biofuels policy geared to liquid transport fuel would require the dedication of relatively modest land resources. For many such countries, the priority is for a broader bioenergy policy that would draw on local biomass resources to attend to a range of issues, involving local energy generation for economic activities, electricity for lighting and the development of alternative energy sources for cooking. We will discuss these broader bioenergy strategies in Chapter 5.

2 BIOFUELS AND THE TECHNOLOGY FRONTIER

The degree to which the promotion of biofuels enters into competition with food production, raising questions of food security, depends on a variety of factors:

- choice of feedstock;
- natural resources involved (especially land and water);
- relative efficiencies (yields, costs, GHG emissions) of different feedstocks;
- processing technologies adopted.

Concern over competition between biofuels and food production has been particularly acute given the overwhelming use of food and feed crops for both ethanol and biodiesel. In the previous chapter, we saw how limits have been placed on the use of food/feed crops for biofuels in the US and have been proposed also in the EU. We also saw how biofuel policies in Africa and Asia have placed this potential competition at the centre of their concerns, giving priority to the use of non-food crops and "marginal" lands. In this chapter, we review recent literature on technologies used to produce biofuels and the way they influence the competition between biofuels and food/feed production.

Research and technology are currently exploring a wide range of different options to address the factors enumerated above with a view to minimizing potential competition between biofuels and food production. We analyse the current state of discussion on these issues, including the time scale for commercial adoption of the different proposed technology routes.

We also consider the potential contribution of emerging technology options to the development of biofuels in developing countries.

2.1 Biofuel technology trajectories

Support for biofuels has become contested as studies emerge connecting their rapid growth to rising food prices and challenging their credentials in terms of their capabilities to displace fossil energy and reduce emissions of pollutants (including GHGs), pointing also to their potential contribution to monoculture and deforestation (Wagstrom and Hill, 2012; Searchinger *et al*., 2008; Lagi *et al*., 2011; Fargione *et al*. 2008; Mitchell, 2008). In the scientific literature, debates continue over the net energy balance of biofuels, over their net contribution to climate change mitigation (especially when account is taken of possible effects on land-use change and the loss of carbon stocks), and over the direct and indirect association of biofuels with deforestation or the ploughing up of grassland (van Renssen, 2011; EEA, 2011).

In this debate, much hope has been placed on feedstocks that would not directly compete with food, and that could be grown on land unsuitable for food crops, such as jatropha, and especially on techniques that could valourize non-edible and ligno-cellulosic biomass, generally designed as second-generation biofuels, or that use algae that would eliminate dependence on crops and involve minimal land use, often designed as 3rd generation biofuels.

The main distinction between first- and second-generation biofuels relies on the techniques used and thus on the types of biomass used as a feedstock. The differences are explained in Box 3.

The main routes for the production of second-generation cellulosic biofuels are illustrated in

Figure 6. As the figure shows, from a technology standpoint, there are two main conversion routes being pursued for second generation biofuels.

- The biochemical route includes the hydrolysis of the lignocellulosic materials for subsequent fermentation of the obtained sugars into ethanol.
- The thermochemical route involves heating the biomass to high temperatures and generally higher pressures than for the biochemical process. Thermochemical routes were believed to be more flexible in terms of the range of feedstocks able to be utilized as well as in the diversity of fuels that can be obtained (Larson, 2008) from ethanol to biomass-to-liquid (diesel) fuels.

Box 3 First-generation, second-generation, third-generation, advanced biofuels

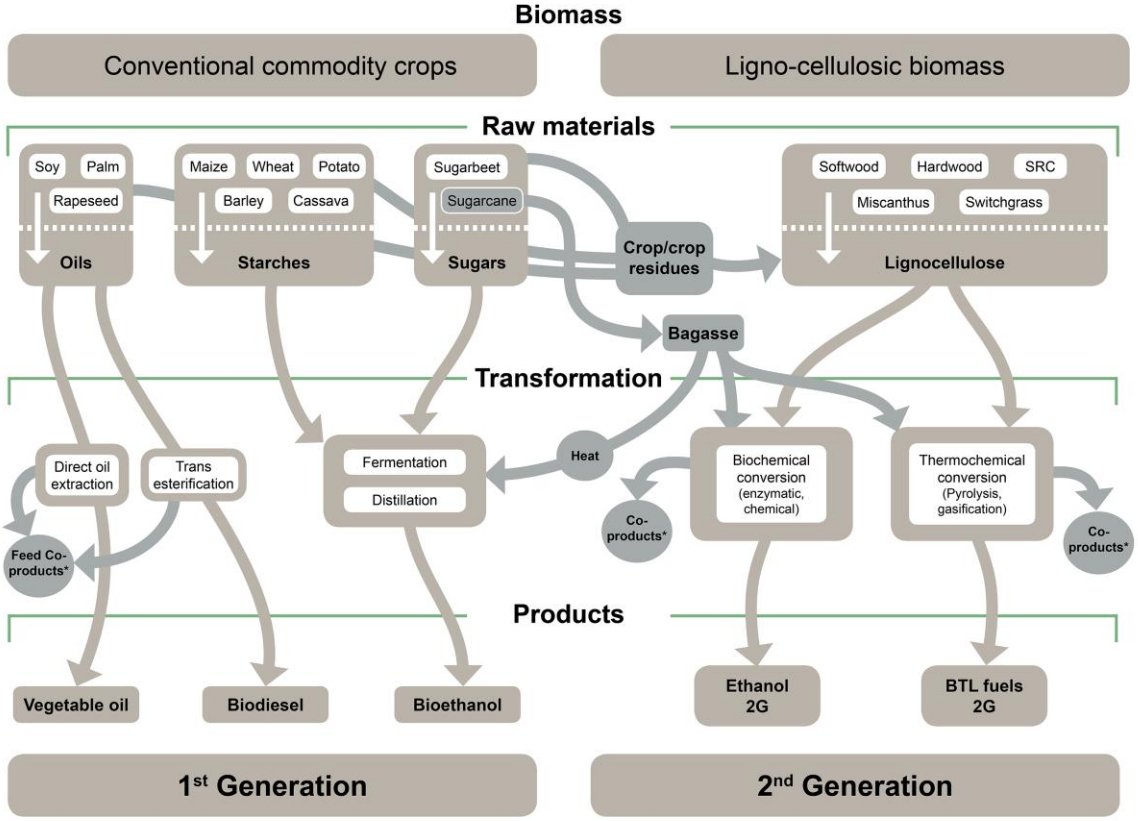
First-generation biofuels usually refer to ethanol produced from sugar-rich (e.g. sugar beet, sugar cane, sweet sorghum) and starch-rich (e.g. corn, wheat, cassava) crops, and to biodiesel made from oilseed crops (e.g. soybeans, sunflower, rapeseed, palm) or animal fat (Gasparatos and Stromberg, 2012; Fischer *et al*., 2010, OECD/IEA, 2010), as well as pure plant oil (PPO). In most cases, these feedstocks can also be used as food and feed.

Second-generation biofuels are those made from non-edible and/or ligno-cellulosic biomass, and typical outputs are ligno-cellulosic ethanol, biomass-to-liquids, and bio-synthetic natural gas (FAO, 2008; IEA, 2010). Typical lignocellulosic feedstocks are agricultural by-products (e.g. corn stover, husks, stalk, cane bagasse), forestry residues (e.g. thinning, treetops and branches), perennial grasses (e.g. switchgrass and miscanthus), short rotation coppice (e.g. willow or poplar) and municipal waste. Biofuels obtained from feedstocks that do not compete for high-quality land with crops or under conditions of hydric stress (e.g. jatropha) are sometimes also labelled as second-generation, even though they use traditional process technologies.

"Advanced biofuels": this denomination was introduced in the US legislation and in its definition is not linked to specifically second- or third-generation biofuels. Under the definition of the EPA, it refers to any "renewable fuel, other than ethanol derived from corn starch, and for which lifecycle GHG emissions are at least 50% less than the gasoline or diesel fuel it displaces." In that latter sense, Brazilian sugar-cane ethanol, despite being first generation biofuel, is classified as an "advanced biofuel" in the US (see Table 4).

"Third generation biofuels" usually refers to biofuels not competing with food crops nor with lands. Typically algae-based biofuels fall within this category.

Figure 6 Pathways for producing first- and second-generation biofuels



More recently, however, the clear line between the outputs that could be obtained from the two conversion routes depicted above have started to blur. Today, a diversity of approaches and pathways are currently under development with the ambition to develop cellulosic biofuels and other bio-coproducts ultimately at commercial scale in “biorefineries”: (i) catalytic pyrolysis and hydrotreating to hydrocarbons; (ii) gasification and Fischer-Tropsch synthesis to hydrocarbons; (iii) gasification and methanol-to-gasoline synthesis; (iv) dilute acid hydrolysis, fermentation to acetic acid, and chemical synthesis to ethanol; (v) enzymatic hydrolysis to ethanol; and (vi) consolidated bioprocessing (single-step enzyme production, hydrolysis, and fermentation) to ethanol (Brown and Brown, 2013).

However, in 2011, first-generation biofuels still represented 99.85 percent of the biofuels produced and consumed worldwide (91 300 000 tonnes/year in 2011), as current production capacity of second-generation biofuels from lignocellulosic raw materials reached only 137 000 tonnes/year (IEA, 2013). The deployment of biofuels from lignocellulosics has not been as rapid as expected and the International Energy Agency (IEA) estimates that, taking into account the projects currently under construction as well as those that have been announced, the further development of lignocellulosic biofuels production capacities might sum up to 620 000 tonnes/year by 2018 (IEA, 2013).

2.2 How do technologies matter for the competition for land, with food and feed?

A first key element in the choice of appropriate feedstock and technology is the amount of biofuel that can be produced per hectare (Worldwatch Institute, 2006). The more surface is needed to produce a certain amount of energy, the more the impact on food security via pressure on land use is likely to be. In this regard, the “land” footprint of biofuels can also be compared with other means of producing energy, as in the study by McDonald *et al*. (2009).

Table 1 Land use intensity for selected biofuel crops, global averages

Biofuel	Feedstock	Ha per Mlge*	Main co-product (yield in Kg/L biofuel)	Co-product use
Ethanol	Sugar beet	350	Beet pulp (0.25)	
	Corn	465	Dried distillers grains with solubles (DDGS) (0.3)	Protein for animal feed, solid fuel
	Sugar cane	300	Bagasse (0.25)	Solid fuel for heat/electricity
	Cassava	420		
	Cellulosic	470	Lignin (0.4)	Solid fuel and chemicals
Biodiesel	Rapeseed	670	Glycerine (0.1), Presscake (0.6)	Soy meal
	Soybean	1 310	Soybean meal (0.8)	Soy meal
	Palm	310	Empty fruit bunches (0.25)	Animal feed or solid fuel
	Jatropha	1 540		
	BtL-Short Rotation Coppice (SRC)	320	Low temperature heat; pure CO_2	
Biomethane	Anaerobic digestion (maize)	250	Organic fertiliser	
	bio-SG (SRC)	280	Pure CO_2 (0.6 L)	

Source: calculated from IEA (2011) and McDonald *et al*. (2009)
* Hectares per million litres of gasoline equivalent

In general, sugars have higher biofuel yields than starch. The "yields per hectare" approach confers also a comparative advantage to tropical areas in the production of first-generation biofuels. Table 1 summarizes results pointing also to yields of main co-products. It further shows that biofuels and biomass burning of energy crops for electricity take the most space per equivalent unit power. Most renewable energy production techniques, like wind and solar power, have intermediate values of this metric. To give some orders of magnitude, with these figures in Table 1, 100 billion litres of corn ethanol (a figure close to the current world total biofuel production) would mobilize an equivalent of 38.5 million ha, an area equivalent to 2.75 percent of the 1 396 million ha of arable lands worldwide in 2011 (FAOSTAT, 2013).

A second key element in the choice of technology is the degree of direct competition of the biofuel feedstock with food and feed.

Second-generation biofuels, as per their definition, make use of non-edible or cellulosic feedstock, and do not therefore directly influence the market for food products. On the other hand, some 1G biofuels, and especially biodiesel, produce co-products that can be an important source of feed for livestock (FAO, 2013). Cooper and Weber (2013) consider that this use can to some extent offset the increase of feed costs induced by the increased demand caused by biofuels development. Some co-products are particularly rich in protein components (see Table 1). They can constitute a cheaper substitute for other protein rich feed, especially in certain regions, such as Europe (Lywood and Pinkney, 2013).

Avoiding competition with food and feed has been a key concern in the design of many policies, particularly in developing countries, which focus on feedstocks not considered as food and especially on those that would not compete for land with food crops. Many expectations have been placed on such feedstocks, as many governmental policies can attest (see Chapter 1 and, for example, the cases of India and China). Jatropha has been seen as an ideal solution to this problem, since it was identified as an oil crop that could flourish in poor soils and conditions of hydric stress. Mostly grown in Asia, less so in Africa and Latin America, jatropha has been the object of a considerable number of investment projects and policy goals. Particularly high hopes have been placed on its potential for biofuels development on the African continent (Diaz-Chavez *et al*., 2010).

It has become clear, however, that, while jatropha might have some of the agronomic advantages initially identified, its economic viability demands high productivity levels, which in turn require better varieties, better quality soils and greater water inputs. It provides no ready solution, therefore, to the competition for resources that has been the main source of criticism of first-generation biofuels (Gasparatos *et al*., 2012). Many biofuel investment projects in Africa, which we will discuss in more detail in Chapter 4, have had the production of jatropha as their goal, but they have now been put on hold or abandoned. On the other hand, jatropha is still seen as a key feedstock in the Biofuel Digest scenario discussed below. There are also projects to use jatropha as a feedstock for aviation fuels. SG Biofuels, California, has developed elite lines of jatropha, which, in partnership with Bharat Petroleum, has a planted area of 86 000 acres (approx. 34.8 thousand ha) in India, and some 75 000 acres (approx. 30.4 thousand ha) in Brazil in a multistakeholder initiative involving JETBIO, Airbus, the IDB, Bioventures Brazil, Air BP and TAM Airlines. In addition, it has an agreement with Embrapa, the Brazilian Agricultural R&D institution, and the Brazilian Biodiesel firm Flagril, for the adaptation of jatropha to the Brazilian savannah region. Productivity in a developing country context is said to be as high as 350 gallons/ha (approx. 1.6 thousand litres/ha) and between 200 and 300 gallons (approx. 910 and 1 360 litres) in the US, as against 60 gallons/ha (approx. 273 litres/ha) for soybean (Biofuels Digest, 2013).

The potential impacts of second-generation biofuels on food security also need to be evaluated taking into account other uses of the feedstock and resources (land and water) that they require, which are very location-specific. Second-generation biofuels can use diverse types of biomass including those that cannot be used as food, such as crop residues, grass, wood or waste. As such, they are not in direct competition with food. But, for certain types of biomass they could directly compete with feed for livestock or their return to soil as nutrients. Moreover, as exemplified by jatropha, even if biomass can be produced on soils that are not fit for crop production, intensive production of biomass generally requires good soil, nutrients and water.

One of the potential advantages of second-generation biofuels is their capacity to valourize perennial plants. But the use of perennial plants has also disadvantages in terms of flexibility from the point of view of land use, since they are a less easily reversible option than annual crops if land has to be reverted quickly to food production. Policy options, therefore, become more rigid with second generation, as argued by Wright (2011) who defends at the contrary the use of food crops with "safety valve" mechanisms that contractually ensure the diversion of biofuel crops to food when judged

necessary. There is also the concern that, if not managed correctly, cellulosic biofuels may limit the necessary return of plant organic matter to the soil, harming soil carbon and nutrient balance, with possible impact on soil carbon sequestration (Moon *et al.*, 2012). Energy, environment/GHG and cost-efficiencies of first- and second-generation biofuels all impact on levels of availability and access to food and their impacts on food security, therefore, need to be evaluated.

As there are likely to be trade-offs in the use of biomass for food versus energy, the terms of the trade-off will depend on the relative performance of different biofuels. The higher the biofuels perform in terms of energy, environmental or cost efficiency, the lower will be the impact on food security for a specific energy, GHG or biofuel economic spending target/figure. Therefore, a consideration of the energy, environmental and cost-efficiency of different biofuels options has direct relevance for the food security debate.

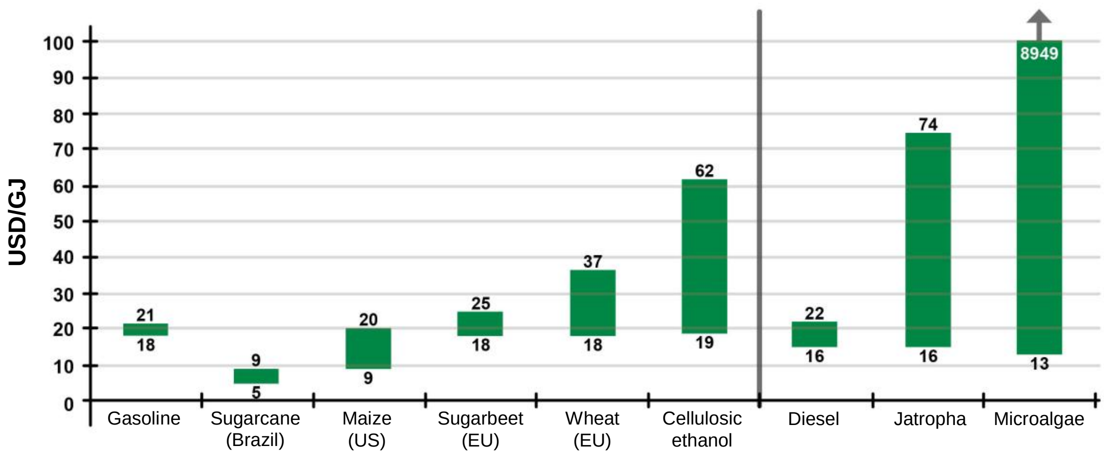
We provide here a summary comparison of the performance of several first- and second-generation biofuels, according to their estimated costs, energy balances, and GHG emissions when compared with the fossil fuels these would displace.

2.3.1 Cost-efficiency

For first-generation biofuels, the key challenge is the cost of the biomass relative to the processing activities, while for second-generation biofuels the challenge of costs is centred on the processing stages. In some cases, collection of biomass can also induce significant costs. Carriquiry, Du and Timilsina (2011) made a comparative review of the costs of biofuels (first- and second-generation) production as against those of fossil fuels (see Figure 7). The results of the study show that in 2009, second-generation biofuels overshoot the cost of fossil fuels by a factor of 5.

It should be noted that the costs presented in Figure 7 do not include credits for co-products. Their inclusion could reduce some of the reported cost advantages of sugar-cane ethanol vis-à-vis that of grain-based ethanol. However, while the relative costs of production of the different biofuels are highly dynamic, some observations can be made. Feedstock is a major cost of biofuel production. Thus, changes in the relative prices of corn, wheat, sugar cane and co-products all have a large impact on the relative costs of production of the different biofuels. Based on trade flows of the last few years, sugar-cane ethanol has been for the most part produced at a lower cost than corn- and especially wheat-ethanol produced in the EU. Recently, however, with high sugar prices and strong domestic demand for Brazilian ethanol, US corn-ethanol has gained competitiveness, exporting to both Brazil and the EU. In fact, the EU has been a consistent importer of ethanol from Brazil and the US, and is expected to continue importing despite local excess capacity and being a market protected by tariffs of different degrees (USDA, 2012).

Figure 7 Biofuel production cost from various feedstocks



Source: Adaptation from Figure 3 in Carriquiry, Du and Timilsina (2011). Note: Co-product credits are not included for maize and wheat ethanol in the study. GJ = Giga joules.

Beyond spatial and time differences, the large variations between the costs of second-generation biofuels (Figure 7 and Table 2) can be explained by uncertainties derived from the lack and low level of robustness of data on related plants, with information often of a proprietary, confidential nature, deriving from a very small number, if not a single pilot plant. 2G biofuels are still too expensive to be produced based on market forces and recent policy support. At their current stage of development, they can be many times the cost of first-generation options and of fossil fuels.

Table 2 Estimated costs of production of different cellulosic biofuels using techno-economic analysis

Author	Feedstock	Biofuel	Production cost (USD/litre gasoline equivalent)*
McAloon *et al.* (2000)	Corn stover	Ethanol	0.95
Solomon, Barnes and Halvosen (2007)	Switchgrass or wood	Ethanol	0.95
Sassner, Galbe and Zacchi (2008)	Salix (willow)	Ethanol	0.90–1.09
	Spruce	Ethanol	0.82–0.87
	Corn stover	Ethanol	0.84–1.08
Frederick *et al.* (2008)	Yellow poplar	Ethanol	0.63
	Loblolly pine	Ethanol	0.71–1.03
Wright *et al.* (2010)	Corn stover	Hydrocarbons	0.58
Kazi *et al.* (2010)	Corn stover	Ethanol	1.41–2.38
Swanson *et al.* (2010)	Corn stover	Hydrocarbons	1.10–1.37
Brown *et al.* (2013)	Corn stover	Hydrocarbons	0.68
Haque and Epplin (2012)	Switchgrass	Ethanol	0.66–1.08

Source: Compilation by authors. Data include input costs and industrial/process costs.
* Inflation adjusted to 2012.

The existing evaluations of costs of producing cellulosic biofuels have been carried out in the absence of large-scale facilities and in a race to be among the first commercially viable. Reliable data are still needed for a more precise assessment of the technical and economic viability of the multiple cellulosic biofuel pathways presented in Section 2.3. More robust data will only be available in the next couple of years at best.

2.3.2 Energy balance

One common way of assessing a fuel’s energy balance is the net energy return on investments (EROI). EROI is the ratio of the energy delivered by a process to the *total* (fossil and other) energy used directly and indirectly in that process. Results greater than 1 indicate that the biofuel is a net energy provider. Results from recent studies are presented in Table 3, which shows that sugar-cane ethanol performs better than the other first-generation biofuels. This is due to the fact that the sugarcane crushed stalk, called bagasse (see

Figure 6), provides more than enough energy to meet the biofuel or sugar plant’s heat and electricity demand, even providing a small surplus power to the electricity grid (Pinguelli Rosa, Villela and Pires de Campos, 2013). Biodiesel also tends to have better energy balances when compared with grain ethanol. It is worth noting both the wide range and potentially high energy balance obtained for cellulosic ethanol. This highlights the notion that, while there may be potential based on some feedstocks and regions, the cellulosic ethanol label is not enough by itself to guarantee desirable energy balances. The large uncertainty surrounding the EROI estimates, reflecting early stages of the development of this technology, should also be highlighted.

Table 3 Net energy return on investments for different fuel types

Fuel	EROI	Countries/regions included in the evaluation
Cellulosic ethanol	2–36 (5.4)	United States (switchgrass)
Corn ethanol	0.8–1.7	United States, Colombia, China
Wheat ethanol	1.6–5.8	United Kingdom, Netherlands, Switzerland, Australia
Sugar-beet ethanol	1.2	United Kingdom
Soybeans biodiesel	1.0–3.2	United States, Argentina, Brazil, China, South Africa
Sugar-cane ethanol	3.1–9.3	Brazil, Mexico, Southern Africa
Molasses	0.6–0.8	Thailand, Nepal
Cassava	1.3–1.9	China, Thailand
Sweet sorghum	0.7–1.0	China
Rapeseed biodiesel (Europe)	2.3	United Kingdom
Waste vegetable oil biodiesel	5–6	
Palm oil biodiesel	2.4–2.6	Southeast Asia, Thailand
Jatropha	1.4–4.7	China, India, Thailand, Africa
Algae	0.01–7.01	

Source: Compilation by authors, based on WWI (2006); Pimentel and Patzek (2005); Shapouri *et al.* (2004); Quintero *et al.* (2008); Kim and Dale (2008); Hill *et al.* (2006); Royal Society (2008); Grant *et al.* (2008).

2.3.3 Greenhouse gas balance

Another goal pursued by the production of biofuels is a reduction in the emission of GHGs. Many studies have been published calculating the potentials of different biofuel pathways in reducing GHG emissions relative to fossil fuels using life-cycle analysis (LCA) techniques (see Table 4). The different pathways involve different combinations of feedstocks, conversion, process technologies, and type and nature of co-product handling.

Different studies make different assumptions, in particular with respect to system boundaries for the calculations, which makes comparisons hard (and sometimes misleading). There are many studies performing LCAs of a single or a few pathways for biofuel production but we are not aware of any recent effort that consistently compares a range of biofuels/feedstock combinations such as that presented in the table. A full comparative analysis of the studies published on the issue is outside the scope of this report. Here we report directly the results found in the literature without any adjustment, and make the reader aware of this unavoidable shortcoming.[26]

Some consensus seems to emerge from Table 4 that biofuels, and in particular sugar-cane ethanol (Goldemberg, 2008) and second-generation biofuels may be useful tools for reducing GHG emissions as they displace fossil-based energy. The estimates are also highly variable and sensitive to the assumptions used in the LCA. A particularly important assumption, not considered in the calculation compiled in Table 4, is the treatment of DLUC and ILUC (Gao *et al.,* 2011; Searchinger *et al*.; 2008, IEEP 2010). This issue is considered in Section 4.

While the US Energy Independence and Security Act of 2007 has introduced the notion of advanced biofuels (with a LCA benefit of 50 per cent), the EU Fuel Quality Directive has introduced a 60 per cent GHG saving threshold from 2018, after accounting for any DLUC effects. Both US and EU regulations include considerations for including ILUC effects in their calculations.

[26] Additional recent articles focusing on ethanol are Wang *et al*. (2012) and Wang *et al*. (2011). Wang *et al*. (2012) analyse different ethanol production pathways including corn, sugar cane, corn stover, switchgrass and miscanthus, but do not compare it with other ethanol feedstocks or biodiesel pathways. Wang *et al*. (2011) analyse the changes in estimates of emission reductions for corn ethanol over time. They find that recent studies tend to show higher emission reductions than older work.

Table 4 GHG emission reductions of select biofuels compared with gasoline and diesel excluding land-use change impacts

Biofuel	Emission reductions (%)*	Biofuel	Emission reductions (%)*
Sugar-cane ethanol	65–105	Palm oil biodiesel	30–75
Wheat ethanol	-5–90	Jatropha biodiesel	40–100
Corn ethanol	-20–55	Soybean biodiesel	52–70
Sugar-beet ethanol	30–60	Lignocellulose diesel	5–120
Rapeseed biodiesel	20–80	Lignocellulose ethanol	45–112[a]

Source: Compilation by authors based on OECD (2008); WWI (2007); Wang, Wu and Huo (2007); Borrion, McManus and Hammond 2012); Kumar *et al*. (2012); Hou *et al*. (2011); Ndong *et al*. (2009); Stratton, Wong and Hileman (2010); Whitaker and Heath (2009); O'Connor (2011).
* Negative numbers mean net increases in GHG emissions.
[a] Includes forest residues, energy crops (such as short tree rotations (e.g. poplar), and switchgrass) and crop residues (e.g. corn stover).

2.4 The timetable for second-generation biofuels

2.4.1 Technology trajectories and investments at a crossroad

The large-scale production of 2G cellulosic ethanol is still in its infancy. According to the IEA report (2013), production capacity for biofuels from lignocellulosic feedstock has tripled from 2010 to 2012 but still only accounts for some 140 million litres per year, 0.15 percent of the current total production of biofuels.

There is still no clearly dominant technology route. Only a few years ago, production of cellulosic ethanol via enzymatic hydrolysis was widely viewed as the most likely technology for the commercial-scale production of cellulosic biofuels (Regalbuto, 2011; Brown and Brown, 2013). Today, at least six different pathways are under development, although often only at a demonstration scale.

Although no commercial-scale (≥50 million litres per year) cellulosic biofuel facilities are operating at present, nine projects involving USD2.7 billion capital investments are expected to start production in 2014 in the US alone (Brown and Brown, 2013). These will have a total capacity of 1 billion litres, using feedstocks such as woody biomass (e.g. yellow pine, hybrid poplar), agricultural residues, corn stover and switchgrass.

A 2013 report by the IEA (2013) has provided a detailed and mapped description of 102 projects, many of which were under construction at demonstration scale. A specialized site compiling and tracking information about advanced biofuels and renewable chemicals recently listed 278 projects in 29 countries (Biofuels Digest, 2012), mostly developed countries, predominantly the US and Europe. There are also projects being pursued in developing countries, including Brazil, China and Mexico. Again, these data need to be taken with caution, as many of the projects announced do not come to fruition.

Despite substantial investments in R&D and the progress made in recent years, significant hurdles still need to be overcome before second-generation biofuels can be produced at commercial scale without public support (IEA, 2013). The hurdles are evidenced in the lack of commercial-scale 2G production, which forced regulatory agencies like the EPA to significantly reduce the cellulosic ethanol mandate of the Renewable Fuels Standard each year up to 2013 (Schnepf and Yacobucci, 2013) (see Table 5).

Table 5 Cellulosic biofuels volumes (in million gallons) anticipated under the Energy Independence and Security Act (EISA) of 2007, revised, and actual production*

	2010	2011	2012	2013
Originally mandated (2007)	100	250	500	1 000
Revised by EPA	5	6.6	8.65	14
Actual production	0	0	0.02	>5?[a]

Source: Elaborated based on Schnepf and Yacobucci (2013) and EPA data available at: http://www.epa.gov/otaq/fuels/rfsdata/2012emts.htm.
* 1 gallon = 3.785 litres
[a] Energy Information Administration (2013).

2.4.2 Second-generation biofuels versus other forms of bioenergy

The production of second-generation biofuels can compete with other forms of bioenergy such as biogas, direct burning for heat or electricity. For instance, biogas also involves traditional process technology but is normally associated with waste or residues and so can be seen as non-competitive with food crops. It is a widely used form of energy in Asian agriculture. Dedicated energy crops, however, are increasingly being used, particularly in Europe, which raises the question of competition for land and food/feedcrop displacement. Synthetic gas through thermal gasification can be seen as a second-generation bioenergy since it is capable of processing the lignin components of residues and waste. Both routes can be further processed into electricity or injected into the natural gas grid. Germany is responsible for some 80 percent of global production of biogas from dedicated crops, basically from corn (Rutz, Ferber and Jannsen, 2010). Initially promoted in the years of crop surpluses and set-aside programmes, its rapid expansion has now raised the issue of crop displacement (Klawitter, 2012). The Netherlands, Austria and Denmark also rely heavily on agricultural crops for their biogas production (AEBIOM, 2010).

In this “biofuel versus bio-energy” debate, the efficiency of the technique, in terms of energy produced per hectare, has to be taken into account (WBGU, 2008), as well as logistic aspects in terms of ease and cost of transport of the raw material/biomass and of the final energy product (liquid fuel, biogas, wood, wood pellets, electricity, etc.).

2.4.3 What perspectives for the US, EU, Brazil and other developing countries?

As we have seen, the introduction of second-generation biofuels has proven slower than initially envisioned by policy-makers and industry participants. The targets set by the US Energy Security and Independence Act included the goal of one billion gallons (3.8 billion litres) of ethanol equivalent to be produced by cellulosic biofuels in 2013, increasing to 16 billion gallons (60.5 billion litres) by 2022 as part of an overall target of 36 billion gallons, from which 21 billion gallons should also come from advanced biofuels.

The cellulosic biofuels targets have been waived on an annual basis owing to the very slow take up of 2G projects (see Section 2.4.1), but they have not been revoked. Considerable political tension has been created and there is pressure for relaxing and for even an outright rejection of the original targets. The influential Biofuels Digest (2012), however, has reaffirmed the target´s feasibility on the basis of a scenario presented in Table 6, underpinned by a description of the different corporations and technologies. This scenario does not project a great share for Brazilian sugar-cane ethanol in the US bioenergy matrix, an assumption possibly open to questioning as Brazilian ethanol has reached “advanced biofuel” status in the US, and is already being imported by the US. The IEA (2010), for its part, sees sugar cane as the only first-generation crop that will continue to have a significant role in the future transport fuel mix.

Such an optimism with regard to the introduction of second-generation biofuels is shared by the Global Renewable Fuels Alliance (GRFA), a world association of biofuels industries: “*By the end of 2013 there are 23 signature commercial-scale advanced bio-refineries slated for completion. Of these 23 refineries, they are in five different countries, using 12 different feedstock strategies, employing 12 different processing technologies and 8 production sets representing 649 million gallons of capacity”* (GRFA, 2012).

In the EU, the recent proposal by the EU Commission of capping 1G biofuels at close to current levels gives a clear signal on the urgency of moving to “second-generation” biofuels. A recent manifestation was the formation of the “Leaders of Sustainable Biofuels” dedicated to the rapid promotion of “no-food competing feed-stocks” (Manifesto, 2013). Here again, opinion within the industry contrasts with the current reality of the technology’s deployment.

Table 6 US 2011 biofuel consumption and US 2022 projections

Subsector	2011 (billion gallons* in ethanol equivalence)	2022 (billion gallons in ethanol equivalence)
Biodiesel	1.2	6.0
Biobutanol	0	9.9
Renewable diesel	0	2.6
Cellulosic ethanol	0.006	6.7
Other crop diesels	0	2.6
Imported sugarcane ethanol	0.17	1.0
Subtotal advanced biofuels	1.35	28.5
Corn ethanol	12.6	7.5
RFS totals	13.95	36.0 (RFS2 target)

Source: 2011 data calculated from the US Energy Information Administration (EIA, 2012), 2022 projection reproduced from Biofuels Digest (2012).
* 1 gallon = 3.785 litres

Brazilian sugar-cane ethanol is likely to keep a strong share of the world bioenergy matrix (IEA, 2010) and while there is interest in R&D, pilot and demonstration facilities for second-generation biofuels (IEA, 2010), these are seen in Brazil more as a complement than a substitute to the existing “advanced 1G biofuel” model.

Until a significant number of projects come on-line, uncertainty will remain about 2G biofuels’ likely contribution to meet expanding biofuel demand.

2.4.4 Second-generation biofuels: are they an alternative for developing countries?

Second-generation biofuels have generated interest not only because they open up the perspective of avoiding direct conflict with food and feed markets, but also because they can rely on feedstocks that could be produced on more marginal lands than prime cropland.

Are second-generation biofuels more interesting to developing countries than first-generation and if so should they therefore be the priority focus for investments?

As we have seen, two main elements – that apply both to developed and developing country contexts – will determine the answer to this question. The first relates to the availability of land and biomass, while the second concerns the availability of technologies and the possibility of their deployment. As regards the first of these, global estimates of available agricultural land for second-generation biofuels vary greatly and will be discussed in more detail in Chapter 4. However, it is notable that the bulk (two-thirds according to IEA, 2013) of the potential for biomass production is generally understood to be situated in developing countries.

Second-generation demonstration facilities have been reviewed by the IEA (2010, 2013), and only a very limited set of the existing pilot and demonstration projects is located outside North America and Europe, while research is circumscribed to Europe, North America and a few emerging countries (e.g. Brazil, China, India and Thailand).

According to the IEA, a typical second-generation biofuel plant should have a capacity of 100 million litres/year, at a cost of USD125–250 million, involving a demand for 600 000 tonnes of biomass/year. Differently from first-generation biofuels, feedstock only accounts for 35 percent of total cost against 50 percent for fixed investment. While contexts are very variable among developing countries in terms of biomass availability, associated opportunity costs, endowments in infrastructure, capacities for investment and qualified personnel, the above figures seem to indicate that second-generation biofuels would be more appropriate for land-rich countries such as Brazil, which combine higher investment capacities with lower population densities. A report by OECD/IEA (2010) points to the challenge of harmonizing large-scale industrial development with small-scale local value chains.

Does this mean that developing country inclusion in a second generation-biofuels model would have to rely on the emergence of a world biomass market for which they would be suppliers to 2G biofuel plants mostly located in countries where the bulk of the biofuel demand will reside? Such a perspective would involve serious challenges regarding the logistics of biomass collection, particularly in the case of countries characterized by smallholdings. For many countries, the consideration of opportunity costs could then point to the advantages of using biomass for local energy, heating and electricity needs, as in the examples provided by the IEA (2010) in the use of saw mill residues in Cameroon and bagasse in the United Republic of Tanzania.

2.5 Conclusions

The choice of preferred feedstock and technology determines much of the impact of biofuel production and policies on food security. It determines the form of competition for food, feed and land, with diverse land needs depending on the feedstock.

Our analysis of biofuel policies in Chapter 1 led us to conclude that the issue of food security must now be analysed in a very changed context where both in Europe and the US preferential treatment is being given to biofuels that are not based on food crops. In our discussion of the technology frontier in this chapter, we are similarly seeing major shifts in the positioning of feedstocks – as in the case of jatropha – and a possible acceleration of second-generation biofuels with still unclear implications for discussions of biofuels and food security in developing countries.

While the timeline for the deployment of 2nd generation biofuels proved overly optimistic as reflected in particular in the Renewable Fuels Standard of the US, the first commercial-scale plants to produce cellulosic biofuels are now coming online. Multiple pathways for the conversion of different feedstocks biofuels are being developed and deployed. In the next couple of years we can expect to see long-awaited data on the costs of these technologies operating at commercial scale and their relative performance. Based on that information and relative performance, the number of pathways can be expected to narrow. Learning-by-doing can lower the costs of the commercial industrial process, which is a major component of the costs of producing advanced biofuels. These industrial advances can take place more quickly than agronomic advances needed to lower feedstock costs of both conventional and advanced biofuels.

As shown by the experience with jatropha, any new biomass produced for biofuels will induce some form of competition for land and water, which could have an impact on food security (an issue discussed in detail in Chapter 4).

These evolutions also have strong implications in terms of potential positive effects in developing countries. The investment and technological needs for second-generation biofuels may make them largely inaccessible to many developing countries. On the contrary, simpler and smaller technologies could be more appropriate, including for the provision of local sources of energy (see Chapter 5).

There is likely not going to be a “one size fits all” approach in terms of optimal technology choice, but rather a multiplicity of approaches with different crops, production modes, logistics, fuels, etc. that will address both energy needs and resource constraints as well as the impacts on land use and competition with food. Learning-by-doing and close monitoring of impacts on market and prices, on land and on social issues, will be key, as we will see in the following chapters.

3 BIOFUELS, FOOD PRICES, HUNGER AND POVERTY

3.1 Introduction: tackling the “biofuels and food prices” controversy

In less than one decade, world biofuel production has increased five times, from less than 20 billion litres/year in 2001 to over 100 billion litres/year in 2011 (Figure 2). The MTBE ban in the US left maize-based ethanol as the only viable octane enhancer fuel substitute, the medium-term (2020) EU targets led to expectations of large-scale oilseed-based biodiesel use and imports, and the adoption of flex-fuel engines for new cars in Brazil rapidly expanded its internal market for bioethanol.

The steepest annual increase of approx. +20 billion litres/yr from above 60 million litres to above 80 million litres (see Figure 2) in recent biofuel production occurred in 2006/2008, concomitantly with a sharp rise in food commodity prices (HLPE, 2011a), quickly accompanied by food riots in the cities of many developing countries. In comparison with average food prices between 2002 and 2004, globally traded prices of cereals, oils and fats have averaged from 2 to 2.5 times higher in 2008 and 2011–12, and sugar prices have had annual averages of from 80 to 340 percent above their 2000–04 prices. This was accompanied by price volatility and spikes unprecedented since the 1970s.

A range of other factors has been adduced in the enormous amount of studies that have since been dedicated to the issue of the “perfect storm” of causes having driven-up food prices; these include rising food demand, combined with a shift to animal protein diets in the large emerging economies, the influence of China´s cereal stock management, weather events in major exporting countries, slowdown in agricultural productivity growth, the impact of high oil prices on agricultural fuel and input costs, and speculation (HLPE, 2011a). But the steeply rising demand for the production of biofuels was identified by many observers and a wide range of organizations, from CSOs to the World Bank, as a major factor.

At that time, knowledge and assessment of the positive and negative, short-term and long-term impacts of biofuels on food prices and on food security (see Figure 1) were rapidly growing but remained preliminary. While there is a general consensus, as reflected in HLPE (2011a), that biofuels provoke a rise in food commodity prices, the controversy still persists on the extent of this impact, and their role in driving price volatility (Abbott, 2012).

Five characteristics explain why the analysis of links between biofuels, food price rises and food security is particularly difficult, and why debate and controversy are still very active within the research and scientific community.

1. A first reason is the geographical remoteness of the impacts in relation to the drivers. The bulk of biofuel production occurs generally in food-secure countries, such as the US, Europe and Brazil. Except when associated with local land acquisitions and local changes of land-use patterns, the effect of biofuels on food security in food-insecure countries is primarily and remotely carried through the transmission of high international prices in local markets, often partially, often asymmetrically, often with a time lag, and differentially hurting net consumers, or benefitting net sellers (HLPE, 2011a).

2. A second reason, as we have seen in the previous chapters, is that biofuels are a broad phenomenon, with three leading players – the US, the EU and Brazil – an increasing importance of developing countries, particularly in Asia, a diversified range of feedstocks[27] and a growing importance of international trade. This obviously complicates the analysis, adding new contexts and dimensions to the mere US corn (maize)-ethanol dynamic. Any extrapolation of findings from one market to another is difficult, and potentially misleading. The challenge then comes from a clear imbalance between available literature on biofuels and food prices (overwhelmingly focusing on US corn-based ethanol, and associated policy and institutional framework) with respect to the extent of the question, both in geographic terms, and also in terms of feedstocks and markets.

[27] Biodiesel, for instance, can use a variety of feedstocks, primarily rapeseed oil, soybean and palm oil, but also different animal fats and used cooking oil; see Chapter 2.

3. The third reason is the challenge to assess jointly short-term and long-term effects. While the “simultaneousness” of the 2007/2008 food price spike with the steep rise in biofuel production was pointing to short-term, almost instantaneous price effects (these are mostly negative effects for food security), it remains that a range of other effects can possibly manifest in the longer term, including more positive effects (Figure 1). While short-term sharp price rises may have severe negative food-security effects, over the long term they may stimulate agricultural investment, strengthen farm incomes and increase rural employment, for example. Feedback mechanisms, therefore, may be positive or negative, and they may also change sign over time. The scientific community is still unevenly equipped to enable a thorough and comprehensive confrontation of short- and long-term effects within the same analytical framework since, as we will see, the tools currently available for studying the problem at hand are limited.

4. The fourth reason is that biofuels are one among the many factors that play a role in the food-price system. Studies on the effects of biofuels coexist with studies that focus on other factors, sometimes in isolation, sometimes in conjunction with biofuels (such as the innovative study by Lagi *et al*. (2011), combining biofuels and speculation), but rarely are they sufficiently comprehensive, and all use very different approaches, in which the isolation of the role of one factor depends on underlying methodological choices. This complicates any attempt to screen the literature to delineate and isolate findings regarding the “biofuel and food-price” effect. This difficulty has led to a confused debate not because of different answers to the same question (biofuel and food prices), but of different answers to very different questions using very different methods and approaches.

5. The impact of biofuels on food consumption by the poor does not depend ultimately – or only – on the strength of the price increase (Figure 1). In fact, low price increases can hide an impact on hunger as a small price effect may simply be reflecting a large reduction in food consumption. Economic models that predict modest price increases owing to biofuels may do so in part because they predict a large cutback in crop consumption, which may express an increase in hunger and malnutrition. Responsive supplies or demands (or both) may lead to muted price changes, which could be confused or misinterpreted as a low impact of biofuels.

Therefore, most of the biofuel policies were designed and launched in conditions of incomplete knowledge and uncertainty over their impacts on food prices and food security.

This chapter explores the state-of-the-art of the “commodity price” pathway on the impacts of biofuels on food security, hunger and poverty, linked to the introduction of the *additional* demand for biofuels to the world market. In an attempt to understand the main contributions to these debates and their implications for the adoption of policy measures, we focus our attention on three main, and separate, questions:

Q1 Which mechanisms make biofuels drive food prices up? What drives the "incremental", additional, separate impact of biofuels on food commodity prices, in different contexts (low or high prices, different feedstocks)?

Q2 Retrospectively, to what extent did biofuels contribute to the food price spikes and increased level of food prices in the specific context of the last five years (2007–12)? In that specific context, what was the share of responsibility of biofuels with respect to other factors?

Q3 What could happen in the future? To what extent might biofuel policies contribute to price increases or high prices in the future? Can biofuel policies be designed or amended to mitigate price volatility?

To do so, the chapter adopts the following approach: to address the first question, the main mechanics at play between biofuels and food prices are described (Section 3.2); the literature and various approaches are categorized, as developed by different scientific communities to analyse the effect of biofuels on food prices, depicting the state of the debate and the competing arguments at play, pointing to differences between corn-based (and wheat-based) ethanol, biodiesel and sugar-cane ethanol (Section 3.3).

To address the second question, the role of biofuels is delineated against the role of other factors in the recent food commodity price increases since 2007 (Section 3.4).

Based on the above, some robust elements are identified (Section 3.5), and the implications are discussed for the relative role of future policies and energy prices, addressing our third question (Section 3.6).

3.2 Basic mechanisms at play between biofuels and food commodity prices

The biofuel and food price debate is a long-standing, controversial one, with wide-ranging views, both in the public debate as well as in the scientific literature. This is due to the number of impacts and feedback loops involved that can positively or negatively affect the price system (see Figure 1). The relative strength of these positive and negative impacts is furthermore different in the short term and in the long term, with delaying effects complicating the analysis substantially. Because of this, conclusions are often very dependent on the priority focus, the domain studied, or the angle of attack of a study. The debate is also steeped in economics. Much of the literature involves different economic models and competing forms of statistical analysis, and it is impossible to avoid at least some of their complexities.

Beyond biofuels, many factors do influence global supply and demand for food. What matters most for the present report and analysis is not the net overall effect of all factors on the net food price – this has been dealt with for example in HLPE (2011a) – but the isolated effect of biofuels on food prices, *everything else being equal*. One difficulty is therefore to disentangle and separate the impact of biofuels from the rest of the factors: we look here at biofuels from the standpoint of their *additional* impact, which leads to *additional* price effects.[28]

When crops are used for biofuels, the first-order, direct, impact is to reduce food and feed availability (see Figure 1): this competition acts to increase prices as users and various types of demand compete for the same available supplies.

If that were the only effect, all biofuels from food crops would come out of a reduction in food consumption, representing a "100 percent competition" and zero-sum game between biofuels, food and feed: the commodity price would then rise rather steeply according to purchasers' highest willingness to pay and highest marginal bid/value under the constraint of available supply.

This is, however, not what happens because of two feedback loops involving feedstock consumption and production, in addition to the possibilities of substitutions between foods and feedstocks, at demand and production levels, in the food and fuel markets.

3.2.1 Feedstock consumption and production feedbacks

Two feedback loops act to lower the tension on the price system after the first, inflationist, impact of an introduction of biofuels.

The first feedback loop is at the level of demand: the price signal causes people to consume less food and, indirectly, less feed. In general, economic evidence indicates that the world's wealthier countries and people cut back little on food consumption when prices rise, while the world's poorer people as a whole cut back substantially more (HLPE, 2011a). To the extent that the reduction in consumption comes from the world's poor, it increases hunger and malnutrition. This is a direct food security concern for this report (see Section 3.6). But, the fact that the poor are further excluded from consumption, also acts perversely to level off price rises. While food demand is generally considered by economists to be relatively inelastic (it does not change much with changing prices), it remains true

[28] For example, prices can go down as a result of many factors. These factors may outweigh or dominate a potentially price increasing effect of biofuels demand: the existence of a net negative total effect (all factors included) does not impede biofuels from bearing a positive effect on prices. Conversely, as Westhoff (2010) points out, an increase in production for feed and fuel does not necessarily imply that the corresponding food and feed demand was met *as fully as* when markets did not also have to supply biofuels.

that, strictly speaking, hunger (and its "depth") is a non-expressed food demand that indeed acts to lower the tension on the price system (HLPE, 2011a).

The second feedback loop is at the level of production: the high price signal can encourage farmers to increase production and therefore supply. Prices do not necessarily increase just because of demand growth; they rise when demand growth *exceeds* the capacity of supply to keep up. If farmers are able to adjust production rapidly to the context of new prices, we are in a situation of high elasticity of supply[29] to increasing food prices. Cochrane's (1993) analysis of the history of US agriculture suggests that periods of high farm prices were followed by investments (which the extra profit permitted) that increased supply, which may be one of the impacts of biofuels (Zilberman *et al.,* 2012). Similarly, some have described, in the case of sugar cane, the effect of the introduction of biofuels leading both to increased demand for sugar cane as well as an increase in supply (Goldemberg *et al.,* 2004). If the increase in production is able to keep pace with increasing demand, price increases will be limited to the marginal rise in production costs associated with reaching higher yields or mobilizing additional lands. As demand for biofuel results from government policies, many have pointed out that it is a demand that can be anticipated by farmers and incorporated into planting decisions. To what extent food producers can positively reply to such new conditions by increasing supply is key to the net effect of biofuels on food prices and purchasing power and, consequently, on hunger and malnutrition.

Box 4 Elasticities of supply and demand

The elasticity of supply (Es) measures the degree to which supply is responsive (percentage of change) to a percentage of change in prices. Es = relative change in supply (%)/relative change in price (%). It is more elastic when it changes more to a given signal.

Relative changes of supply can be measured in the short run or in the long run. Supply is normally more elastic in the long run than in the short run.

The elasticity of demand (Ed) measures the degree to which demand contracts (resp. expands) to an increase (resp. decrease) in prices, *ceteris paribus*, i.e. holding constant all the other determinants of demand, such as income. Price elasticities of demand are almost always negative. Ed = relative change in demand (%)/relative change in price (%).

The two feedback loops are to be analysed together to compute the *net* effect of biofuels on food prices. The more supply and demand are responsive to price increases (the more elastic the supply and demand), the less prices will finally rise in response to any increased demand for biofuels, but the reduction in consumption (or "depth of hunger") can still be large. Put another way, either a large supply response, or a large demand adjustment, or both, can hold down prices.

If, on the contrary, supply and demand elasticities are small, the introduction of biofuels may cause large price increases.

The hypotheses, which different studies often not very explicitly assume on the respective value of the short -and long-term price elasticities of supply and demand, are critical to the analysis. The factors determining the strength of the elasticities, and their underlying assumptions are, therefore, crucial. For example, the elasticity of supply to higher prices is determined by the availability of land (Chapter 4), by technologies (Chapter 2), and by labour (Chapter 5), etc. The speed and amplitude of response of all these factors and of each individually have different repercussions on prices. The quicker land, technologies, labour and investments can be mobilized in response to high prices, the less an introduction of biofuels will push prices up. The elasticity of demand can be either low or high depending on the situation of countries, income distribution, the population profile and levels of urbanization (HLPE, 2011a).

[29] The elasticity of supply can be lower in the short term and higher in the longer term as farmers need time to adapt and increase supply in response to a price signal. As mentioned before, the fact that the strength of the feedback can vary over time is particularly important.

Box 5 Low price effects can hide large demand adjustments

Some economic models have predicted relatively low price increases in the long run from biofuels, but have done so in part because they predict a diminished consumption of crops for food and feed with price increases. This decline in consumption helps balance supply and demand without large price increases. For example, an analysis by scholars at IFPRI using the IMPACT model estimated that roughly a 60 percent increase in biofuel production in 2020 from 2010 levels would have negligible impacts on all grain prices, and only around 33 percent impacts on soybean oil prices, but would involve large reductions in food availability. Comparative analysis by the European Commission's Joint Research Centre of the results of the IMPACT, GTAP (run by researchers at Purdue University) and the FAPRI-CARD (run at Iowa State) models shows that from 34 percent to 52 percent of the maize or wheat used for ethanol is not compensated by increased production, and therefore represents a net decrease of food availability and consumption (Edwards, Mulligan and Marelli, 2010). An analysis based on US data (Oladosu *et al.,* 2011) showed that corn use for ethanol has resulted in large reductions in its use for livestock within the US, and in increased production (see also Figure 10 in this report). This confirms that price increases by themselves do not serve as an indicator of food security and nutrition since shifts in diets can occur and demand can adjust with effects on the poorest that are disproportionate, and even diminishing, price effects (HLPE, 2011a; FAO, 2011).

3.2.2 Substitution effects between products, at the demand or at the supply level, in food and fuel markets

In addition to the above, following the introduction of a biofuel demand, one has to consider the effects triggered by the possibilities for substitution between different feedstocks (either on the demand or on the supply side). Three effects need to be considered here:

- **Substitution at the level of food demand:** Food consumption and technologies for foods and fuels supply chains can – to a certain degree – switch from one commodity or feedstock to another. This leads to possible effects of substitution within types of feedstocks. For example, in the domain of vegetable oils, rapeseed oil and palm oil demands have been found to be fungible to a certain degree in the food market (ICCT, 2013). If prices of wheat go up, other cereals might be used by a household as substitutes within the diet. Substitutions can take place also in the feeds market: if corn prices go up, livestock producers can shift to other sources of feed. As a consequence, a positive correlation is introduced between the price of a specific biofuel crop, and the price of all the other feedstocks that could be substituted for it. In such cases, substitutions and increased international trade act to alleviate the tension on the original market. However, any price effect following the introduction of a biofuel demand for a commodity might propagate, directly or indirectly, to the markets for substitutes.

- **Substitutions can occur at the level of production**: Biofuel crops compete at the margins with other crops for the same cropland. If the corn price goes up, producers will have an incentive to grow corn. There will be less planting of other crops that could have been grown in the same areas, thereby reducing their production, or these crops are pushed into less productive land. Both factors reduce production and push prices up.[30] Such production effects constitute another reason why crop prices tend to move together: they introduce a correlation between a biofuel crop (price) and all the other crops (prices) that could be alternatively grown under the same agro-ecological conditions. Land prices can also be affected, leading to a more generalized price effect on agricultural commodities.

- **Finally, the possibility for substitution at the level of demand operates also in the fuel market**, as biofuel is per definition a substitute for fossil fuels. The introduction of capacity to convert large quantities of crops into fuel (installed biofuel production capacities) opens up the possibility of transmitting price effects from the energy to the food market, and vice versa. It is

[30] Abbott (2011) highlights the large increases in harvested area in the period corresponding to the expansion of biofuels. These amounted to 27 million ha compared with the 2005-06 average, and do not include the displacement of secondary crops by major crops (ICCT, 2013). This expansion for biofuels implies a sharp decline in easily available areas for the expansion of other crops, and a transfer of market tightness.

rational for actors in the fuel market to buy biofuels at a price up to its value as a fuel. In a situation of high oil prices, and with biofuels production capacity providing a physical link between the markets for energy and agricultural commodities, the price of feedstocks should in principle follow their opportunity value as a source of energy. These linkages are complex and depend also on the constraints imposed by mandates, or compulsory blending rates of biofuels in transport fuels.[31] We explore these effects and the positions adopted in the literature in more detail in the next section.

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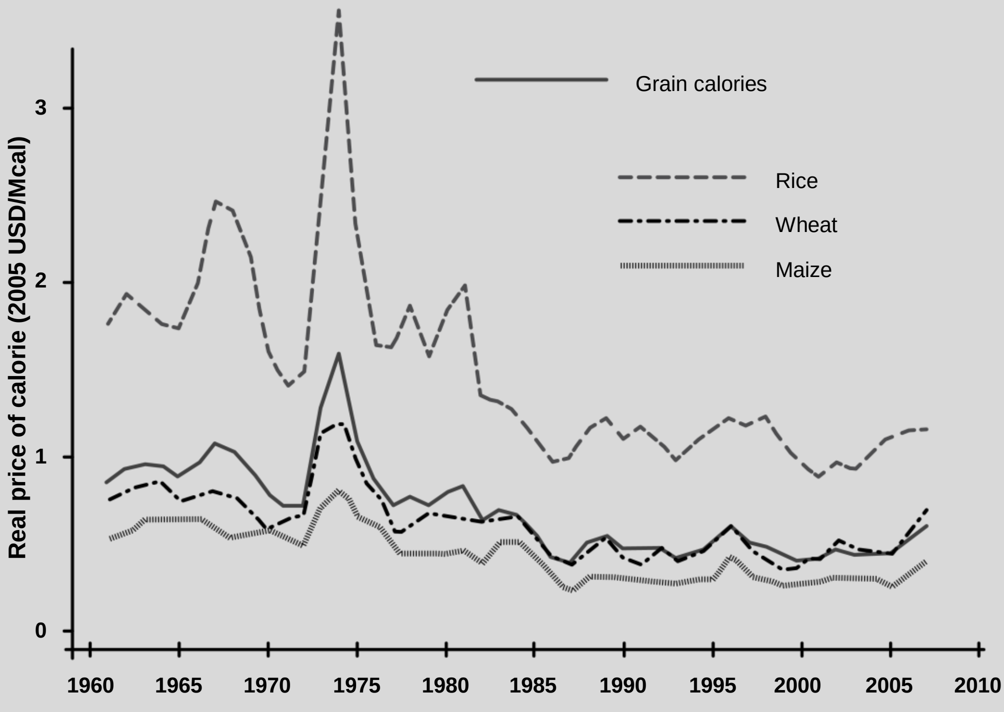
Box 6 Substitution effects and market linkages between feedstocks

There is a close historical relationship between the price of maize and the price of wheat, and rice is also correlated although less perfectly, see Figure 8 or Baffes and Haniotis (2010) for a thorough statistical correlation. These prices tend to track each other when enough consumers are able to shift from one grain to another, and when a sizeable number of farmers are able to shift production from one grain to another in subsequent years (Westhoff, 2010). Substitution is never perfect. For example, there is broad agreement that the sharp rise in rice prices in 2008 was the result of many factors in addition to biofuels, as globally traded rice is a small fraction of world production (Abbott, Hurt and Tyner, 2008; Headey and Fan, 2010). Yet, overall, there is evidence that tightness in one market is likely to translate into tightness in others, as highlighted in a recent paper from economists of the University of California at Berkeley that shows that low world inventories for aggregate grains (maize, wheat and rice) better explain changes in prices than world inventories of individual grains (Bobenrieth, Wright and Zeng, 2012).

Figure 8 Market linkage between grain wheat, rice and maize (1960–2010)



Source: Adapted from Wright (2012). The prices are shown in 2005 USD real terms, deflated from the nominal prices using the World Bank Manufactures Unit Value Index (MUV).

[31] For instance, the production of biodiesel is currently not competitive in economic terms with fossil fuel (see Chapter 2), and is only viable because of compulsory blending targets or because of biodiesel production subsidies. This makes it difficult to envisage a transmission effect from the oil market to the biodiesel feedstock markets.

The introduction of biofuels, everything else being equal, will result in a global pressure on demand leading to higher food prices (HLPE, 2011a). Food grain and oilseed prices move very closely together because of substitution possibilities in supply and demand (de Gorter, Drabik and Just, 2013).

To analyse price effects of biofuels, one has to consider the existence (or not) of possible substitutions either at the demand or at the supply level, in the biofuel feedstocks markets and in the food market that are in competition with them.

Possibilities of such substitutions enable to identifiy three main categories of biofuels: (i) grain-based biofuels; (ii) sugar-based biofuels; (iii) oilseed based biofuels. Each of these categories has its own dynamics. It has also its main player (see Fig. 2): USA for grain-based biofuels, Brazil for sugar-based biofuels and EU for the production and consumption of oilseed-based biofuels. All are considered in section 3.3.

3.2.3 Potentially differing short-term and long-term feedbacks and substitution effects

Finally, and equally important, impacts might be different (and even of a different sign) in the short versus the long term. The responsiveness of supply and demand will vary over the time considered. In the short run, supply in particular is less responsive because farmers face obvious constraints to expand their production within a year or two. In fact, within a few months, the only supply response may come from increased sales by owners of crop stocks. Such short-term limitations on the supply response imply that prices have the potential to rise more in the short run than the long run, when the incentive to invest and increase production will bear fruit. On the demand side, the responsiveness (elasticity) to price changes can also adjust with time as income conditions and habits evolve or as social protection programmes are introduced (HLPE, 2012b), pointing to the potential role of rural development and of access to economic growth in alleviating the problem.

3.3 State of the literature related to biofuels and food prices

To approach the above “mechanics” of the impact of biofuels on food prices, the scientific community uses several methods and tools. All these have been mobilized to explore the causes of the recent global price increases and can be divided into four major groups:

1. A first category of papers includes more or less simple economic models or elasticity calculations that were designed specifically to analyse the role of biofuels in food prices increases, but which vary greatly in approach (e.g. de Gorter, Drabik and Just, 2013; Drabik, 2012; Hochman, Rajagopal and Zilberman, 2011; Roberts, 2010; Bair *et al.,* 2009).

2. Another group of approaches focuses primarily on changes to supply and demand factors since roughly 2005 to analyse what could most plausibly lead to price increases (e.g. Alexandratos, 2008; Headey and Fan, 2010; Abbott, Hurt and Tyner, 2008; Abbott, 2011; Trostle *et al.,* 2011; Westhoff, 2010; Pfuderer and del Castillo, 2008).

3. A third category of papers includes studies estimating the economic consequences of biofuels using various world agricultural models (e.g. Hertel, Tyner and Birur, 2010; Timilsina *et al*., 2012; Rosegrant, 2008; Tokgoz *et al*., 2012), as well as broader review papers that have relied upon them (e.g. National Research Council, 2011; HM Government, 2009; Baffes, 2010).

4. A fourth category of studies essentially uses statistical methods to analyse statistical relationships between crop prices and other factors such as oil prices (e.g. Mallory, Irwin and Hayes, 2012; Kristoufek, Janda and Zilberman, 2012; Zhang *et al*., 2009a; Vacha *et al*., 2012), or inventories (e.g. Wright, 2011; Dawe, 2009).

Additionally, there are a large number of papers that have focused on the role of speculation, some of which point to the role of biofuels as a joint factor (Lagi, *et al.,* 2011).

The above literature is characterized by a primary focus on the US corn-based ethanol industry and associated policy and institutional framework. This is not surprising given the importance of corn in the world´s food systems and the dominant role of US corn in global production and trade. Grains in general, and corn in particular, are important for food security. Corn is both a basic staple and a central ingredient in the animal protein diet. As a basic staple, it has close substitutes in wheat and coarse grains and some degree of interchangeability with rice. In addition, it is one of the most widely traded agricultural commodities and many countries depend heavily on imports of corn. Furthermore, it occupies a large proportion of cropland and any major new demand for its use leads to the dislocations of other crops. Price effects, therefore, can ripple on further to other crops that compete for the same land, among which oilcrops. Land prices can also be affected, leading to a more generalized price effect on agricultural commodities. There should be no surprise, therefore, that the attention given by the scientific and research community is heavily skewed to the analysis of price impacts of US corn ethanol.

Biofuels, however, are a much broader phenomenon than US corn ethanol. For example, Brazilian sugar-cane ethanol or biodiesel for the EU and other countries present different contexts in the underlying economics, possibilities for substitutions and insertion into agricultural commodity and food markets. Price effects of biofuels can be quite different in each case and, although there are evident interconnections, they deserve to be looked at case by case, considering their specificities.

In addition, while the US and Brazil rely on domestic feedstock and are also the dominant ethanol exporters, the EU has established biofuel targets that have led to a major dependence on imports (both of biofuels and feedstocks), primarily, as we shall see, from developing countries.

Because of the above, we look specifically in this section at US-corn ethanol (Section 3.3.2), at Brazilian sugar-cane ethanol (Section 3.3.3) and at EU biodiesel (Section 3.3.4). But before going into the specificities of these markets, let us look at the more transversal issue of the connection of food and energy markets introduced by biofuels, and their price effects (Section 3.3.1).

3.3.1 Linkage of food prices to oil prices via biofuel production capacities and biofuel demand

One of the factors driving demand for ethanol has been rising oil prices. A large number of economic studies have analysed relationships between oil prices and crop prices.[32]

As many studies have observed, there have been times since 2007 when high oil prices made the production of ethanol from maize competitive with gasoline, particularly with added tax subsidies (Tyner, 2010; Mallory, Irwin and Hayes, 2012; Abbott, Hurt and Tyner, 2008; Abbott, 2012). In these periods, ethanol producers should keep running business to satisfy demand, buying corn until its price rises to a “break-even point”. Although ethanol producers, like any other purchasers, would prefer that prices of maize not rise, each producer will find it profitable to keep buying corn and producing more ethanol until the “break-even point” is reached. Beyond that break-even price making ethanol is not profitable. In a competitive market, and when production capacities of ethanol are high enough to divert a substantial share of the grain market, which was the case since 2007, corn prices adjust to the “break-even point”. Figure 9 remarkably attests to this sudden link between the corn price and the “gasoline break-even point”, starting mid-2007.

[32] A number of articles have used a variety of statistical techniques to estimate the correlations between oil prices and commodity prices (Kristoufek, Janda and Zilberman, 2012; Vacha *et al*., 2012; Mallory, Irwin and Hayes, 2012; Serra, 2011; Zhang *et al*., 2009a; Tyner, 2010). In general, these papers found little correlation prior to 2007, a close relationship in 2007–08, and then a relatively close but uneven relationship thereafter. These purely statistical relationships match well the expectation that the demand for ethanol, spurred by the demand for oil, was able to drive the price of corn and, through it, of other food commodities. The uneven relationship after 2009 reflected a variety of factors including the limitations on biofuel expansion imposed by the blend wall (Abbott, 2011) and regionally uneven relationships between oil prices and gasoline prices in the US due to refining bottlenecks, and State air requirements. Yet a thorough review of this literature in Serra (2011) concludes that there is evidence that ethanol and/or crude oil prices affects corn price levels in the long run.

According to the analyses by Abbott, Hurt and Tyner (2008), Tyner (2010) and Babcock (2011), the break-even conditions prevailed during much of 2007 and 2008, and oil prices were capable of driving the price of corn to USD6.00 and to USD7.00 a bushel. The crop price can track oil prices only if capacities are not restricting biofuel production in response to oil prices (Abbott, 2012). As Mallory, Irwin and Hayes (2012) and Abbott (2012) argue, these conditions continued thereafter (even when ethanol demand was hitting the blend wall), thanks to exports. Only during periods where biofuel plant capacity are limited, or with other unexpected developments (such as the 2012 drought that led food and feed users to push corn prices even above their fuel energy value) the price of corn would deviate from its break-even price with ethanol.

Significantly, this relationship between oil prices and corn does not appear to apply to other crops as directly. Biodiesel prices do not appear to be economically competitive even with high oil prices, and ethanol production levels in Brazil vary driven by a wider range of factors beyond oil prices. Yet, because of the correlation between corn prices and other crop prices, the pressure of high oil prices on corn translates into higher prices of other crops.

This relationship, created by biofuels, between oil and crop prices has a number of implications.

- First, it corroborates the role of rising biofuel demand in the driving-up of crop prices, with oil price in the driver's seat. It is not merely that the prices were "financially" correlated but that the incentive exists for the ethanol industry to continue to "physically" buy corn until prices rose to break-even levels. This can explain an important proportion of the crop price rise.
- Second, the linkage also explains why an expectation of high oil prices *in the future* can also help to drive crop prices because they can establish a floor price for corn so long as ethanol expansion is not limited by a blend wall or some other inhibition. That expectation probably also played a role in rising crop prices over the last five years.

Box 7 Is there a correlation between oil and biofuel prices?

The relationships between oil, ethanol, and biofuel feestocks prices (sugar, corn, etc.) is at the center of innumerous scientific works, with results which are often difficult to compare (Zilbermann, 2013).

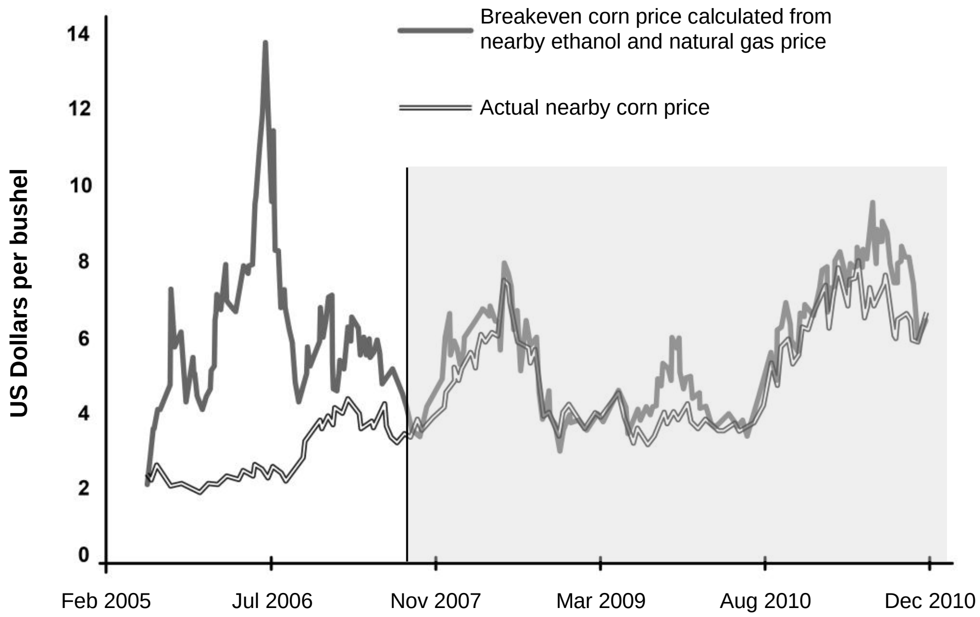
As Zilberman *et al.* (2012) have pointed out, the difficulty of the statistical analyses to capture the relationships between energy and food commodity prices is explained not only by the blend wall but also by the great deal of noise in the ratio between oil prices and gasoline prices, leading to occasionally sharp diversions between gasoline prices in different major regions. Zhang *et al.* (2009b), applying sophisticated statistical methods, found that in the US, between March 1989 and December 2007, gasoline prices influenced both the price of ethanol and oil, and that increases in ethanol prices had short-term, but not long-term, effects on agricultural commodity prices.

A study on Brazil by Serra, Zilberman and Gil (2011) used weekly international crude oil and ethanol and sugar prices, observed from July 2000 to February 2008, to assess volatility spillovers in Brazilian ethanol and related markets. Another study on Brazil by Serra (2011) uses non-parametric correction to time series estimations and supports the long-run linkage between ethanol and sugar-cane prices. Both studies found that the ethanol prices, sugar and oil prices are correlated in equilibrium, and that markets transmit the volatility from the oil and sugar markets to ethanol markets, with minimal transfer of volatility in the other direction. However, other studies found the transmissions to either occur in the opposite direction (Serra and Zilberman, 2009; Block, Corobel and de Oliveira Veloso, 2012) or to run in both directions (Melo, da Mota and Chaves Lima, 2008).

Conversely, biofuel policies have been seen as having an effect on the price of oil and on transport fuels, but there are still strong controversies in the literature. According to Al-Riffai, Dimaranan and Laborde (2010), using IFPRI's MIRAGE-BIOF general equilibrium model, the projected increased consumption of biofuels under the EU and US mandates will lead to a reduction in demand for oil and thus a slight decline (–2 percent) from the 2020 baseline world oil prices. The business-as-usual EU and US mandate scenario is modelled to have favourable impacts in terms of transport fuel prices in the US by 2020, with a 3.9 percent decline effect relative to the 2020 baseline, and almost no impact in Europe, and an increase of 4 percent in Brazil (due to the higher global demand for sugar-cane ethanol).

On the basis of an econometric analysis of historical data, Du and Hayes (2009) found the expansion of corn ethanol in the US to have lowered the price of gasoline in the country. Those results and the underlying reasoning were however heavily contested by Knittel and Smith (2012) from the MIT and UC Davis.

Figure 9 Biofuel production capacities open the door for a close relationship between oil prices and food commodity prices.



Source: Adapted from Mallory, Irwin and Hayes (2012).

3.3.2 Rising US corn-ethanol demand and related tension on corn and oilseed markets

The principal change in the rate of major commodity crop demand growth in the last years has come from biofuels. This has led to highlighting the “tipping point” role of biofuels in pushing prices upwards, in a context of continued increasing demand.

Corn, the feedstock for US ethanol, has been a central focus of the debate. The US has historically been both the world’s leading producer and exporter of corn, responsible for as much as 50 percent of world trade. The share of US corn production directed to ethanol increased in one decade from less than 10 percent to over 40 percent in the 2010/11 crop year, and remained at that high level in 2011/2012. Not only did the US exports and share in international corn trade decline as a result, but a significant part of the expansion of corn production in the US came at the expense of other major global crops, including soybeans. This was seen to have two effects: an increase in the price of corn and of its close substitutes like wheat on world markets, and a stimulation of food and feed production in other regions of the world, at the same time as major quantities of corn were subtracted from the feed market. Even after accounting for return of co-products to the feed market, this is a large and persistent new demand for corn that surely has induced price dynamics (Abbott, 2012).

Box 8 The rise in net returns to farming in the US shows a market imbalance between supply and demand

A sign of an imbalance in supply and demand is an increase in prices in excess of costs. Although some papers have suggested that rising energy costs were driving up crop prices, one analysis by IFPRI economists in 2010 estimated that the rise in oil prices, which had already been substantial by 2007, could only explain 8 percent of the increase in corn prices in the US and 20 percent of the increase in wheat prices. That was true even on the assumption that farmers were able to pass on 100 percent of their cost increases (Headey and Fan, 2010). According to the Economic Research Service of the US Department of Agriculture, production costs for corn increased by 34 percent between 2000 and 2008, while prices increased by 146 percent in the same period. Land values also soared (Oppedah, 2013). Although other factors, such as low interest rates, can contribute to rising land values, the combination of very high net returns and rising land values provide reinforcing evidence that higher production costs were not likely a significant factor driving crop price increase (Westhoff, 2010).

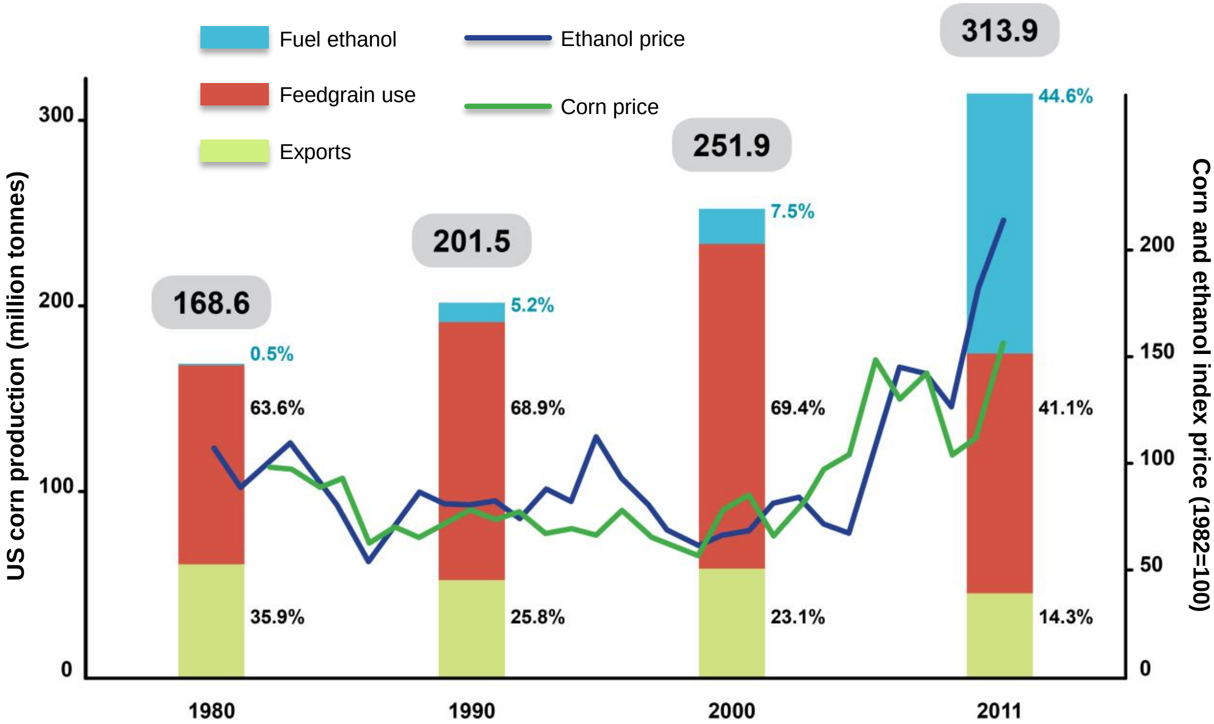
Box 9 Do feed co-products matter?

The use of either grain or oilseeds for biofuels leaves a large co-product useful as an animal feed. In the case of ethanol from grain, the co-product is dried distillers grain with solubles (DDGS) and, in the case of biodiesel, the co-product is principally oilseed meal. Yet, even with the production of co-products, the diversion of the grain or the vegetable oil into the biofuel itself does sacrifice some food production and therefore creates pressures on prices.

To evaluate the overall impact of corn-ethanol production on food prices, the animal feed co-products, which are the result of ethanol production – dry and wet distiller´s grains – must be taken into account. Any analysis that fails to account for these co-products will overstate the impacts of biofuels on food supplies. With the expansion of ethanol production, these animal feeds become produced in sufficient quantities to affect the animal feed market, competing with soy meal. Co-products are even more important in calculating the price effects of biodiesel. Soybean, which is by far the principal feedstock in the US, Brazil and Argentina, and rapeseed in the EU, produce protein meal, which at certain levels of biodiesel production can similarly exert downward pressure on feed markets and therefore on animal protein products.

Source: FAO (2013).

Figure 10 Ethanol and corn prices, and US corn production for fuel, feed and exports



Source: Adapted from Bastianin, Galeotti and Manera (2013). Data from http://faostat.fao.org for corn production. Corn and ethanol prices, shares of fuel, food and export uses from Batianin, Galeotti and Manera (2013)

3.3.3 Brazil and sugar-cane ethanol

Sugar is not a staple food in the same way as corn or wheat. Average consumption worldwide is 24 kg per capita and many emerging countries, which are increasing their consumption rapidly, including India and China, are still well below this level. With the sharp rise in world sugar prices from 2009–11, Brazil´s exports of sugar have noticeably increased. There is evidence also that as large emerging countries shift to a more urban diet, the demand for sugar increases. An indication of this has been the recent sugar purchases on the world market by Indonesia, and this country´s direct foreign investments in Brazil´s sugar-cane sector. Sugar may well, therefore, become a sensitive product for

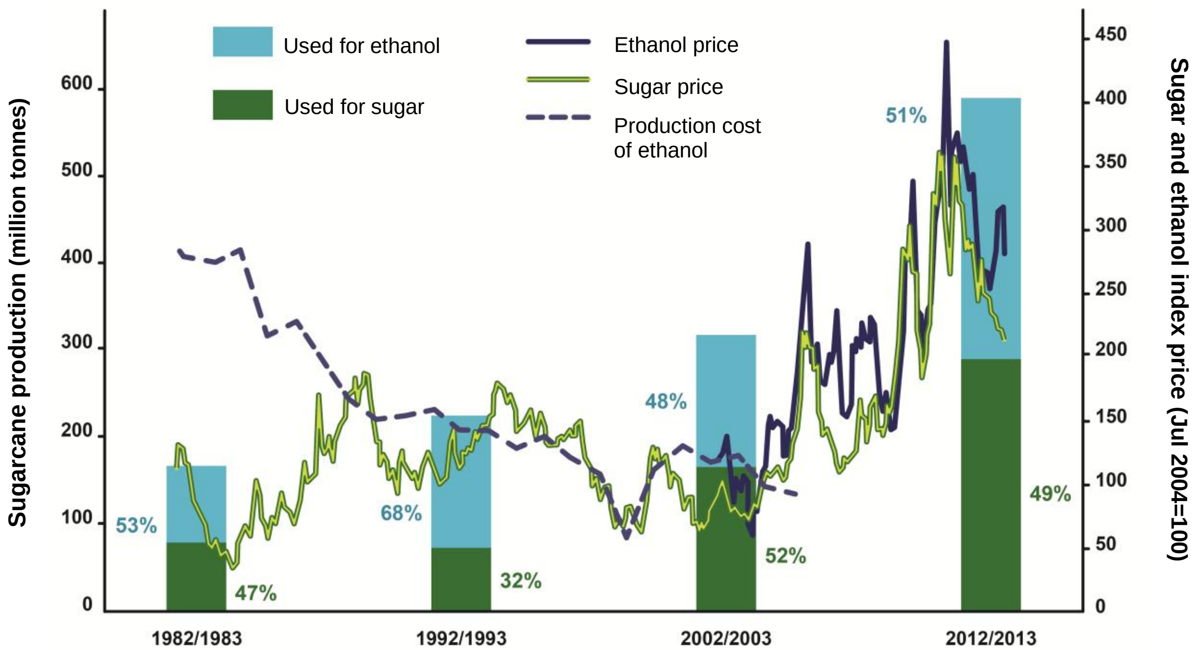
developing countries food systems. From the point of view of food security, however, the global sugar market is less central than corn.[33]

The structure of the global sugar market is singular. Brazil alone accounts for some 50 percent of this market, which depends on few producer countries. India is also a major producer and tends to define trends in world sugar prices, depending on the outcomes of its traditionally fluctuating harvests.

Roughly speaking, half of Brazilian sugar cane goes to ethanol and half to sugar, and sugar-cane expansion generally implies a proportional increase in both sugar and ethanol production (Figure 11). There is some disagreement in the literature on the degree of flexibility available to sugar mills to switch from one product to the other resulting from shifts in relative prices. Nevertheless, the growth in sugar devoted to ethanol corresponded to almost 60 percent of the increase in demand for raw sugar (see Figure 11).

To assess if and how sugar-cane expansion could affect the supply, and therefore the prices, of sugar and other foodstuffs, Elobeid *et. al.* (2012) ran two scenarios, using the FAPRI/CARD model, in which global ethanol consumption was increased by 25 percent relative to a business-as-usual baseline case. For the first scenario, the authors allowed Brazilian producers to extend cropped areas. In the second scenario, the ability to expand area in Brazil was reduced significantly. For both cases, the prices of sugar increased by about 4.3 percent. Such moderate impacts, and the lack of a larger difference between the scenarios could indicate the capacity of producers in Brazil to intensify production in existing cropland, increase the areas subject to double cropping, and release some pasture to be used for crops.

Figure 11 Sugarcane production, ethanol and sugar production and prices in Brazil



	1982/1983	1992/1993	2002/2003	2012/2013
Sugarcane	166.1 Mt	223.4 Mt	316.1 Mt	588.4 Mt
Ethanol	5.82 Mm^3	11.73 Mm^3	12.49 Mm^3	23.21 Mm^3
Sugar	8.86 Mt	9.26 Mt	22.38 Mt	38.24 Mt

Source: www.cepea.esalq.usp.br for ethanol price in Brazil; www.indexmundi.com for world sugar price; MAPA (2013) for sugarcane, ethanol and sugar production; Meyer *et al.* (2012) for the production costs of ethanol, based on Goldemberg (2007). The world sugar price is a very close proxy to the Brazilian sugar price available at www.cepea.esalq.usp.br. Mt = Million tonnes, Mm^3 = Million cubic meters

[33] Sugar has a variety of competitor products in the sweetener market. It also competes with corn fructose in soft drinks, which creates therefore a link connecting corn and sugar prices.

The above analysis suggests that Brazilian sugar-cane expansion does not significantly affect the supply, and therefore the prices, of other foodstuffs. Other ethanol-producing countries largely use either sugar beet, or molasses. Molasses are a by-product of sugar production, and, therefore, their use does not affect the sugar market, while, at the same time, increasing returns from production (Goppal and Kammen, 2009).

Econometric studies (such as Serra, 2011) have shown prices of Brazilian ethanol to be correlated to the prices of crude oil and sugar. While the diversion of large amounts of sugars to ethanol production lead, everything else being equal, to an increase in the price of sugar relative to what it would have been without ethanol, these studies suggest that, given the overall increase in sugar cane production, the total effect has been mild and that, in the Brazilian market, world sugar and oil prices influence ethanol prices more than the reverse (Serra, 2011).

Production costs of ethanol in Brazil have steadily declined since 1975 (Goldemberg, 2007 and Figure 11 and prices in the ethanol market seems today more driven by other market-related factors than net ethanol production costs, such as the opportunity value as a gasoline substitute, and the opportunity value of sugar (which has increased), Figure 11 shows.

3.3.4 Biodiesel and the EU

Biodiesel production is increasing rapidly in the US, is dominant in the EU, and has experienced strong growth in a number of countries – particularly Brazil and Argentina using soybean and Malaysia and Indonesia using palm oil. Nevertheless, world production of biodiesel is much smaller than ethanol in terms of absolute volume (Figure 2). However, it is not smaller in terms of the amount of feedstock utilized relative to the size of the market. OECD/FAO (2011) projected that 16 percent of total vegetable oils produced in 2021 would be used for biodiesel production. In addition, as indicated in our reference both to soybean and palm oil, biodiesel can use a wide variety of vegetable oils, animal fats and even used cooking oil. Therefore demand for biodiesel can have impacts on several markets.

Differently from ethanol using either corn or sugar, vegetable oil feedstocks command higher prices, which makes biodiesel far less competitive with conventional diesel fuel without the recourse to incentives (see Chapter 2). The existence and growth of the biodiesel market, as a result, depend heavily on support policies. Data from the EIA (2012) show that when support policies have been removed in the US, biodiesel production has dropped proportionately.

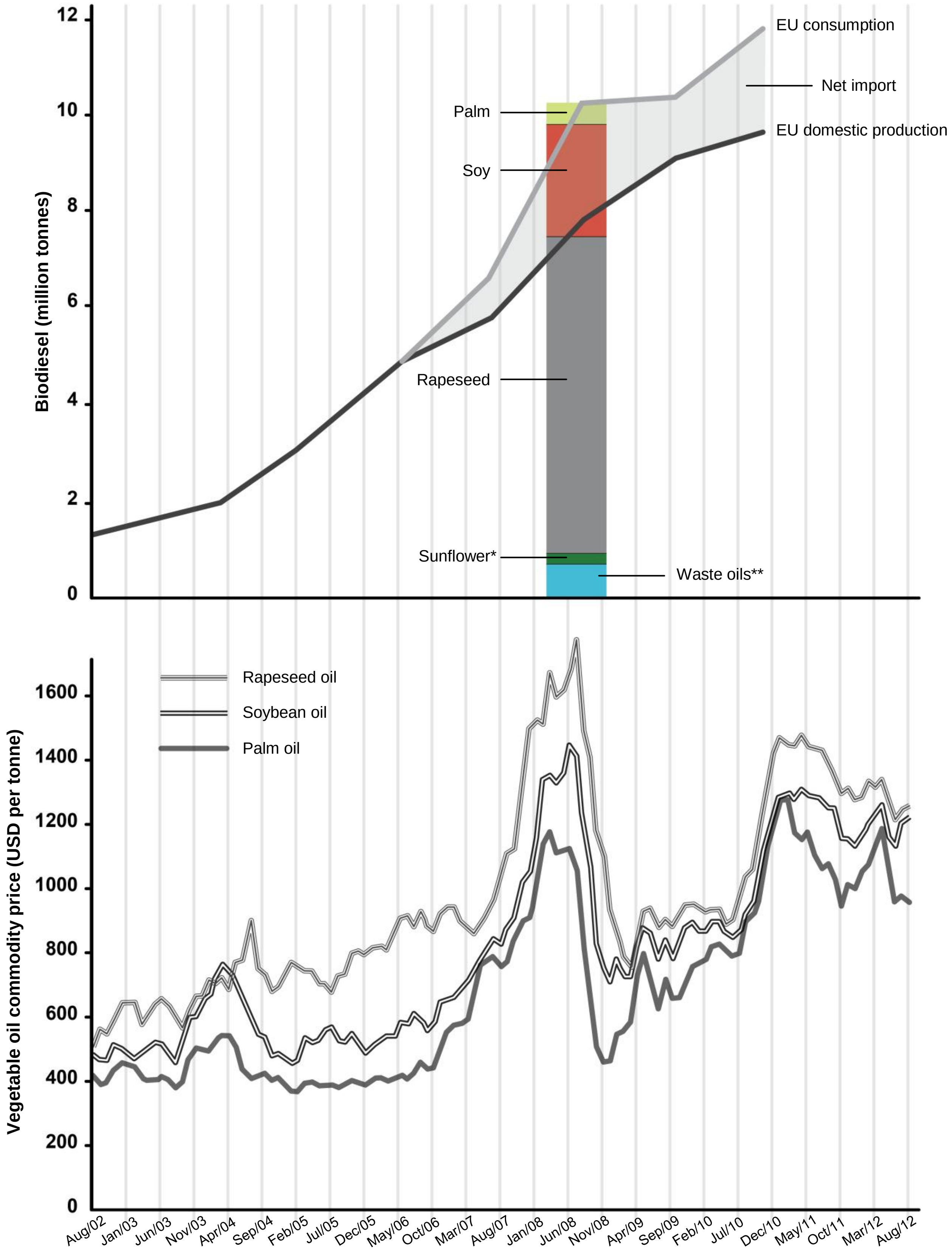
The importance of support policies to make biodiesel economically competitive makes it difficult to find a relationship, if any, between energy and biodiesel prices. In principle, however, the same dynamic would apply as in corn ethanol with fuel, feed and food market players able to arbitrate and play off the comparative value of these feedstocks. In the short term, as in the case of the US 2012 drought, food demand may determine its price, but in the long term the price will tend to reflect the energy value of feedstock.

A number of studies have examined the impact of biodiesel production on food prices, although considerably fewer than in the case of corn ethanol. One model-based study that has analysed some 18 different animal fats and vegetable oils assuming biodiesel production increases to 2012, in line with the RFS mandates, as against a baseline with no biodiesel production, concluded that prices increases ranged from 8 to 38 percent (Thompson, Meyer and Green, 2010). The study highlighted that any demand shock on one product could have a wave effect on the markets for other oils and fats.

The US, Brazil, Argentina, Colombia, Malaysia, Indonesia and Thailand all have biodiesel programmes but they all base their programmes on the domestic production of feedstock, either using soybean or palm oil. In the EU, the dominant vegetable oil crop is rapeseed and when the biofuel targets were initially cogitated this feedstock received great stimulus because of the predominant diesel model for the car fleet. As other energy crops, it was exempt from the planting restrictions on set-aside lands (see Chapter 2). With the definition of biofuel targets for EU member countries, rapeseed production exploded but was unable to accompany the biofuel industry´s demand for feedstock (see Figure 12).

Three major questions were posed. To what extent were the EU targets influencing the global market for vegetable oil feedstocks? To what extent were these developments affecting food market prices for vegetable oils? And concerns were also raised in terms of indirect land-use change (ILUC) impacts and consequences of EU biodiesel programmes, which we discuss in Chapter 4. Here we will focus on the price transmission factors involved.

Figure 12 EU biodiesel production and consumption 2002–2010, feedstock mix in 2008 (top) and vegetable oil commodity prices (bottom)



Source: Adapted from the European Biodiesel Board (EBB) and ICCT (2013); ICCT has used data from FAOSTAT (2013), USDA (2011).

* Feedstock split from IFPRI 2008 baseline (Laborde, 2011)

** Estimated as difference between IFPRI 2008 baseline and total 2008 consumption.

A number of important analyses have addressed these questions – Laborde (2011), Al-Riffai, Diamaranan and Laborde (2011), ICCT (2013) and Jannsen and Wilhelmsson (2013) – which were largely provoked by the insistence of leading NGOs that the EU biofuels programme was leading to encroachment on rainforests and the occupation of peat swamps with large-scale oil palm plantations (Gao *et al.*, 2011). The connection between the two phenomena, however, has been challenged by the European Biodiesel Board (ICCT, 2013) since it is argued only a relatively small proportion of biodiesel in Europe directly processes palm oil, as can be seen in Figure 12.

The ICCT (2013) study, however, shows that although rapeseed oil production increased by over 4 million tonnes from 2000 to 2010, some 3 million tonnes of palm oil were imported in the same period.

Figure 12 shows, using data from the World Bank, that the relevant vegetable oils for biofuels and food ingredients closely track each other. The evidence would seem to be overwhelming that imported palm oil is replacing rapeseed oil in the food industry to compensate for the diversion of rapeseed from its traditional markets into biodiesel. Laborde (2011) adds a further hypothesis with regard to the imports of palm oil, suggesting that the food industry prefers to use palm oil to avoid the risk of using soybean oil from transgenic soybeans. This analysis makes clear that the price convergence of the different vegetable oils is not only valid for their use as feedstock for biofuels but that the same products are largely fungible also for the food industry.

In a recent study, Jannsson and Wilhelmsson (2013) examined the detailed plans of the member countries for the expansion of biofuel production to achieve the EU targets. They conclude that, while these only involve a limited expansion in land use within the EU, there is, in addition to reallocation of land, a substantial increase in imports of primary agricultural products. They argue that the expansion of biofuels in Europe establishes a closer link between agricultural and fuel prices and leads to increases in prices of primary agricultural products, particularly vegetable oils used for biofuels.

3.4 Relative role of biofuels versus other factors in the 2007/2012 price increases

The two previous sections described the findings of the literature with regard to the mechanics by which the introduction of biofuels is said to have had a role on food prices, all other factors – such as the ones reviewed in HLPE (2011a) – being equal. Indeed the *specific, additional* effect of biofuels on prices is the most relevant issue to this report on biofuels and food security. At a first level, these effects can be seen as independent, and separable from the contribution of most of the other effects.[34]

However, as we depicted in the introduction, in the search for the culprit for the 2007/08 price rise, the international community's main question was "what happened?" This question, which we identified in the introduction to this chapter, is relevant to this report given that the examination of the other factors often looked like a discussion "in negative" of the role of biofuels. We therefore quickly go through them in this section.

We do so in pointing to two important caveats:

- First, the need to avoid confusion and misuse of those findings for future policy-making. The main policy-relevant question for the future is not if biofuels were "more responsible" than speculation, weather or other factors for the observed food-price increase in 2007/08. While trying to conclude if biofuels were responsible for 70, 50, 30 percent or none of the price increase in 2007/08 is not without its importance; this, however, does not mean that such a quantitative result can be transposed to future contexts. What is policy relevant to the design of biofuel policies for the future is the understanding of the way biofuels act *specifically* on the agriculture and food system, which we have shown in the previous sections.
- Second, we must face the difficulty of comparing "incomparable" studies, which all have very different focuses and approaches, different geographic perspectives, different time periods under consideration, and, most importantly, different factors being analysed.

[34] At second order, correlation can exist between some of the causes; see Section 3.4.2 for a discussion regarding biofuel and stocks, and biofuels and speculation.

With these caveats and highlighting that our aim is not to revisit here the findings of HLPE (2011a) or of the Interagency Report for the G20 (FAO *et al.,* 2011), we briefly summarize the range of factors (Section 3.4.1), highlighting also the ones being possibly correlated with biofuels (Section 3.4.2) in the 2007/12 period, drawing attention to the corresponding caveats (Section 3.4.3), notably in terms of the appropriate use of tools to produce the estimations.

3.4.1 Other factors relevant to food price increase in the recent context

1) The first category of factors mentioned is the rise in crop production costs, notably as a result of rising input costs, especially fertilizers and energy costs (Sands, Ronald and Westcott, 2011). According to the OECD-FAO Agricultural Outlook (OECD/FAO, 2011), a 25 percent increase in oil price translates into a 14 percent increase in fertilizer prices. In addition, costs of fuel for tractors, and other machinery along the supply chain, increase. However, in 2007/08 energy costs rose at a much lower rate than the rising food prices (Headey and Fan, 2010), questioning the role of this factor for the recent price increases, and pointing to the fact that increases in production costs were more likely to have resulted in lower profits to producers rather than increased prices.

2) Problems of production and a slowing down of yields and productivity increases for some crops, in particular owing to weather, with studies pointing to the fact that weather and extreme event-related fluctuations in the production of particular crops were sometimes larger, over a certain period, than the increase in biofuels (Pfuderer and del Castillo, 2008). These slowdowns in productivity have also been challenged. In general, in line with HLPE (2011a), it is fair to say that yield variability owing to weather in the last five years has helped to explain price variability but not the sustained price increases.

3) Rising world demand for food crops and feed. As the global population rises and many people become wealthier, food demand rises. Several papers have referred without much discussion to rising food and feed demand in China and India as contributing factors to the recent price surge. However, it must be noted that in relation to the recent price spike, apart from China's increased reliance on soybean imports to meet its needs, little evidence has been found that food and feed consumption has been rising any faster in recent years than previously (Alexandratos, 2009; Abbott, Hurt and Tyner, 2008; Abbott, 2011; Headey and Fan, 2010; HLPE, 2011a).

4) Low world stocks: in such situations, and especially when it is concomitant to large increases in demand, prices have a high potential to spike (Wright, 2011; Bobenrieth, Wright and Zeng, 2012). Although few agricultural economists or market traders doubt the significance of low stocks, there are times when stocks are low and prices do not spike. Yet, as Wright (2011) shows, price spikes generally occur when stocks are low and combined with some additional demand shock. To the extent that biofuels have, first, contributed to reducing stocks and, second, created an additional shock on demand, they likely reinforced the role of low stocks to provoke price increase.

5) Changes in Chinese inventories, exports and imports, particularly a large rise in the last few years in soybean imports. In the early 2000's, China was reducing its stocks. For the first four years of the decade, China sold about 39 million tonnes of maize (corn), contributing roughly 13 percent of world exports in those years (306 million tonnes), lowering the pressure on the market. By 2008, those exports ceased. At the same time, China increased its reliance on imports of soybeans. Overall, between 2005 and 2011, yearly imports grew by 26 million tonnes.

6) Role of energy costs in driving up the costs of retail food by increasing the costs of processing, transport and retail.

7) Speculation has been studied by many. For a good list, see the summary in Aulerich, Irwin and Garcia (2012). The prices of any commodity are in part speculative because expectations about future prices determine what owners of crops are likely to ask for those crops. Particularly when markets are tight, guesses about future supply and demand will sharply influence prices. These guesses can be termed speculation, but are in fact inherent to commodities markets: they are presumably not perfectly rational at all times, and can explain why prices fluctuate. However, for reasons described in HLPE (2011a), speculation has not been identified as the main reason for the rising prices, but rather as a source of more volatility on the short run.

8) Exchange rates imply that world food price increases in recent years have not been quite as large as commonly reported. The implication is not that a declining US currency boosted prices (although it definitely did in countries with currencies that track the dollar) but rather that the world prices did not really increase as much as the dollar-denominated indices would indicate.[35] Unfortunately, there is no clearly preferable currency for measuring world crop prices. It remains that the US dollar measure and dynamics of US dollar exchange rates have led to a mechanical increase of the world average crop price (in dollar units) in the period under consideration. Headey and Fan (2010) suggested that the depreciation of the dollar accounted for roughly a 20 percent increase in world crop prices.

9) Finally, the very reactions that some countries adopted as a protection against high prices contributed to amplify the crisis. Protectionist measures such as export controls and large, protective purchases helped to drive prices to their extreme heights during the 2007–08 crisis, and they have continued to play a more moderate role since then on food prices rises (HLPE, 2011a; FAO, 2011).

Unsurprisingly, the more drivers are looked at in one approach, the more likely it is that the *share* of responsibility of each driver is reduced, together with biofuels effects. This includes also consideration for crop technology developments (Carter, Moschini and Sheldon, 2008). For example, Sexton and Zilberman (2011) suggested that a technology revolution in the major commodities concerned with the diffusion of genetically modified (GM) seeds has ensured lower prices than they would have otherwise have been, pointing to a role of the GM ban in Europe and Africa, and in the US on wheat, having had an effect as important on food prices as biofuel policies. The policy-relevance of such analysis is however dependent on beliefs about the capacity of GMOs to sustainably and safely raise yields (see e.g. Tabashnik, Brévault and Carrière, 2013).

3.4.2 Biofuels can act to amplify the role of other factors in price rise

At a first level, the introduction of biofuels can be seen as an additional factor acting on top of these other factors, and independent from them. In those cases, we can separate the problems and look at each factor, and at related policies to address the different issues, one at a time. This goes out of the scope of this report and has been addressed elsewhere (HLPE, 2011a).

In some cases, however, the introduction of biofuels might have had not merely an additional, but an *amplifying* effect with respect to that of another factor. It is then pertinent to look at the interplay between biofuels and such factors, since it is likely to show amplifying effects (i.e. the effect of the factors working jointly is superior to the sum of the individual effects). In such cases, policies have to carefully examine the joint context.

This might, for example, be the case for speculation, with biofuels adding to the game. It might also be the case with respect to stocks. As Abbott (2011) shows, the surge in demand related to biofuels after 2005 came after a period when China in particular had reduced its stocks and the biofuel growth helped drive down stocks further to levels that matched times of many prior price spikes. *"There is a point at which ending stocks are so small that they reach minimum or "pipeline" levels. This means total stocks will be used up at the time the new crop is ready to harvest. When market participants perceive that consumption will exceed available supplies such that stocks will drop below pipeline levels, prices rise to ration out the short supply. Prices continue to rise until a sufficient number of end users reduce use, and/or producers have time to respond by increasing production. The line between surplus stocks and shortages can be very thin… The transition from surplus stocks or "too much" to "too little" came quickly for most agricultural commodities from 2006 to 2008. Once that thin line was crossed, prices were "unbolted" as everyone asked what the value of food should be in a world of "too little."* (Abbott, 2011)

[35] Estimates of world price increases generally use one or more of the FAO commodity price indices, which are denominated in US dollars. They also tend to compare prices in the early 2000s with prices since 2006. The dollar was strong compared with other currencies in the first period, whereas it weakened in the latter part (Trostle *et al*., 2011). World crop prices measured in other currencies, therefore, indicate substantially smaller price increases. While corn prices in 2011, for example, are more than three times higher than prices in the early 2000s when measured in US dollars, they were only a little more than double when measured in Euros (Abbott, 2011).

3.4.3 Synthesis of main findings and estimates with respect to the recent commodity price increase

When asking "What has happened?" during the last decade in terms of food commodity prices and the reason for high prices and high volatility, very few studies exist that at the same time provide a qualitative, quantitative and fully comprehensive description. Therefore, estimates in terms of the responsibility of biofuels in price rises are difficult to compare, as they refer to different periods, different markets, different policies, different geographic coverage, etc.

For all these reasons, the *previously* central question ("What was the responsibility of biofuels in the 2007/8 price spike *at the time*?"), as enlightening and informative as it might be, could very well be a diversionary exercise *today* when the key issue is to look at future policies or at other contexts, and to guide action and project what would happen in the future.

Taking these important caveats into account, we list in Appendix 1 some of the key results found in the literature as per the major reviews of the last two years: Timilsina and Shrestha (2010). IEEP (2012); Zilberman *et al.* (2013); National Research Council (2011). To add to the complexity, authors have used two very different and potentially confusing metrics to express their results:

- either in **net** percentage of deviation from a "no policy" baseline, or from the start of the policy. If the price index was 100 without biofuels, or at the start of the policy, then a 20 percent net effect means a price index of 120 because of biofuels;
- or in **relative** percentage (or share of responsibility attributable to biofuels) of the observed price increase between a particular year and the observed price peak. As the FAO food price index has moved from 90.4 to 211.7 between 2000 and 2012, a 20 percent *relative* effect over this period would be equivalent to a 29 percent *net* effect.

Some could argue that the share of responsibility of biofuels was higher *in fine* than their relative effect, as they have in fact triggered a cascade of side-effects that would not have happened otherwise, such as low stocks, trade bans, large land-use shifts, speculative activity (Mitchell, 2008). Here we account only the primary effects attributable to biofuels.

The wide band of price effects identified within the individual studies, and the discrepancies between them, caution against firm conclusions. In addition, since these studies are based on simulations, the results are very sensitive to the specific assumptions of each model. The research tools for analysing the price effects of biofuels (and other variables) on food crops have become increasingly specialized. If their results are to be intelligible for policy-makers, more information needs to be available on the different models, which underlie figures used in published documents, and the implications of these different assumptions for evaluating their final results. Modelling results should not be used without great caution for policy-making (Box 10).

3.5 Can robust conclusions emerge?

In the preceding sections, we have looked at the two first questions laid down at the beginning of the chapter: By what mechanism and to what extent can biofuels potentially drive food prices up in different contexts? To what extent did biofuels contribute to the food price spikes and heights of the last five years, with respect to other factors?

The following robust pattern emerges from the observations and analysis and the results of the different bodies of literature:

1. *Caeteris paribus*, the introduction of a rigid biofuel demand does affect food commodity prices (e.g. Zilberman *et al.,* 2012). This observation holds in every context, even in the context of prices going down for reasons other than biofuels.

2. In the last few years of short-term (since 2004) commodity food price increase, biofuels did play an important role. The fact that biofuels have been the most important contributor is still disputed. The important role of biofuels is mainly due to:

- difficulty of the recent growth in total supply to keep up with the growth in total demand, including the biofuel component (MTBE ban in the US, other mandatory biofuel policies);

- rise in oil prices translating to food prices via biofuel production capacities, as the latter created an opportunity gain for key food-crops (corn, oilseeds, sugar).

3. Different biofuels have different impacts. Impacts can translate from one crop to another as far as substitutions between those crops can be made in the field or at demand level. Situations in different markets can vary: first, ethanol markets and biodiesel markets do not evolve in the same way; second, in the ethanol market, an increase in demand has different effects if met by increase in corn-based ethanol production or by an increase in sugar-cane ethanol production.

4. Biofuels establish a link between the food and energy markets. Transfer of volatility can be different in one direction or another. The existence of such linkages, as well as the induced correlation between prices, is widely recognized. However, the strength of the correlation is disputed. In addition, short-term (effects on volatility) and long-term correlations are shown to be quite different, as well as very dependent (and variable) among the different biofuel feedstocks and pathways.

These findings do confirm the results of HLPE (2011a) to a large extent, while refining them in important ways.

Box 10 Are long-term models appropriately used?

As discussed above, economic models have generally estimated that biofuels caused price increases that vary from a few percent to a few tens of percent depending on the model and the level and type of biofuel demand analysed. We point here to the caveats in using the results of such studies for short-term or long-term predictions.

General equilibrium models (Timilsina and Shresta, 2010) and many variations or derivatives of the GTAP model (Hertel, Tyner and Birur, 2010; Banse *et al.*, 2008) form the vast majority of models used, and by design they attempt to estimate the impacts on prices in a long-term equilibrium. That is the point at which farmers and other participants of the economy have taken full advantage of time to increase supplies in response to price increases and prices therefore reflect the long-term marginal costs of production. Such models, however accurate they may be over the long term, are less suited to depict short-term disequilibria and increases, such as the current situation in which the rate of demand growth has pushed agricultural markets out of long-term equilibrium, i.e. with crop prices well in excess of the sum of production costs and of the “normal” rate of return on investment. It is more difficult for them to capture what may be short but decisive periods in which supply does not catch up with a strong surge in demand. This limitation tends to make their conclusions look more “optimistic” as, if biofuel demand were to stop growing, these models would predict only modest price increases after a few years.

In theory, partial equilibrium models could also assess shorter-term changes, or longer-term changes with more accuracy. But to do so, they would need to do three things better: (i) more accurately depict the physical and agronomic reality of the different sectors, taking into account how “physical” and productive constraints act to limit the space for equilibrium of pure economic accounting (Sassi *et al.*, 2010), (ii) more accurately represent situations of developing countries (Lebre La Rovere, Gitz and Pereira, 2007), (iii) improve the estimation of elasticities, currently derived from past periods with prevailing modest changes in supply and demand conditions. As such, these models are generally limited in evaluating rapid, large changes in supply and demand conditions, which come close to the borders of the short-term production constraints, and of the income effect for households. This limitation applies not merely to the partial or general equilibrium models discussed above, but also to many analyses that extract elasticities from the literature specifically to estimate the impacts of biofuels on the recent price increases (Bair *et al.,* 2009; CBO, 2009; Hochman, Rajagopal and Zilberman, 2011).

The discussion in Djomo and Ceulemans (2012) is particularly helpful in presenting the advantages and drawbacks of many general equilibrium, partial equilibrium and other LUC models, in a context where very little real world data are available to validate model predictions.

These observations are neither critiques of the models, nor of the efforts to analyse the long-term future impacts of biofuels using models. Models are important for exploring the complex interactions between many commodities and sectors that are affected by the rise of biofuels. Model development has been a tremendously competitive area in research over the last decade. There is, however, a need for the scientific community to look back at the range of models developed – their key comparative advantages, strength and weaknesses – to compare them and their results. International Initiatives along these lines, such as the Agricultural Modeling Intercomparison Project (AGMIP) or the Center for Integrated Modeling of Sustainable Agriculture and Nutrition Security (CIMSAN) are to be encouraged.

In this new context, and given the concerns over the role of biofuels having pushed-up prices cumulatively to other factors, claims have been made to use biofuels mandates in a flexible way, in relaxing them in the event of a food commodity price spike (FAO *et al.*, 2011), creating a “system grain store’ (Durham, Davies and Bhattacharyya, 2012). These authors have shown that removing mandates at the start of an hypothetical price spike could abate the spike by 15-40%. As FAO *et al.* (2011) has shown, available options to introduce flexibility into existing biofuel subsidies, tax expenditures and mandates are second-best solutions and in practice present very real design, operational and political economy problems: first, eliminating or reducing the biofuel mandate could be very costly for biofuel producers and could lead to demands for compensation from governments); second, the design of the mechanism would need to include clear rules and procedures and be protected from political pressure which is likely to be intense in relation to any decisions relating to the mandate; third, any mechanism to modify the level of mandates or subsidies will require international policy coordination and harmonization. The present report proposes that Governments adjust biofuel policies, devise and coordinate buffering mechanisms so that biofuel demand does not pose a threat to food security from price rises.

3.6 Policy implications of fast-changing contexts for crop-based biofuels

In the beginning of this chapter we have raised three main sets of questions, and we can now better address the third. What could happen in the future? To what extent could biofuel policies contribute to price increases or high prices in the future? Can biofuel policies be designed or amended to mitigate price volatility?

The corn-ethanol sector in the US, and also the ethanol and biodiesel sector in Europe, are facing rapidly changing contexts. As pointed out by Abbott (2012), fast-changing developments in policy, technology, processing capacity both in industry and agriculture result in very different factors being successively dominant or “binding” in the relation between biofuels and prices, defining very different short term price regimes, within which price movements have to be analysed, and which are very different from the ones in 2005–08 (Abbott, 2012).

In the US, following a phase of expansion created by the MTBE ban and the set-up of RFS mandates (see Chapter 1), the biofuel sector now faces a different context whereby the demand could hit a ceiling, as the MTBE substitution policy and the RFS mandates reach their targets, and as the blending wall (limit to the incorporation of ethanol into gasoline[36]) approaches, constraining the amount of corn that can be directed to the internal market to its current level. Without modification of the blend wall, growth of internal demand in the US could temporarily be limited to the overall growth in the use of transportation fuel. There remain some uncertainties, however, such as a possible acceleration in the adoption of a higher 15 percent blending wall for recent vehicles. Over time, that would allow up to a 50 percent expansion of ethanol.

The RFS targets, as ambitious as they might be (Chapter 1), gave visibility and predictability in terms of regular growth, acting to preclude new bursts of growth. The “advanced biofuel” target within the RFS created a demand for imported ethanol from Brazil.[37] At the same time, the US exported comparable quantities of corn ethanol to Brazil. This bilateral trade puts on the table the question of the coordination of national policies, as shown by a recent publication by Meyer, Schmidhuber and Barreiro-Hurlé (2013), pointing to incurred transportation costs, associated GHG emissions, and driving up prices. The US sector might be looking at export opportunities for corn ethanol, which the persistence and expansion of mandates in other countries could allow. In the period from 2009 to 2011, the US took over from Brazil the position of lead ethanol exporter to Europe. However trade restrictions recently imposed by the EU on US ethanol may revert this position.

In Europe, the recent proposal of the EU Commission to cap food-crops-based biofuels at a 5 percent blending rate could act as a move towards more stable and controllable market demand for food-based biofuels.

While in South Africa, India and China, corn, being a food crop, has been excluded from biofuel policies, this is not the case in Argentina and now Brazil. Corn-ethanol production in Argentina is quite

[36] For more details on the blend wall see: http://www.eia.gov/todayinenergy/detail.cfm?id=8430.

[37] Close to 0.7 billion litres in 2011, as per Figure 1 in (Meyer, Schmidhuber and Barreiro-Hurlé, 2013)

competitive and in a phase of expansion (see Chapter 1). Brazil has recently developed corn-ethanol, and it is likely that it may become an attractive option in the Centre-West of the country for domestic use in a context of economic and logistic challenges in accessing grain export markets. These developments may have an important impact on global corn prices given the increasing share of Brazil and Argentina in world markets, concomitantly with a decline of the US share exactly because of the increased domestic use to fulfil domestic ethanol demand.

From a policy perspective, this might point to the need to identify regions where important yield gaps persist, which has led to the focus on Africa. On the other hand, it might point to the urgency of R&D investment in advanced biotechnology, development and diffusion of which has until now been called in check.

The oil price context could also change the picture. Pending a continued trend of rising oil prices, there will be increased competitiveness[38] of corn- and sugar-cane ethanol with respect to fossil gasoline, even without incentives or tariff protection (for example, the US eliminated the tax credit for corn ethanol at the end of 2011). As biodiesel competes economically only in situations of very high oil prices, it will remain, until major technological advances occur, driven by government policies, and any change in these could stop its growth.

Rising oil prices opens in theory an almost infinite market worldwide for biofuels (HLPE, 2011a), with biofuel demand growing as *long as oil prices remain higher than the cost of biofuel production.* This leads to oil prices ultimately defining an “opportunity floor” on crop prices: when a substantial industrial biofuel capacity exist, farmers and traders are able to direct their produce to the most remunerative market. This also opens a space for transmission of volatility and speculative behaviour from the petroleum market to food markets. In contrast, it highlights the role played by technical or political incorporation ceilings/limits, such as the blending wall in the US, fuel quality considerations and other obstacles such as subtargets or technical segmentation of the biofuel market due to consideration of the performance or origin of feedstocks.

[38] Iowa State economists have estimated that prices above USD80 per barrel for oil make corn-ethanol production economical at corn prices from USD200 to USD300 / tonne, while Tyner (2010) calculates the need for higher oil prices.

4 BIOFUELS AND LAND

Biofuel production, except when relying on crop residues and waste, requires land. It thus competes for land with other agriculture activities, including production of other forms of bioenergy, other economic activities, urbanization and, increasingly, with land protection for environmental objectives, especially protection of biodiversity and carbon sequestration.

Three main questions emerge by which land use and land-use change considerations are a key factor at the crossroad of biofuels and food security: to what extent is land availability a constraint to biofuel development and to ensuring world food security? Second, to what extent were large-scale land acquisitions driven by biofuel expansion plans? Third, the much debated issue of "direct and indirect land use change", which emerged in the assessment of the contribution of biofuels policies to mitigate climate change, is also very relevant to the issue of food security, as such land-use change can come at the expense of food production.

The debate on land availability is very much oriented by prospective considerations on what is/would be the land needed to produce a certain quantity of biofuels versus what is/would be the land "available" globally, given the need to increase food production to satisfy a growing demand. Answers to these questions are driven by the assumptions made in terms of yield (crop yield, biofuel yield) and by the information on "land availability".

Much of the literature on land availability is devoted to calculations on the amount of agronomically "suitable" and available land, whereby lands are attached either high or low suitability parameters. Major assessments (e.g. Fischer *et al.*, 2011; Erb *et al*., 2007) suggest that ample amounts of land can be mobilized to confront future food demand on the condition that good management practices be adopted, and the same arguments are developed when discussing biofuels. The argument has also been advanced that some biofuel feedstocks would not be competing with food, even not via land use, as they could be grown on "marginal" areas not suitable for food crops. This has led to high expectations with regard to jatropha and second-generation biofuels.

Discussions on the global amount of land available from an agronomic point of view often hide other dimensions of "land availability". Many authors point to the need for a clearer picture of what "available land" means; some preferring to use the word "underutilized" land, while others contest the very notion, arguing that most, if not all, land is already used, in various ways (HLPE, 2011b). Some critical analyses on land availability argue that land that is apparently idle or underutilized is in fact generally integrated into traditional forms of land use, ranging from itinerant pasturing, to fallow lands, to land used for energy, complementary foods and raw material for a variety of non-food activities. Other critical dimensions of land availability include considerations of the need to preserve biodiversity, pristine ecosystems, carbon-rich ecosystems and areas critical for water management. In all cases, despite some progress, as for example in the field of "environmental footprints",[39] lack of consensus on the definitions and the measurement of the various dimensions of land-use and availability make their confrontation difficult even at scientific level.

Confronting the various dimensions to assess land availability cannot be done without going down in scales and assessing land use not only at global level but also, more concretely, at local level, including all types of use, shared, partial or temporary, about which huge information gaps remain.

The second debate identified relates to the role of biofuels as drivers of domestic and foreign, large-scale investments in land, often called "land grabbing". In the initial accounts, and in the literature that has emerged as from 2008 focusing particularly on SSA countries, biofuels were identified as a central, if not the leading, motive behind these investments.

Subsequent analysis has reduced the weight originally attributed to biofuels, identifying a wider set of motives: (i) food security by capital-rich and resource-poor emerging countries; (ii) speculative interests in securing scarce resources in the wake of the financial meltdown of 2008; and (iii) an increasing convergence of food and bioenergy markets through the use of common feedstocks (sometimes called "flex crops"), which can be directed equally at fuel or food markets depending on price advantages. Nevertheless, there is ample documentation that large-scale biofuel investments are playing an important role in transforming land use in many developing countries.

[39] See http://www.footprintnetwork.org/en/index.php/GFN/page/academic_references/ for a review.

For many, biofuels and related land and production capacities investments can provide important new opportunities for income and employment generation, in addition to bringing much needed capital, technology and knowledge to developing countries agriculture. Other analyses have identified negative impacts of biofuels on poor farmers and their communities, either directly in the form of land expropriations or indirectly through the concentration of resources on large-scale farming operations.

This discussion forms part of a larger debate on the appropriate development model for African agriculture, whereby some favour the promotion of medium- and large-scale commercial farming operations while others argue that a broader-based modernization of traditional farming provides better development potential in terms of income, employment and non-farm economic activities (HLPE, 2013). These same discussions inform the biofuels' literature on suitable farming models (see Chapter 5).

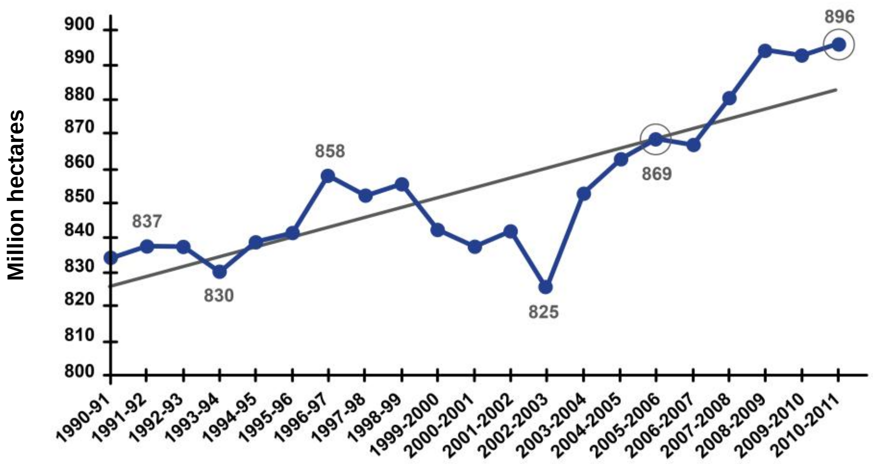
Thirdly and finally, the much-debated issue of "direct and indirect land use change", which emerged in the assessment of the contribution of biofuels policies to mitigate climate change, is not without impact on food security. If one of the aims of a biofuel policy is to mitigate climate change through the substitution of fossil energy, it is logical to factor in the net impacts on land-use change and on land carbon emissions or sequestration. However, minimizing direct or indirect land-use change for the sake of minimizing losses of biomass and soil carbon can come at the expense of food security if it leads to favour use of existing croplands for biofuels, rather than forest or pastures.

4.1 The issue of land availability

Most estimates for biofuel and bioenergy potential assume a dedicated provision and use of land to grow either food crops or cellulosic energy crops, and the following sections address potential implications on land use.[40]

The provision of land to meet biofuel demand can come either from additional lands put into cultivation for biofuels, or result from taking space from other uses. The latter triggers a competition with all uses and related resources needed (Foley *et al.,* 2011): food production, biomass production, environmental considerations, urbanization, industry...

Figure 13 Harvested areas (1990-2010) for the 13 major crops



Source: USDA Production, Supply & Distribution online database *http://www.fas.usda.gov/psdonline.*
The 13 major crops as per Bruinsma (2009) are: wheat, rice (paddy), maize, soybeans, pulses, barley, sorghum, millet, seed cotton, rape seed, groundnuts, sunflower, sugarcane.

To a certain extent, the observed 27 million ha increase in harvested areas for 13 major crops in the period of rapid expansion of biofuels (2005–10) seems to shows that room has been found to expand

[40] Some biomass for energy may not come from dedicated land uses, but from waste products, including post-consumer waste, forests exploitation, animal wastes and crop residues. Some of these sources are explored in Haberl *et al*. (2012). They would not impinge on food supplies, except maybe for crop residues if their use leads to excess removal of plant residues disrupting the balance of soil organic matter, potentially harming productivity.

cropping at world level in reply to growing biofuel demand. However this figure, by construction, also masks the displacement in use of crops towards biofuel feedstocks such as corn, soybean and rapeseed, a phenomenon identified by ICCT (2013) in the case of Europe (see Chap. 3).

In this section we look first at the notion and extent of available land (Section 4.1.1) and look at how the global demand for food (Section 4.1.2) and energy (Section 4.1.3) translate into demand for land.

4.1.1 "Suitable" land available for crop production

a. FAO estimates

Estimations of available land for crop production generally focus on the physical potential to produce crops on land that is not presently under crop production. The analysis that has almost certainly had the greatest influence is that undertaken for more than 30 years at IIASA called Global Agro-ecological Zones (GAEZ), and that FAO has incorporated into its projections of future agriculture for at least two decades. This analysis uses global spatial datasets to estimate the rainfed cropping potential on land for a wide range of crops. Any land deemed suitable for any single crop is considered potential cropland: cropland potential at a certain location is therefore deemed independent of pre-existing land uses, for example, whether land is urban, forest or grazing land. According to FAO using the GAEZ classification of land types, there is a gross balance of 3.2 billion ha of prime and good land not used for growing crops, leaving a net balance of 1.4 billion ha, after subtracting built-up areas, forests and protected areas (Alexandratos and Bruinsma, 2012).

The GAEZ results available in the late 1990s have been criticized as highly optimistic. For example, Young (1999) argued that the results estimated large areas of potential cropland even in regions where low land availability had already resulted in the conversion of areas highly unsuitable, such as areas of steep slopes. He also argued that the analysis failed to account properly for competing land uses and that the use of global datasets leads to broad areas being considered as suitable for cropping even though only portions of each "cell" would be suitable.

FAO points out that 70 percent of this potential cropland in SSA and Latin America has substantial soil or terrain constraints (Alexandratos and Bruinsma, 2012). It also points out that:

> *"It is enough for a piece of land to support a single crop at a minimum yield level (40 percent of the maximum constraint-free yield) for it to be classified as suitable (prime or good) land. For example, large tracts of land in North Africa that permit the cultivation of only olive trees (and a few other minor crops) are counted as suitable, even though there may be little use for them in practice."*

It concludes, "much of the land balance cannot be considered as a resource that is readily useable for food production on demand," and the estimates need to be treated "with caution". Although the GAEZ assessment of cropland potential is probably the most well known because it is being used by FAO in its publications, in reality all integrated land-use and climate models include some method for estimating potential cropland. We review below some of the major ones.

b. Other sources

The Global Biomass Optimization Model (GLOBIOM), also by IIASA, uses the Environmental Policy Integrated Climate (EPIC) crop model to estimate cropping potential based on agronomic criteria and good management practices. The Massachusetts Institute of Technology (MIT) model, for its part, assumes that any land with sufficient rainfall can be improved through inputs or drainage to produce crops. The IMAGE model generates an underlying estimate of land productivity using climate and soils, and from that forms land supply curves in each region. In general, these models do not estimate any fundamental physical limitations in the capacity to meet future land needs; the limitations are a function of cost generally due either to declining productivities as land expands or otherwise increasing costs to bring that land into production.

Box 11 The notion of "available land"

Most of the estimations of global "available land" are grounded on their biophysical suitability to grow crops. As such, they implicitly consider that any land suitable for crops that is not already in use for that purpose is "available". Grasslands are then considered to be "available" for crops even though they are already utilized. The fact of land not being actively cultivated or used at a specific point in time is not enough to prove that it is "available", that it has not been nor ever will be used. For example, fallow land is land that has been in active use and will be again – in fact it is intentionally left idle as a means to restore/rebuild its productivity. If not intentionally left "idle", its productivity would suffer an irreversible decline – as would the sustainability and resilience of that production.

Land suitable for crops should not, therefore, be identified as necessarily "available". Putting this land into crop cultivation may displace other food-related activities, such as grazing, or modify existing systems, both of which will have food security implications, often on the most vulnerable populations. Notions of land availability need to take into account the degree to which its change of use implies displacement of existing production together with the implications of such displacement. Moreover, even global estimations, to be reliable, need to take into account and integrate the various uses of land, which are locally very specific.

4.1.2 Global demand for land resulting from projections of food and feed demand

Despite the variations that result from inherent uncertainties in forecasting food supply and demand up to four decades ahead, the great bulk of studies indeed point to an increasing demand for land for food, for timber and for urban use. Increased food demand is the first parameter to assess future "land availability" for bioenergy, as the more food is needed, the more difficult it will be to find a place and "free up" lands for bioenergy.

Food and feed demand in 2050

According to the latest FAO projections (Alexandratos and Bruinsma, 2012), meeting food demand by 2050 will require roughly a 60 percent increase in agricultural production compared with the base year of 2006. This large increase is still relatively conservative and also holds biofuel production at the net numbers projected by OECD for 2019 (OECD-FAO, 2011). This projection covers both a rise in population and a growing middle class worldwide, consuming proportionately more meat and dairy, as well as vegetable oil, fruits and vegetables. FAO´s projected rise in consumption of animal products is actually lower than that projected by others based on the global, historical relationship between income and their consumption (Tilman *et al*., 2011). FAO assumes that people in SSA will still be able to afford only extremely limited quantities of food, and that people in India will choose to eat little meat. The FAO projection is also based on a slightly lower population growth rate than the revised forecast by the UN population agencies (Alexandratos and Bruinsma, 2012, p. 21), and assumes that food supplies remain inadequate to eliminate food insecurity in SSA and southern India (Alexandratos and Bruinsma, 2012, p. 40).

Tilman *et al*. (2011) estimate a 100–110 percent increase in global crop production until 2050, with the difference from the FAO estimate being due to different methods, a greater reliance on quantitative trends, and emphasis on income–dietary expenditure rather than on the use of expert opinion. Other studies (Agrimonde, 2009; Erb *et al*., 2009) fall in between these two figures, but closer to Alexandratos and Bruinsma (2012).

These studies, and others (Godfray *et al*., 2010; Havlik *et al*., 2013), then estimate land needed to meet food demand. A subfield of this literature focuses in particular on the potentially enormous land-use challenges of meeting growing demand for livestock products (Pelletier and Tyedmers, 2010; Popp, 2010).

Land needs to satisfy food and feed demand in 2050

Assumptions on areas needed to satisfy this growing demand are of course extremely dependent on hypothesis on yields and yield growth. Extremely different estimates of future yield growth, and assumptions about livestock production, among other factors, lead to different estimates of net land-use needs from model to model.

Tilman *et al*. (2011) examine several alternative pathways of development. The first assumes no technology improvement and mimics past trends with lower-yielding countries increasing production mainly through extending cultivated land and higher-yielding countries by improving yields. In such a scenario, global land extension by 2050 would be one billion ha. A land sparing pathway would reduce this number to 0.2 billion.

Smith *et al*. (2010) summarize a wide variety of model projections, which vary from a 5 to 30 percent increase for cropland, and a variation in grazing area from a decline of 5 percent to an increase of 30 percent. Because the grazing area is so large, a 10 percent increase implies land expansion of over 300 million ha.

Underlying assumptions on yield increase and multiple cropping are particularly important. FAO (Alexandratos and Bruinsma, 2012) projects that total world cropland will expand by 69 million ha from 2006 through to 2050. This figure assumes that double-cropping or reductions in fallow land will provide 48 million more hectares of harvested land each year without expanding cropland area. It does not account for the need to replace degraded land, estimated at 2 to 3 million ha per year (Alexandratos and Bruinsma, 2012).

FAO assumes that most of the production increase will be realized through yield growth, at a slower rate than in the past, and, for cereals, at the same linear rate of 44 kg/ha as in the past. Yield increases are projected to be very different depending on countries and products, reflecting the existence of major yield gaps. Globally, total agricultural output is expected to increase by 1.1 percent per annum from 2005/2007 to 2050, down from 2.2 in the preceding equal period, and cereals by 0.9 percent per year versus 1.9 percent. Nevertheless, this will not be easier than in the past as it will require important investments.

The rate of yield growth is of course hard to project, but the comparison with the past reveals the challenge of increasing yields enough to avoid cropland expansion even without an increase in biofuels.

The period from 1962 through to 2006 saw a doubling of irrigation, and the initial introduction of synthetic fertilizer and scientifically-bred seeds to most of the world. Even with that growth, cropland area probably expanded approximately 176 Mha globally during the period, representing a gain of 230 Mha in developing countries, and a loss of 54 Mha in developed countries (Alexandratos and Bruinsma, 2012).

Grazing land, according to FAO data, expanded by an additional 250 million ha between 1962 and 2006 (FAO, 2006). FAO projections implicitly rely on an increase in the quantity of meat and milk generated by the world's grazing land to meet the overall increase in milk and dairy: it projects that feed from crops will increase, but less than proportionate to the rise in production, leaving the rest to come from grass and other forages. Increased output can result from better management of grass, or more efficient conversion of feed into meat and milk. If not, more consumption will result in more conversion of forest.

Researchers in Brazil and other parts of Latin America have demonstrated great potential to increase the output of milk and meat on the tropical grazing lands carved out of forest (Gasques, Bastos and Bacchi, 2004). Yet even if Brazil doubles its beef output per hectare, that would contribute no more than15 percent to world beef production. The global potential for intensification is less well understood, and much of the world's grazing land is too dry to produce much more output, while other grazing lands, such as many of those in Europe and New Zealand, are already intensively managed. Overall, the prospects of increasing this production without expanding grazing land seem challenging.

This is particularly true because, regardless of the technical potential, increases in beef and dairy demand will continue to create incentives to clear forest as well as to intensify existing grazing lands. On the positive side, zoning regulations and voluntary pacts by leading economic players (meat packers and supermarkets) as in the Brazilian "Beef Pact" (*Pacto pela Pecuária*) promoted by the business NGO, Ethos,[41] mark the beginnings of an institutional framework that may discipline pastureland expansion more effectively in the future.

[41] www1.ethos.org.br

Importance of other non-food demands

In addition to increases in food demand, a growing population will also demand more timber supplies, with a common estimate of 70 percent (Smith *et al*., 2010). Lambin and Meyfroidt (2011) estimate that this demand will require roughly 50 million ha of additional plantations by 2050. An alternative assessment for the OECD by the Netherlands Environmental Agency projected an increase by 1 billion ha in the quantity of managed forest, although most of that will presumably result from the management of natural forests (OECD/FAO, 2011), which will compete heavily with biodiversity but not with food.

Finally, the world's growing urban population is also likely to consume more land. One review paper finds estimates ranging from 66 to 351 million ha (Lambin and Meyfroidt, 2011). Not all of that will be arable land, but much of it probably will because of the relative ease of building on flat land that is already cleared and because many urban areas originally developed in areas of high agricultural productivity.

4.1.3 Additional land needs in light of envisaged biofuels and bioenergy goals

There are very few studies available that attempt to evaluate the amount of lands currently mobilized worldwide for biofuel production. This is due to the absence of any international reporting mechanism whereby countries provide data on land used for biofuel (either for domestic use or for exportation), or even production and consumption.

Using results of typical biofuel yields from Table 1 in Chapter 2, a production of 100 billion litres (a number close to the current global biofuel demand) would represent an equivalent of 20.4 million ha of sugar cane, or 38.5 million ha of corn, or, if it were biodiesel, 58.8 million ha of rapeseed. Those numbers compare with the 1 396 million ha of arable lands worldwide in 2011 (FAOSTAT, 2013). This leads to the conjecture that today's biofuel production probably mobilizes around 2–3 percent of arable lands globally.

The additional land needed for biofuel production depends primarily on the size of the market, biomass yields and industrial productivity. Yields, as we have seen in Chapter 2, vary greatly with feedstock choice, and industrial technologies are also on the threshold of new productivity horizons. Depending on the biomass and technology, land inappropriate for food production could also be used for growing biofuel feedstock. Similarly, crop and livestock management systems may establish new synergies between biofuels and food production.

Once biofuel targets and mandates began to be put in place, studies emerged with estimations of the crop production, and its possible technological and regional distribution, which would be necessary to fulfil typical amounts of 5 or 10 percent of gasoline substitution at global level.

In 2006, the OECD, for instance, calculated that, for the major user regions, a 10 percent biofuels share would require an average of 37 percent of the total land dedicated to cereals, oilseeds and sugar cane in these regions, ranging from 3 percent in Brazil to 72 percent in the EU or 9 percent taking into account worldwide crop production (OECD, 2006).

Given the striking difference between the percentages of cropland which would need to be dedicated to biofuels in Brazil and the EU according to the OECD scenario, it is not surprising that the Brazilian Government and its leading research institutions focused on the global potential of the emerging biofuels market. A study undertaken at the request of the Brazilian Government by the ethanol research center (Interdisciplinary Center for Energy Planning – NIPE), at the University of Campinas, São Paulo, concluded that Brazil could supply ethanol to substitute 5 and even 10 percent of projected global gasoline use by 2025, without negatively affecting either the environment or food production (Leite *et al.,* 2009).

Calculating light vehicle gasoline consumption at 1.7 trillion litres in 2025, a 5 percent substitution would require 102 billion litres of ethanol, some five times the 2005 production levels. Given existing sugar-cane productivity, around 70 tonnes/ha, and improvements in the average efficiency of milling operations, 17 million ha would be required directly for sugar-cane production plus a further 4 million to be planted as forest, in line with the Brazilian forest code requirement of 20 percent of forest plantations for any sugar-cane expansion. These numbers do not take into account the possibility to transform the bagasse into fuels via cellulose technology: such a scenario would reduce the demands on cropland to 14 million ha for the same biofuel target.

Such extra land for biofuels would be made available through the intensification of grazing techniques and also by cultivation of degraded pastureland, calculated as between 50 and 70 million ha. Mixed cattle and sugar-cane production practices would also be stimulated and the mixed livestock/crop model has been adopted as a priority for the key savannah region by the Brazilian Agricultural Research Corporation (Embrapa).

The same study (Leite *et al.,* 2009) concluded that this 5 percent target could be doubled to 10 percent of global light vehicle fuel (205 billion litres) within a perspective of sustainable land use and the guaranteeing of food production. The conclusions of the study became the basis of subsequent Government strategy. These conclusions have triggered debates within and outside Brazil. A first line of debates concerns land-use effects and related potential carbon losses and GHG emissions (see Section 4.3.1). The second line of debates regards effects on biodiversity from the development of monoculture over forests, grasslands, and other biodiversity-rich ecosystems, such as the savannah *cerrado* region, which, it is argued, has been "traded off" against the protection of the Amazon and Pantanal (Galli, 2012).

Wider bioenergy goals and land-use

Biomass is in demand not merely to produce liquid biofuels, but for electricity and power. Today, modern bioenergy represents only 10 percent of global bioenergy use, and biofuels for transport only 2.2 percent of all bioenergy. The vast majority (90 percent) of global bioenergy use – or around 47 exajoules (EJ) per year – is traditional bioenergy usage (burning wood, charcoal, dung, biomass residues, etc.) on which about 40 percent of the world's population, mostly in developing countries, depend, but which represents only around one-tenth of current global primary energy use (WBGU, 2009).

The WBGU (2009) has estimated the total sustainable technical potential of bioenergy in the year 2050 to be 80–170 EJ per year (including ca. 50 EJ per year from wastes and residues). The International Energy Agency (IEA, 2010) has established, in its blue map scenario which sets the goal of halving global energy-related GHG emissions by 2050 (compared to 2005 levels), a goal of biofuels producing 150 EJ/yr or 20 percent of the world's energy supply (750 EJ/yr projected in this scenario) by 2050, with biofuels[42] accounting for 30 EJ/yr. IEA estimates that this would require and area of 375-750 Mha for biomass cultivation.

The potential competition arising from this goal is revealed by the following broader estimations. Haberl *et al*. (2012) calculate that the current total world harvest of biomass (for food, feed, fibre, wood products, traditional wood use for cooking and heat, and including world's crop residues and harvested forage) contains a chemical energy value of roughly 230 exajoules, an amount equivement to only a share of the 2011 world primary energy consumption, roughly 530 exajoules (EIA, 2012). To produce these outputs, people manage in the order of 75 percent of the world's vegetated lands (Haberl *et al*., 2012).

The OECD projects an energy demand of 900 exajoules in 2050 (Marchal *et al.,* 2012). That implies that the totality of today's biomass harvest, if entirely used for energy, would supply less than 20 percent of total world energy in 2050. Presumably, the use of dedicated energy crops could produce energy with somewhat less land use than the global average for harvested timber, crops and forage, and might require less water, but pressure on land and water associated with bioenergy targets as high as 20 percent of the world energy would still be enormous.

Many claims have been made (e.g. Goldemberg and Coelho, 2003) that a modern bioenergy sector could be able to supply energy-poor countries, in replacing traditional, inefficient forms of bioenergy, such as charcoal. In much of Africa, for example, energy use is extremely low. The opportunities exist, therefore, for a shift from traditional to modern uses of bioenergy for local consumption, possibly with moderate impact on land use (as efficiencies in biomass use are improved), and with positive impacts on local development. We explore both the tensions provoked by land competition and the potential for bioenergy strategies for local development in the next section and in Chapter 5.

[42] To achieve this very ambitious result, the IEA assumes that first generation biofuels made from cereals and oilseeds will have disappeared by 2040-2045, with the exception of bioethanol produced from sugar cane for 3 EJ in 2050 (10% of biofuels at that date). The remaining, that is 90%, will be 2G biofuels made from ligno-cellulosic resources. (Guyomard, Forslund and Dronne, 2008)

4.2 Biofuels within the "land grab" or "international large-scale land acquisitions" debates

Besides the debates on global numbers, many authors point to the need for a clearer picture of what "available land" means, some preferring to use the concept of "underutilized" land, other contesting the very notion, arguing that most, if not all, land is already used, in various ways. Such considerations call for assessing land use not only at global level but also more concretely, at local level, including all types of land use, shared, partial or temporary. It must be recognized also that we are confronted with huge information gaps when assessing land use.

4.2.1 Data sources on land investments

Debates over the impact of biofuels in the food price hikes of 2008–09 are paralleled by discussions over the importance of biofuels in the surge of global land investments as from this date. This phenomenon was initially brought to the world's attention and monitored by the NGO GRAIN[43] and was baptized by them as "land grabbing". The International Land Coalition (ILC), a network comprising 116 organizations from over 50 countries, established the Land Portal[44] with the similar concern of monitoring large-scale land investments. In addition to leading international NGOs, its partners include FAO, the EC and the Gates Foundation. In 2012, the ILC, together with the French Centre for International Cooperation in Agronomic Research for Development (CIRAD), the cooperation organization of the German Government (GIZ), the University of Bern's Centre for Sustainable Development Research (CDE) and the German Institute for Global and Area Studies at the University of Hamburg (GIGA) launched the Land Matrix site.[45] This initiative is also supported by leading NGOs and the EC. A report based on its findings (International Land Coalition, 2012) was presented at a meeting of the World Bank on this theme in 2012. The Center for International Forestry Research (CIFOR) has also developed a database of land deals (See Appendix 2).

The World Bank calls the same phenomenon "cross-border or transnational large-scale land acquisitions", and has made important contributions to this debate, principally through research and publications led by Deininger and Byerlee (2011). Its most systematic research, whose findings we discuss below, was based on the data collected by GRAIN and cross-checked with the ILC data. Deininger and colleagues concluded that although in principle official data from country registries of land deals would be the ideal data source these are not readily available. Data on six countries, however, were obtained through the aggregation of information from regional registries, and these confirmed that there had been "a recent and marked increase in land transfers" (Arezki, Deininger and Sellod, 2011, p. 12).

In its 2011 report, the partners of the Land Portal concluded that between one-third and two-thirds of all land investments were biofuel-related. Since 2000, 1 217 transactions have been registered involving over 83 million ha, corresponding to 1.7 percent of total agricultural land. Africa is the principal target with 754 transactions accounting for 56.2 million ha, which equals 4.8 percent of the continent's total agricultural land, an area equivalent to Kenya. Asia comes next with deals amounting to 17.7 million ha, followed by Latin America with 7 million. These data relate to reported transactions involving no confirmation that the deals have been concluded or that investments have begun. Some 625 deals involving 43.7 million ha are from sources considered "reliable", although here again this does not imply confirmation of completed deals.

GRAIN launched a report in 2012 using more restrictive criteria: deals dating from 2006 that have not been cancelled and involving large-scale foreign investments for food crops. They register 416 deals covering 35 million ha and argue that 10 million ha are now the subject of such investments each year. The World Bank team (Arezki, Deininger and Sellod, 2011) draw attention to the scale and speed of such investments – from 1961 to 2007 there was an annual average rate of expansion in cultivated land area in Africa of some 1.8 million ha as against reported demand for land in Africa in 2009 alone of 39.7 million ha. The GRAIN report excluded non-food crops such as jatropha, which in its database is shown to have motivated land deals of millions of hectares. Nevertheless, even using these more restrictive criteria, biofuels come a close second to food in GRAIN's identification of the motivations for

43 www.grain.org

44 www.landportal.info

45 www.landportal.info/landmatrix

investments although, as we have seen, it is difficult to make a clear distinction between the two in the case of first-generation biofuels.

4.2.2 Analysis of the evidence provided by the data sources

The World Bank team has subjected the GRAIN data to detailed econometric analysis. Their concern was to understand the push and pull factors involved in these investments. To make the notion of "available land" operational, it was defined as "land with high potential for rain fed cultivation that is currently not utilized and that excludes forests, protected areas and areas with a population threshold above a certain maximum". When analysed according to these criteria, "available land" emerged as a key pull factor. Investor countries were examined in terms of their food import dependence and this variable emerged as a key push factor. These results clearly confirm one component already identified in the literature – land investments by resource-poor, capital-rich countries. The results showed only a weak correlation with cultural affinity between the countries of origin and destiny. The most surprising finding from the point of view of the World Bank team was the strong correlation between high levels of land investment intentions and "weak land governance and protection of local land rights" (Arezki, Deininger and Sellod, 2011, p. 20). These findings are consistent with the enormous scale of many of these investments and the prevalence of conflict associated with their implementation. The World Bank´s promotion of Principles for Responsible Agricultural Investment (PRAI) finds its justification in this finding.

Williams (2012), from the International Water Management Institute, has insisted that water is in fact the key resource behind these investments. Land deals, however, are being negotiated without explicitly taking into account the water implications of large-scale projects, often because land and water are subject to different regulatory systems and different governmental responsibilities. Large-scale projects can lead to water being overdrawn, and to the diversion and the drying up of water sources. Rulli, Savior and D'Odorico (2013) have provided the first detailed assessment of the associated appropriation of water in these land investments, using both GRAIN and Land Matrix data. They conclude that "the per capita volume of grabbed water often exceeds the water needs to produce the food for a balanced diet and therefore would be sufficient to improve food security and abate malnourishment in those countries" (op. cit. p. 892).

The analyses differ in the relative weights attached to food, fuel and speculation as the prime motives for land investments. All, however, see biofuels as an important driver and as involving the same characteristics as investments for food, principally as regards their large scale, their implications for water use, their concentration in areas of "available " land, and their impact on land-use rights. Jatropha might initially have been an exception, seen to flourish on marginal lands and in conditions of hydric stress. Many of these projects (calculated at over 2 million ha in SSA) have been put on hold or abandoned and may well be reconverted to food crops or reorganized on the basis of improved genetic material and farming practices. It should be recognized also that the data refer to "reported" investment projects, most of which have not begun to be put into operation. It should be no surprise, therefore, that biofuel production and exports are currently embryonic.

A more recent study by EPS-PEAKS (2012), for the UK Department of International Development (DfID) has also analysed these data and declares from the outset that "the biggest driver for global transnational land acquisitions appears to be biofuels." (op. cit. p.1), an affirmation repeated throughout the report. This study also analyses the Land Matrix, and calls attention to cases of exaggeration and to the high level of domestic transactions in the data (some 40 percent). Some 48.9 million ha are identified, which compares with the figure of 56.6 million by the World Bank and 51–62.1 million ha in a study by Friis and Reenberg (2010). The study notes that IFPRI (2009) reached a figure of 15–20 million ha in the period 2006–09, valued at USD20–30 billion. EPS-PEAK identifies a large number of domestic acquisitions and calculates transnational transaction at around 26 million ha. Both in terms of area and number of transactions, jatropha emerges in first place (4.4 million ha and 99 deals) followed closely by palm oil and sugar cane. In contrast to the media, which it argues assigns priority to food interests: "the large proportion of jatropha, oil palm and sugar-cane points to the growth of investments in biofuels, which may be inflated due to media reports but are undoubtedly a major driver of transnational land acquisition" (op. cit. p.12).

4.2.3 Biofuel investments and customary land rights

A study by the ILC, CIRAD and the Resource Conflict Institute (RECONCILE), Kenya (2011) has called attention to the fact that while at the local level the power asymmetries might recall colonial times, in fact we are dealing with agreements being reached on a voluntary basis by sovereign states either with other sovereign states or with private actors. In addition, in most cases, the “beneficiary” states have actively promoted such investments. It argues that, properly conducted, these investments could provide an opportunity for mobilizing the “capital, technology and expertise needed to stimulate agricultural production and improve African economies.” (p. ii). The opportunities and risks are presented in Table 7.

Table 7 Opportunities and risks of large-scale land investments

Opportunities/Positive impacts	Risks/Negative impacts
Access to capital and technology for increased production	Restriction/denial of access to strategic resources provoking conflicts
Development of infrastructure in rural areas	Undermining production for local consumption and food security and/or flooding of local markets
Employment opportunities both on- and off-farm	Undermining local genetic resources and environment with monoculture, agrochemicals and pesticides
Improvement of food security	Appropriation of customary rights with no compensation
Stabilization of global food prices and participation in international markets	Breaking up of social networks through fencing

Source: ILC/CIRAD/RECONCILE (2011, pp.13, 18, 22).

While espousing overall optimism with regard to the potential of these investments, the study argues that “substantial policy, legal and institutional reforms have to be undertaken at global, national and local levels to circumvent the risks that have been identified” (p. ii).

CIFOR, from a less sanguine perspective, has carried out case studies in SSA, in Ghana, Mozambique, the United Republic of Tanzania and Zambia, highlighting the complexities of defending local communities’ land rights (German and Schonevend, 2011). Whether dealing directly with private investors or with the State as intermediary, the asymmetries between these actors and the local communities are enormous. State actors may use land deals to eliminate community rights, creating leasehold contracts, which may then revert to the State. Alienation of land may be facilitated by lack of democratic procedures in the community and through the manipulation of information by investors. CIFOR explores the role that more detailed zoning regulations might play but concludes that the costs of enforcement would in many cases be prohibitive. It therefore recommends the strengthening of the local community’s legal rights, including democratic procedures of decision-making within the community.

Many studies have documented the key role of biofuels in large-scale land investments and their consequences for the displacement of traditional communities (Matondi, Havnevik and Beene, 2011; Biofuelswatch, 2012). A particularly systematic account is that provided by Cotula, Dyer and Vermeulen (2008) in a study conducted for FAO/International Institute for Environment and Development (IIED) entitled *Fuelling exclusion.* This study recognizes that biofuel investments may bring benefits in income, employment and greater market access. In practice, however, these land deals almost always infringe on traditional community land rights, particularly those relating to what are argued to be “marginal lands”, but which provide key resources for the local community such as pastureland, wood for fuel, foodstuffs and raw materials for artisan production. Food insecurity, therefore, for the local community, is often the principal result of large-scale biofuel land deals.

4.2.4 Best use of available land? Large-scale versus smallholder strategies

The debate on large-scale biofuel investments is part of a broader policy discussion on the strategy of promoting large-scale farming in land-abundant developing countries and regions. This new view on the competitiveness of “mega” farms is rather emphatically presented in an article for *The Economist* “Brazilian agriculture: the miracle of the Cerrado”.[46] A cautious variant of this view is put forward by the World Bank (Deininger and Byerlee, 2011). They argue that the family farm has been historically the norm in agriculture and that large farms were a response to market failure where integration could compensate the lack of basic public goods. Today, however, market failure is a common feature of new “available” lands, which in addition tend to have little access to labour. Further favourable factors include: new information technologies that allow for greater controls over production and labour and the demand for high-cost environmental standards even for basic commodities. On the other hand, investment-receiver countries would need to have growth in non-agricultural employment to absorb labour, difficulties in closing the “yield gap” through lack of public goods and suitable land with low population densities. In the light of this analysis the World Bank and related organizations favour such investment as long as the appropriate institutional reforms are adopted.

The opposing view has been developed in a series of articles by Jayne and colleagues (2010a, 2010b, 2012) as applied to SSA. They note that “a significant and growing share of Africa’s farm households live in densely populated areas” (2012, p. 2) in spite of the un- and underutilized arable land. In five of the ten SSA countries studied, 25 percent of the rural population lived in areas of over 500 people per square kilometre. This is the case because farm sizes are declining, there are great differences in landholding sizes within the small farmer sector, half or more of the smallholders are net buyers of food or go hungry, and most of these control less than one hectare. The central issue in these countries is therefore inadequate access to land and an inability to exploit available unutilized land on the part of the majority of the rural poor in conditions where off-farm employment (a pre-condition emphasized by the World Bank analysis) is scarce and unskilled. The conclusion here is that food security is directly threatened by the priority being given to large-scale investments and policies that only favour more commercial farms. Food insecurity is the result of land constraints for the majority of the rural poor. Policies facilitating their access to land, therefore, should be a priority from the point of view of food security and agricultural modernization. Most States, however, are committed to redefining communal lands for the benefit of large-scale private investments, including biofuels.

Given the importance of biofuel objectives in current land investments in SSA (and developing countries in other continents although to a lesser degree), the biofuel strategies being promoted must take into account the food security implications of the different choices. On the one hand, large-scale investments are welcomed as an appropriate development strategy for the current situation of SSA countries, if community rights are recognized and respected. From this perspective, the provision of a social security net would be the most effective complement for ensuring food security. According to the second perspective, un- or underutilized land should be made available to the majority of the rural poor who have access to less than one hectare of land. Otherwise rural poverty and food insecurity will be aggravated in a context where off-farm employment and urban migration do not present alternatives.

4.2.5 Consensus on need for institutional reforms on governing land investments

Whatever the differences on development strategy and the policies to ensure food security, there is consensus on the need for institutional reforms to regulate land investments and ensure local communities property rights.

On the “land tenure” side, major progress was achieved in 2012 when the CFS adopted the *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests*.

On the “responsible investment” side, much of the work is still currently ongoing to achieve broadly owned international agreement on principles for responsible investments. .

[46] http://www.economist.com/node/16886442, The Economist, 26 August 2010.

At its summit in Seoul in 2010, the G20 “encouraged all countries and companies to uphold the Principles of Responsible Agricultural Investment” and requested “UNCTAD, the World Bank, IFAD, FAO and other appropriate international organizations to develop options for promoting responsible agricultural investment”. The seven “Principles of Responsible Agricultural Investments” (PRAI[47]) as developed by the Secretariat of these four organizations, require that:

1. existing rights to land and associated natural resources are recognized and respected;
2. investments do not jeopardize food security but rather strengthen it;
3. processes for accessing land and other resources and then making associate investments are transparent, monitored and ensure accountability by all stakeholders within a proper business, legal and regulatory environment;
4. all those materially affected are consulted and agreements from consultation are recorded and enforced;
5. investors ensure that projects respect the rule of law, reflect industry best practice, are viable economically and result in durable shared values;
6. investments generate desirable social and distributional impacts and do not increase vulnerability;
7. environmental impacts due to a project are quantified and measures taken to encourage sustainable resource use while minimizing the risk magnitude of negative impacts and mitigating them.

The International Finance Corporation (IFC), the investment branch of the World Bank, has developed Performance Standards, to be adopted by investors when financed by the IFC. Standard 5 is entitled “Land Acquisition and Involuntary Resettlement”, which would seem to contradict the PRAI principles. Involuntary resettlement, here, includes both physical and economic displacement from project-related land acquisitions. What is remarkable about this document is that, although the IFC considers that involuntary resettlement should be avoided, it recognizes that it may be “unavoidable”, in which case the Performance Standards should be followed. What makes resettlement unavoidable in the eyes of the IFC is the conflict between customary rights and the legal system of the country in question. It is understood that the former must cede to the latter, which flies in the face of the principle of “free, prior and informed consent”. This is particularly serious in the light of the conclusion of the ILC’s analysis of transnational land deals: “investors prefer countries with weak land tenure systems” (Anseeuw *et al.,* 2012, p. 37), which, as we have seen, is shared by the World Bank team’s analysis.

Individual governments were initially welcoming the new foreign investments in land but an increasing concern with their scale and the conflicts they were provoking led an increasing number of countries to introduce or reapply legislation calling for a limitation of such purchases by foreigners, among these Brazil, Argentina and Ukraine. International NGOs such as Oxfam have called on the World Bank and other finance institutions to stop large-scale biofuel investments in countries with problems of hunger.

At the 36th Session of the Committee on World Food Security in October 2010, the CFS: “taking note of the ongoing process of developing Principles for Responsible Agricultural Investments that Respect Rights, Livelihoods and Resources (RAI), and, in line with its role, decided to start an inclusive process of consideration of the principles *within the CFS*”.[48] This consultative multistakeholder process was launched by the CFS in 2012 and is currently ongoing,[49] aiming to develop, and ensure broad ownership of such principles for responsible agricultural investment. According to the CFS, these should promote investments in agriculture that contribute to food security and nutrition, and support the progressive realization of the right to adequate food in the context of national food security. The Principles are expected to be finalized and adopted at CFS in October 2014. They aim to provide practical guidance to governments, private and public investors, intergovernmental and regional organizations, CSOs, research organizations and universities, donors and foundations. They will be voluntary and non-binding and should be interpreted and applied consistently with existing obligations under national and international law.

In the light of the analysis presented in this report, the HLPE recommends to governments to ensure that the principles for responsible investment in agriculture, currently being elaborated by the CFS, will be effectively implemented and monitored especially in the case of investments for biofuel production.

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47 http://siteresources.worldbank.org/INTARD/214574-1111138388661/22453321/Principles_Extended.pdf

48 Para. 26 ii of CFS 36 final Report, available at http://www.fao.org/cfs/cfs36/en/

49 http://www.fao.org/cfs/cfs-home/resaginv/en/

The principles of free, prior, and informed consent and full participation of all concerned in land-use investment should be used, as preconditions for any land investments. Measures taken to implement the *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests* should ensure that biofuels investments should not undermine tenure rights, and ensure that women participate fully in land negotiations and that their land tenure rights are recognized.

4.3 Direct, indirect land use change, and competing demands

4.3.1 Direct and indirect land use change

Biofuel production could result in both direct and indirect land-use change. Direct land-use change occurs when feedstocks for biofuel production are new crops directly established on forest or grasslands. Fargione *et al.* (2008) have shown that converting rainforests, peatlands, savannas, or grasslands to produce food crop–based biofuels could create a “biofuel carbon debt” by releasing a soil and biomass stock of CO_2 from 17 to 420 times greater than the annual GHG reductions that these biofuels would provide by displacing of fossil fuels.

Indirect land-use change (ILUC) occurs when the feedstocks for biofuel production are not triggering land-use change on-site, but elsewhere due to the need to compensate foregone production now used for biofuels. This is why biofuel might not induce land-use change locally, but might well lead to “displace” food or pasture lands for livestock production, which then moves to other regions, and is responsible there for deforestation (Gao *et al*., 2011). These indirect impacts may take place even on different continents (Kim and Dale, 2008, 2011).

The ILUC effect has become a controversial issue in international debates but also in some national debates, such as in Brazil. Deforestation rates in the Amazon are still high but have been reported by Brazil as having recently decreased (Tollefson, 2013), and there is currently little or no sugar cane directly planted in the Amazon region. The question is therefore whether on the one hand, the expansion of sugar cane over cattle ranching does indirectly lead to deforestation, as cattle ranching encroached into the Amazon region, or whether, on the other hand the intensification of cattle ranching does relieve the pressure on land use, leaving space for sugar cane without too much effect on forests (Novaes and Almeida, 2007; Lapola *et al.*, 2009; Andrade de Sá *et al.,* 2012), as shown by Nassar *et al*. (2009), using and the Brazilian Land Use Model (BLUM), developed jointly between ICONE[50] (a Brazilian research center on agricultural trade) and researchers at Iowa State University in the USA.

Calculating ILUC effects is complex and requires establishing the link between biofuel production in a certain place and new crop production established on former forest or grassland elsewhere. The measure of ILUC effects can only be left to modelling and assumptions, and cannot be directly assessed. A considerable number of studies have attempted to model and quantify the ILUC effects and related GHG consequences, including the Greenhouse Gases from Agriculture Simulation (GreenAgSiM) model (Dumortier and Hayes, 2009; Searchinger *et al*., 2008), the Food and Agricultural Policy Research Institute (FAPRI) model (Fabiosa *et al*., 2009), and the GLOBIOM model (Havlík *et al.,* 2009; Schneider and McCarl, 2003), among others. The debate is still vivid in the scientific literature and the dominant scientific view - sometime heavily contested by some players in the industry- is that, despite large uncertainties related to quantification and to the underlying modeling approaches, indirect land use change and land use patterns can have a significant impact on the GHG reduction attributed to biofuels (Deluchi, 2003; Hertel, 2011; Searchinger *et al*., 2008; Croezen *et al.,* 2010, Sanchez *et al*. 2012, Gasparatos, Stromberg and Takeuchi, 2013).

Both the EU and US regulators include indirect land-use change considerations in their methodologies to calculate greenhouse gas emissions of biofuels, based on the developing science. The US EPA has acknowledged[51] having used the best available models and quantification of underlying uncertainty for its Renewable Fuel Standard “advanced biofuels” classification, and that its modeling of GHG emissions “provides a reasonable and scientifically robust basis”. Recognizing the evolution of model development, the EPA has announced in 2010 that it would request the National Academy of

[50] http://www.iconebrasil.org.br

[51] See the arguments developed by the US-EPA in the proposed rulemaking for the Renewable Fuel Standard Program (RFS2), available at http://www.epa.gov/otaq/renewablefuels/rfs2_1-5.pdf.

Sciences to undertake an evaluation of the approach taken on GHG life-cycle assessment, and in particular indirect land use change, and make recommendations for subsequent rulemakings.

The direct and indirect land-use change debate is relevant to food security for two main reasons.

- First, policies which tend to favour biofuels grown without inducing *direct* land-use change also favour competition in terms of end-uses (i.e. food or fuel destination of harvests) out of already cultivated lands.
- The second dimension of this debate is that of *indirect* land-use change: even if no direct land-use change is observed (biofuels are produced on existing cropland), such biofuel production could "push" the displaced food/feed or other production towards forests and grasslands, inducing, like in a "domino" movement, indirect land-use change. There is currently much debate regarding "if" and "how" indirect land-use change has to be taken into account in the design of biofuel policies. While the debate is focused on carbon storage considerations, it is also relevant for food security since what is an "indirect" land-use change relative to biofuels, is a "direct" land-use change relative to food (food crops expanding directly on other lands), and vice-versa.

In other words, minimizing "ILUC" effects could come at the expense of food security and create "indirect food insecurity" (IFI). In turn, minimizing IFI could lead to ILUC effects.

As the agricultural area for food production is more likely to expand than contract over the next 40 years, bioenergy is unlikely to be able to expand into existing agricultural areas without either impinging on food production ("IFI") or displacing agriculture into other natural areas ("ILUC").

The dilemma in the case of biofuels and bioenergy based on dedicated land use (as opposed to using waste materials) then becomes: "what lands" would have limited "carbon costs" *and* are available in excess of those needed to meet food needs?

4.3.2 The potential of "marginal" and "abandoned" land

One alternative would be to use presently unused, "potential croplands" or other lands for bioenergy identified in some of the studies above. For bioenergy to avoid competition with food production, it must directly use non-agricultural lands.

Whether this alternative cropland exists largely depends on whether carbon and biodiversity are also considered as criteria. Biofuel policies in Brazil include both these criteria in their Sugarcane Agroecological Zoning, and both the EU and the US include carbon reduction criteria for qualification as biofuel feedstock.

EU also integrates a criterion excluding biofuels, which would be produced in areas of particular importance for biodiversity.

The land identified for bioenergy potential generally falls into two categories. The first consists of woodland and grazing land (sometimes restricted to "extensive grazing land"). The new GAEZ analysis has now separated out denser forest, and made clear that the roughly 1 billion ha it estimates of potential cropland that is very suitable or suitable for cropping consists of grassland and woodland (Prieler, Fischer and van Velthuisen, 2013). Estimates of bioenergy potential from land also focus overwhelmingly on these lands (Hoodwijk *et al*., 2005; Van Vuuren, Vliet and Stehfest, 2009; Cai, Zhang and Wang, 2011), and these are the underlying studies cited in broader, official reviews (Chum *et al*., 2011; Bauen *et al*., 2009).

This presents two issues. First, this category includes lands already used for grazing, and by definition, those grazing lands with the greatest productive capacity. Grazing land provides the bulk of all animal feed (Wirsenius, Azar and Berndes, 2010); and the FAO estimate assumes an increase in the output of milk and meat from grazing land. Diverting these potentially productive grasslands does compete with food production and, if they are diverted, pasture productivity would have to increase by even more on the remaining grazing lands to avoid land expansion.

Second, these lands often have high carbon content and make large contributions to biodiversity. Studies have estimated high carbon costs of ploughing up temperate grazing land (Searchinger *et al.,* 2008; Fargione *et al.,* 2008). Others, however, are more optimistic given the adoption of good management practices (Conant, Paustian and Elliot, 2001; Smith and Conen, 2004). In the tropics, these analyses target those wetter savannahs capable of producing crops, which are combinations of grasses, shrubs and trees and often have high levels of carbon (Gibbs *et al.,* 2008; Fargione *et al*., 2008). Whether these lands produce GHG savings over time frames deemed appropriate by governments depends on the carbon losses associated with their conversion relative to the savings in fossil fuels from their biomass production. None of the estimates of bioenergy potential cited above analyse the carbon losses of converting these lands to biofuel production, but instead they often assume that lands not deemed to be forests do not have carbon releases.

By contrast, extremely few savannah areas would qualify as low "carbon debt" lands following clearing for biofuels[52] (Beringer, Lucht and Schaphlff, 2011). Savannahs are also centres of biodiversity in general, as can be seen by an examination of various maps of vertebrate biodiversity presented in Grenyer *et al*. (2006).

The other principal category of lands often considered appropriate for bioenergy are "abandoned" agricultural lands. The world's agricultural area is constantly experiencing some shift, and as cropland or grazing area expands in some areas, it is abandoned elsewhere.

Substantial attention has focused in particular on a study estimating bioenergy potential from all abandoned agricultural land that has not yet been reforested, which is presented in two papers (Campbell *et al*., 2008; Field, Campbell and Lobell, 2008). Abandoned agricultural lands (i.e. lands which were once in production but are no more in 2000) were estimated between 386 and 475 million ha, an amount which might produce 8 percent of world primary energy.

Other bioenergy potential studies have also relied on abandoned land (Haberl *et al.,* 2012). This includes the projected abandonment of agricultural land in particular regions that can be used for bioenergy despite net expansion of agricultural land overall (Haberl *et al.,* 2012; Fischer *et al.,* 2010). In some cases, projections also include "potentially abandoned land", which will be created if agriculture intensifies sufficiently to free up land on a net basis (see papers discussed in Haberl *et al*. (2012)).

One has to mention however that using abandoned lands for bioenergy would avoid food impacts, but not necessarily avoid carbon impacts, as we have seen in the previous section.

4.3.3 Taking into account multiple functions of land use

One of the limitations of the early biofuel policies, for example in the US, Europe and Brazil, is that they were originally formulated without much concern to avoid competition in terms of land use or in terms of food use. Therefore, those policies encouraged bioenergy producers to obtain their feedstocks from common stores. As a result, crops that would otherwise have gone to food production, which were also the more agronomically and economically efficient to grow, were favoured as biofuel feedstocks.

Biofuel development reveals the need for more integrated land-use policies, taking into account the various functions of land – economic, social and environmental – and their contributions to food security.

It also shows that national policies can have important consequences even outside national borders and, most importantly, that these consequences can be very different according to local circumstances.

This is why national policies increasingly require the fulfilment of criteria on land use for biofuel production or integration into targets (see Chapter 1).

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52 Beringer, Lucht and Schaphlff (2011) excluded areas that did not payback their carbon debts within 10 years, which is equivalent to a 50 percent GHG reduction over 20 years, the period used by Europe to evaluate the GHG balance of biofuels.

India, China and South Africa explicitly aim to avoid competition for land with food production into their national borders. Brazil excludes sugar-cane production from certain areas (essentially the Amazon and Pantanal) to protect biodiversity. EU also includes in its sustainability criteria (eligibility criteria for biofuels to count against targets), that feedstocks must have been produced on land that is neither of particular importance for biodiversity, nor carbon-rich ecosystems. This is part of a certification process described in Section 5.

These examples show the growing concern to integrate and address the potential consequences of increased competition for land. They would gain by being completed by an explicit assessment of the impacts on water resources.

Moreover, potential social consequences should be better addressed by ensuring the implementation of the *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests*.

5 BIOFUELS AND BIOENERGY: SOCIO-ECONOMIC IMPACTS AND DEVELOPMENT PERSPECTIVES

In this chapter we are primarily concerned with income, employment and development effects of biofuel policies – key conditions of access to food security.

The world´s poor and food insecure are heavily concentrated in Southeast and South Asia and sub-Saharan Africa (SSA). Half of the world´s poor (below US$2 a day) live in India and China, a quarter live in populous lower-middle-income countries such as Pakistan, Indonesia and Nigeria, and a further quarter live in low-income countries, primarily those with fragile States (Sumner, 2012).

For many of these countries, the issue of threats versus opportunities of land investments for biofuel and feedstocks (very often for export) has become over-riding. The EU, a major player, concerned with policy coherence for development, is launching studies on the impacts on developing countries of the EU biofuel policies and of increased biofuel demand in developing countries (Diop *et al.,* 2013).

Bioenergy for rural development and energy security, however, is equally central, together with the issue of transport fuels in domestic markets of the leading countries in these regions. Indeed, as from 2012, non-OECD countries are now consuming more transport fuels than the OECD countries (Nelder, 2012). Joint consideration of socio-economic impacts and development perspectives of food and fuel policies is now, therefore, also a domestic imperative in many developing countries.

For some like Msangi and Evans (2013), solving some of the underlying problems of food security in the same countries that aspire to develop their own biofuel sector, could address many of the issues holding back the development of thriving agribusiness enterprises and of a wellfunctioning and highly productive food sector in these countries.

As we have seen throughout this report, by and large, developing countries are still in the process of putting policies together on biofuels, with many investments and initiatives still in various stages of implementation. An appreciation of impacts of national policies over time and on a macro or regional scale is, therefore, still largely speculative.

An exception here is the Brazilian case, which in terms of sugar-cane ethanol has now a 40-year history, and a decade if we consider its ambitious biodiesel programme. We look at the literature that discusses these two experiences from a food security and rural development perspective, while recognizing the huge differences that separate Brazil from most developing countries when we consider food and energy security and rural development. We start this chapter by reviewing the Brazilian case (Sections 5.1 and 5.2).

Some pioneering studies are available in other contexts, where computable general equilibrium (CGE) analyses have been developed, such as the ones by Arndt and colleagues (2008, 2010a, 2010b) to analyse the implications of biofuel adoption in food- and energy-insecure developing countries (Section 5.3). These include two studies of Mozambique and the United Republic of Tanzania. In most cases, however, we have to resort primarily to local case studies. Many of these have focused on land conflict and displacement effects, dealt with in the previous chapter. Other projects provide important contributions, which we review, such as the FAO BEFS studies on Peru, Thailand and the United Republic of Tanzania, (FAO, 2010a), The Biofuels and the Poor Project,[53] supported by the Gates Foundation, or the Global-Bio-Pact initiative.[54]

A growing number of studies have tried to bring to the attention of policy-makers the importance of taking gender into account in biofuels development. Labour productivity and gender consideration are intimately interlinked, as Kes and Swaminathan (2006) have demonstrated in placing "time consumption" (and especially women) as a component of food and energy insecurity. We consider in more detail the gender impacts of biofuels/bioenergy in Section 5.4.

Because of the importance of traditional bioenergy in the energy matrix of many developing countries, appraising socio-economic impacts and development perspectives of biofuel policies has to relate to the evolution of the whole bioenergy sector. In many developing countries, biofuels for transport are

[53] www.biofuelsandthepoor.com

[54] http://www.globalbiopact.eu

only a subcategory of the wider question of bioenergy. In SSA, from 50 to 90 percent of energy comes from the primary combustion of biomass and its transformation into charcoal and char, and food insecurity and energy dependence on primary biomass are tightly correlated (Ewing and Msangi, 2009). Hundreds of initiatives are currently exploring the opportunities for developing modern bioenergy for cooking, electricity and small-scale power generation for other local economic activities. A new index, the Multidimensional Energy Poverty Index (MEPI) developed by Nussbaumer and colleagues (2011), which focuses on the different elements of energy deprivation and is able to capture both its incidence and intensity, may provide an important aid to the formulation of these bioenergy policies.

A number of scholars have produced typologies to identify both the conditions under which biofuel/bioenergy policies should be adopted in developing countries and the specific focus that these policies should have in each country, given an appreciation of key variables (Pingali, Raney and Wiebe, 2008; German *et al.,* 2010; Maltitz and Stafford, 2011; BEFSCI, 2010; Ewing and Msangi, 2008). These different approaches to evaluate potential impacts of biofuel production at national or local level provide useful tools to facilitate and orient decision-making from policy design to implementation and investment choices. They also form the basis for various certification mechanisms designed to appraise biofuels respecting certain sustainability criteria.

5.1 The Brazilian ethanol experience from the perspective of local and rural development

While other concerns have often been the major focus of analysis, a number of important pieces of research have been produced in recent years on the impact of the Brazilian sugar cane/ethanol complex for local and regional development. The results of these studies, such as the one developed at Stanford University and led by the Brazilian researcher Martinelli *et al*. (2011) (Box 12), are potentially important for other developing countries given the number of such countries currently experimenting with sugar-cane ethanol.

While there is concern about the negative health and environmental consequences of large-scale sugar-cane production, many authors such as Martinelli *et al*. (2011) leave open the question whether the wealth creation and local economic development benefits positively offset the social costs that these imply. Other authors have strongly insisted on the need to include the positive health results of the adoption of ethanol as transport fuel in the major cities (Goldemberg, 2008).

Obviously, many precautions have to be taken if one is to translate results from Brazilian studies to other contexts, particularly in relation to African and Asian countries, if only because urban and rural population densities might be very different, and Brazil represents a very specific context of a vast country but with a vast majority of the population living in cities. For example, São Paulo State is 95 percent urban, and formal employment is also 95 percent urban. The displacement effects of sugar-cane expansion are, therefore, likely to be very different in Brazil than in other contexts with dense rural populations.

The Brazilian sugar-cane context is also very specific in terms of mechanization and changing labour composition: it involved a sharp decline in employment, an increase in minimum qualifications, and an increase in average wages for sugar-cane workers, reflecting increased productivity, which had advanced from 5 to 10 tonnes of cane cut per day over the past two decades. The question if the expansion of sugar cane has led to an overall increase in employment is still debatable. For example, in the State of Sao Paulo, the labour intensity of sugar cane (8 workers per 100 ha) is lower than the average for all agricultural activities (10 per 100 ha). On the other hand, sugar cane remains four times more labour-intensive than extensive cattle-raising. Nevertheless sugar cane substitution for other crops may not necessarily lead to an increase in relative employment.

Most of the research in the Brazilian context is still based on datasets that pre-date the full impact of the adaptations of the Brazilian sugar-cane ethanol sector to the demands of international criteria governing biofuel markets. These include the ending of harvest burning and an acceleration of mechanization, a commitment to formally contracted labour, and the acceptance of agro-ecological zoning, which prohibits sugar-cane production in the Amazon, in the wetlands of the Pantanal and in areas of rich original biodiversity. Access to credit depends on respecting proper labour conditions for employment (although denunciations of degrading work conditions persist) and access to exports is leading firms to adopt sustainable certification schemes.

Box 12 Sugar and ethanol production as a rural development strategy in Brazil: evidence from the State of São Paulo

Martinelli and colleagues (2011) have compared development indicators in the municipalities of the State of São Paulo, where over 50 percent of Brazil´s sugar cane is located, distinguishing them according to whether the municipalities were predominantly based on cattle, mixed cattle and sugar cane, sugar cane, sugar cane with processing mills, or non-rural activities. A series of controls were put in place to minimize the impacts of other variables – access and proximity to the State´s capital, previous levels of development, and unrelated economic activities. A series of indices was used: the Human Development Index (HDI) of the UN, an HDI index developed on the basis of São Paulo´s Social Responsibility Index (SRI) and the Rio de Janeiro Municipal Development Index (MDI).

The results showed that the HDI, the SRI and the MDI for cattle municipalities were significantly lower than all the other categories, and that this index was highest in the municipalities with both sugar cane and processing mills, higher than non-rural municipalities. Levels of wealth distribution, however, were not significantly different in these municipalities. The non-rural category had a lower level of land concentration but was also the lowest in terms of education. These findings suggest that it is not the sugar-cane production that is key, but its integration with processing activities that has a more important multiplying effect. Nevertheless, sugar-cane municipalities scored higher than cattle and the study concludes that municipalities without an agricultural base have not been able to generate viable alternatives.

Individual studies of the impacts of sugar-mill investments on employment and wealth creation in municipalities in the States of São Paulo (Montangnhami, Fagundes and Fonseca da Silva, 2009) and Paraná (Shikida, 2008) respectively, both relating to the advance of sugar cane into cattle-ranching regions, give support to the positive conclusions of the Martinelli *et al*. (2009) study. Data that take into account the relative importance of the sugar mill in the local economy both with regard to employment and multiplier effects lead the respective authors to conclude that the arrival of the sugar mill was the principal factor that reverted outward migration, and was able to absorb within the municipality the displacement of rural labour resulting from mechanization.

A study by Balsadi and Borin (2006) applied a Quality Index, based on earnings, level of formality, education and other forms of support, to analyse the degree of improvement of employment (both in quantity and quality) in the sugar-cane sector, and concluded that each of these indicators had shown significant improvement over the period studied – 1990–2002. Petti and Fredo (2009) updated these data for 2005 and reviewed Balsadi and Borin’s findings. The authors confirmed the increase in formal employment and the results on education and earnings.

Brazil is actively promoting the adoption of its model of sugar-cane ethanol in many countries of Latin America and Africa, and, therefore, an appraisal of its implications for rural development and food security is crucial. At the same time, given the uniqueness of Brazil in terms of land abundance and the level of development of its agribusiness sector, a favourable conclusion with regard to Brazil does not necessarily imply that this model can be successfully reproduced in other countries, especially those with large and even predominantly rural populations (see our discussions of the respective positions of Deininger and Byerlee (2010) and Jayne, Chamberlin and Muyanga (2012) in the previous chapter).

5.2 The Brazilian biodiesel programme: an alternative development strategy?

Brazil is also heavily involved in biodiesel production, which was projected, in contrast to sugar-cane ethanol, as an innovative biofuels programme (National Program of Biodiesel Production and Use, PNPB) explicitly oriented to social inclusion and regional development, particularly for Brazil’s most impoverished Northeastern region. The choice of oilcrops was to be guided by their regional suitability (palm oil in the North, castor oil in the Northeast, soybean in the South and Centre-West) and in each region a percentage of family farmers, especially those organized in associations or cooperatives, would have to participate in the provision of feedstock, a pre-condition for the biodiesel firm to obtain access to the market. The market itself is organized by auction controlled by the National Petroleum Agency (ANP) and distribution organized by Petrobras. Only firms with the Social Certification of family-farm participation, provided by the Ministry of Agrarian Development (MDA) have access to 80 percent of the volume auctioned at any given time. The obligatory blending, initially fixed at 2 percent (B2), quickly evolved to B5 on the basis of a rush of investments, with the market increasingly

attracting the leading players of the soybean agro-industrial complex (Flexor, Kato and Recalda, 2012).

Great efforts were undertaken to involve the small farmers of Brazil's semi-arid Northeastern region through the promotion of castor oil, a traditional crop in the region, as a feedstock for biodiesel. Rural unions, social movements, NGOs, State governments and public research and extension services formed a unique network for the promotion of development poles, which in their most ambitious formulation would include primary processing (extracting the oil) by the small farmers' organizations. At the same time, it was recognized that soybean, as the best organized crop and with large-scale production readily available, would, at least initially, have to play a leading role if the targets were to be achieved. The Government not only defined obligatory targets, but ingeniously designed the institutions of the market and called on public agencies and firms to ensure their implementation (Abramovay and Magalhaes, 2007).

After some eight years, in spite of the extraordinary effort to promote biodiesel as a development option for family farming based on its different regional production systems and in spite of major investments in production undertaken by Petrobras (now with three plants in the Northeast), the soybean-based, large-scale model entirely dominates the feedstock of the biodiesel programme with some help from cattle fat (the fuel output now representing more than 80 percent of the cattle fat market). The soybean agro-industrial complex had lobbied for a biodiesel programme prior to the launching of the National Program by the Lula Government in 2003–04, in the search for alternative outlets for vegetable oils, whose markets have been increasingly challenged by palm oil. Even if soybean oil is less efficient in energy content when compared with most other feedstocks for biodiesel (Chapter 2), it has, however, animal feed as a key co-product and all the logistical, financial and management advantages of a globally competitive food/feed crop chain.

Today, in Brazil, only 20 percent of biodiesel feedstock is estimated to come from the family-farm sector and 90 percent of this is soybean from the best-organized components of the family-farm sector in the South.[55] Soybean, in this context, employs 10 workers per 100 ha, and advocates of a B20 scenario in 2020 have projected a significant creation of jobs – up to half a million employment opportunities (FGV/UBRABIO, 2010). In the Northeast of Brazil, castor oil is a traditional crop and, as a high-quality oil crop, has access to more highly priced markets. In general, biodiesel producers buy the castor oil produced by family farmers and sell the product in alternative non-biofuel markets, using soybeans brought from other regions as the biodiesel feedstock. Increasingly, the State firm Petrobras is assuming this role, while the biodiesel private sector lobbies for a change in the rules that would free it from dependence on the "fiction" of the social certification (Reporter Brasil, 2010).

It may well be that a considerable number of small farmers are now "benefitting" from the biodiesel programme, but this is rather the expression of a "social" expenditure borne by the programme rather than the result of an economically successful biofuels programme based on family farming. It would be precipitate, therefore, to take the Brazilian biodiesel programme as a successful example of family-farm integration, ready to be transposed into other contexts. What it shows, rather, is that without stable and sufficient access to land and accompanying assets and services, it is very unlikely that public support or preferential market access can transform vulnerable family farming into a viable proposition (de Carvalho, Potengy and Kato, 2007).

In the Northern region of Brazil, large investments are now being made in palm-oil plantations led by major enterprises such as Petrobras and Vale, a Brazilian mining company. Petrobras, for example, on one hand, has a project to produce biodiesel from palm oil using family-farmer participation (Pará Project) but, on the other, maintains large monoculture plantations to export palm to Portugal in a joint venture with Galp (Belém Project). These experiences of incorporating family farmers on a contract basis have given mixed results and it is not clear that this will be the prevailing model (HLPE, in press). Additionally, there remain doubts about the benefits of this kind of large-scale initiative, with many studies denouncing negative impacts such as deforestation (in a sensitive ecosystem, the Amazon), depopulation of rural areas, competition for water, or contamination from the use of pesticides and herbicides.

[55] www.biodieselbr.com

5.3 Attempts to evaluate socio-economic implications of biofuels/energy developments in the developing country context

Some pioneer studies aim to evaluate socio economic consequences of biofuel/energy development in developing countries. Most of them rely on models and projections to estimate potential impacts at national or local levels. Some studies evaluate ex post impacts at project levels.

5.3.1 CGE analyses

Some pioneering studies are available in other contexts than Brazil, where CGE analyses have been developed, such as the ones by Arndt and colleagues (2008, 2010a, 2010b) to analyse the implications of biofuel adoption in food- and energy-insecure developing countries.

Arndt and colleagues (Arndt *et al*., 2008, 2010a, 2010b; Thurlow, 2008) have carried out a series of analyses of the impact of fuel and food price hikes and large-scale biofuel export production on GDP and on rural and urban poverty/food insecurity in Mozambique and the United Republic of Tanzania, using a CGE analysis. In Mozambique, they identify a clear transmission of international fuel and food prices, with the former having double the impact. Mozambique is completely dependent on imports for modern fuels and heavily dependent on food imports of wheat, rice and maize, but has an open trading policy.

On the basis of assumptions that are clearly specified in the articles, the model is able to analyse impacts on trade, investment and wages, and discriminates between urban and rural populations and within the latter between net buyers and net sellers, cash-crop producers for export and subsistence farmers. Its principal findings are that Mozambique in the short term suffers a sharp reduction in imports, a decline in the welfare index of 5 percent, a decline of 7 percent in household consumption, with an overall decline of over 1 percent in GDP. The urban poor are the hardest hit, together with the subsistence rural sector. Overall there is a 4 percent increase in the national poverty headcount, amounting to around one million people.

Over the longer term, pressure for exports to improve the balance of payments favours the cash-crop export sector (tobacco and cotton), rural wages increase, together with the rural incomes of the subsistence sector through the increase in maize prices. The urban poor and the food importing regions of the South suffer most.

Arndt *et al.* (2008) also analyse large-scale biofuel investments for export within the same framework. The assumptions are that all biofuel production is for export, all investment is foreign and additional to existing investments, and all profits are repatriated. There are two production models, plantation sugar cane for ethanol, and jatropha outgrower schemes for biodiesel. A total of 50 percent of production is on previously unused land and 50 percent on already cultivated land, taking the place of food and cash crops for export, which leads to rising food prices and increased imports. The market is fundamentally guaranteed by the bioenergy mandates in the EU, and sugar-cane ethanol is modelled to be competitive in that context as far as the price of oil exceeds USD70/barrel. Overall, the model points to an annual additional increase of GDP of some 0.65 percent, rising to 2.4 percent for agriculture and 1.5 percent for industry. The national poverty headcount declines by 5.9 percent, taking 1.4 million over the poverty line.

Much of this positive response, however, depends on the ability of agriculture to respond with increased productivity. It is argued that, while sugar/ethanol has a major impact on rural employment, especially on the poorest (labour intensity is 34 workers per 100 ha – more than four times the levels of São Paulo, Brazil), the outgrower model for jatropha (that has a labour intensity of 50 workers per 100 ha) has important spillover effects for food production (techniques and inputs).

The assumption of increased productivity, however, does not take into account the deepening poverty of the subsistence sector, analysed by Jayne, Chamberlin and Muyanga (2012), and which was considered in the previous chapter, as farms are repeatedly fragmented. In this view, most farmers no longer respond to traditional productivity stimuli and in practice benefits accrue to new middle-sized farms. Along similar lines, Thurlow (2008) argues that biofuel promotion is, proportionally,[56]

[56] Percentage change in poverty rate induced by one percent growth in agricultural GDP led by the specific crops.

significantly less pro-poor than the promotion of food crops such as horticulture (10 percent more pro-poor) millet (35 percent more pro-poor) and maize (70 percent more pro-poor). On the other hand, the size of the biofuel market means that it could well be responsible for a larger absolute poverty reduction.

And finally, the analysis does not take into account GHG emissions, although it presupposes that 50 percent of biofuel expansion will come from previously uncultivated lands. Fargione *et al*. (2008), as the authors recognize, calculate that opening up the Brazilian savannah land to sugar cane, lands similar to those in Mozambique, leads to the equivalent of a 17-year carbon debt. The authors conclude that there are many imponderables, and caution that Oxfam's concerns – that biofuels bring high food prices, an aggravation of poverty (especially urban), a reduction in smallholder lands, the use of capital intensive technology and substandard wages – "are not idle worries" (op. cit. p.15).

Arndt *et al.'*s second study (Arndt, Pauw and Thurlow, 2010a) on the United Republic of Tanzania, using the same CGE model, is a contribution to the FAO BEFS project. The United Republic of Tanzania is an SSA country highly committed to biofuel/bioenergy development and one that has been a privileged object of biofuel investments and projects. Its population is expected to rise from 48 millions in 2012 to 138 million in 2050. As in Mozambique, the country is overwhelmingly rural, with 80 percent of its workforce employed in rural activities, and agriculture representing 33 percent of GNP. Differently from its southern neighbour, however, it is largely self-sufficient in food production, importing some 15 percent of primary foodstuffs and 20 percent of processed food. It also has an important agricultural export sector. It is calculated that ethanol can be produced at USD0.37/litre from a mixed cassava system and USD0.43/litre from a large-scale sugar-plantation system, both of which are competitive with Brazilian and US ethanol. Ethanol from smallholder outgrowing systems, however, would not appear to be internationally competitive.

Since there was no biofuels programme in place at the time, the study established six scenarios based on two feedstocks (cassava and sugar cane), two basic scales of production – plantation and smallholder outgrower, with a mixed variant for cassava – and two ways by which feedstock are expanded, either at the expense of existing crops or on new land.

Food prices are seen to rise, but the expansion of ethanol is primarily at the expense of traditional cash-crop exports, negatively affected through the appreciation of exchange rates and to a lesser extent from land and labour competition. National GDP rises and new employment opportunities are created by biofuels. All the models show positive household welfare effects, but the outgrower cassava was most effective at raising the incomes of poorer households. The study concludes by favouring a mixed cassava model with large commercial farms guaranteeing minimum supplies, although its analysis suggests that these commercial farms will be created at the expense of the smallholding sector.

Here again, as in the Mozambique study, the results very much depend on yield improvements in the smallholder sector. Otherwise new lands will have to be incorporated, and once again the GHG implications are not considered. The implications of biofuels for water use are similarly not taken into account in either study. The model sets the ambitious target of one billion litres over the 12-year period. We have seen in the Brazilian case how the adoption of ambitious blending mandates stimulates scale and makes the progressive inclusion of smallholders more difficult. In a similar way, an ambitious programme based on large-scale foreign investments, which is presupposed in this model, brings pressure for rapid return on investment (ROI) results, which in their turn favour the adoption of scale in production and logistics.

5.3.2 The BEFS methodological toolkit

The BEFS project "analyses the extent to which bioenergy can be an instrument to enhance agricultural productivity for the benefit of the poorest groups, which include smallholders. It is not an *ex ante* endorsement of bioenergy but rather an exploration into whether a bioenergy sector can be economically viable and if so can the sector be structured in a way that delivers on socio-economic fronts" (FAO, 2010b, p. 42).

The BEFS starting point is that biofuels are neither good nor bad in themselves and that the evaluation of their positive or negative impacts for food security depends on a holistic analysis of the country/region in question and the dynamic of its integration into global markets (FAO, 2010b). The analytical framework comprises four major components: an analysis of the country's agriculture within an international context; a detailed assessment of its natural resources; biofuels feasibility studies;

and a socio-economic analysis. This framework has currently been applied to the analysis of three countries, covering the three developing continents (Peru, the United Republic of Tanzania and Thailand) and has been developed with a view to it becoming a key instrument in the elaboration of biofuel policies.

The analysis of agriculture adopts a 10-year time frame to allow for an appreciation of the way global trends are likely to impact this sector, which concentrates the greater part of the poor and food-insecure. Natural resources are examined from the perspectives of land suitability, water resources, using the Water Evaluation and Planning (WEAP) methodology, and bioenergy potential, using the WISDOM program. This is followed by a comparative analysis of liquid biofuel production costs in the light of different production arrangements with a view to assessing the viability of options that include smallholder participation. The socio-economic analysis includes the CGE program, discussed above, to evaluate countrywide impacts of different assumptions, together with an analytical tool for the analysis of impacts at household level. The BEFS project therefore incorporates a CGE analysis, but within a more holistic analysis.

5.3.3 The "Biofuels and the poor" project[57]

A research project, "Biofuels and food security in the developing world: pathways of impacts and assessment of investments", supported by the Gates Foundation, proposes an international collaborative effort to systematically address the effects of biofuels expansion on the global poor and address the "lack of understanding of the distributional consequences across sectors and regions from the expansion of biofuels" (Huang *et al*., 2012). The project aims to:

> *"build a global analytical platform that will link national and international energy and commodity markets to quantify the direct and indirect effects of biofuels expansion from the global down to the household level. Our approach will build on a number of existing global and country models, linked in new ways and expanded to capture novel connections between energy and food markets. As such, it will represent the first systematic, detailed effort to address the effects of biofuels expansion on welfare in poor countries, and the first available analytic tool for assessing possible biofuels investments in individual developing countries, (...) shedding light on when and where such investments might help or hinder efforts at poverty alleviation."* (Project Overview and Executive Summary).

The project includes case studies on China, Senegal, Mozambique, India, Brazil and the US and the lead team is made up of researchers from IFPRI, the Freeman-Spogli Institute for International Studies (Stanford University), the University of Nebraska, and the Center for Chinese Agricultural Policy, with accompanying teams in each of the case-study countries.

The two central questions the project poses are: (i) How will the rise in demand for biofuels affect food prices, products and trade at a global level? and (ii) How will the development of global biofuels affect prices, production, trade and the unskilled wage in developing countries? The project proposes a systematic effort to track the patterns of biofuel production through the development of more appropriate modelling instruments. However, the same analytical framework, based on the GTAP general equilibrium model modified, still predominates, and the methodological caveats highlighted in Chapter 3 apply. Preliminary results show that in a context of growth in biofuels, "agricultural production and trade will change remarkably" (Huang *et al*., 2012, p. 446).

It is further argued that, in general, in a context of increased biofuel production, net producers will benefit and net consumers will suffer, and that an "increase in biofuel production globally will likely reduce per capita consumption for the poor who are net food purchasers" (op. cit. p. 448). Here, however, the model is unable to provide quantitative results because it does not differentiate consumers by their income, pointing to the need to develop detailed household studies in complement, such as – Agoramoorthy *et al.* (2009), Arndt *et al*. (2010b) and Schut, Slingerland and Locke (2010).

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[57] http://biofuelsandthepoor.com/

5.3.4 Microlevel analysis

The above methods and project (CGE, FAO BEFS, Biofuels and the Poor) rely on general equilibrium modelling as the core method to assess socio-economic impacts. We have seen in Chapter 3 that such approaches are not perfectly suited to address microlevel issues or short-term, transition effects.

Some studies analyse ex post impacts of projects at local level. Negash and Swinnen (2012), for example, have carried out a very thorough quantitative empirical survey analysis of the impact of a biofuel feedstock programme on smallholders in Ethiopia.

They argue that Ethiopia is an important country to study because it combines extreme energy dependence (which would tend to call for the development of biofuels) with high levels of food insecurity (which suggest that such biofuels would compete with food). At the same time, Ethiopia has a longstanding ethanol programme and has public and private investments in biofuels both within outgrower and plantation models. They focus attention on the organization of the biofuel value chain and the different ways in which smallholders may be integrated: as workers on plantations, through leasing land for biofuel production, as outgrowers and as producers in small-scale oil initiatives. They also provide a brief overview of the ongoing debate over the relative merits of outgrower and plantation models for smallholders.

The authors have studied a private contract-farming programme for the production of castor bean by smallholders in a heavily food-insecure region in the South of the country. Under this contract farming programme, which involves 3000 smallholders, the "*farmers receive all the necessary inputs such as fertilizer, herbicide, technical assistance. In return they allocate part of their land for castor production (a minimum of one hectare but no more than 25 percent of the land – observed average was 15 percent), and pay in seeds during harvest. The price of castor seeds is set in advance. The firm's extension workers at village level are responsible for training farmers, facilitating group formation, input distribution and the follow up of cultivation and output collection*" (Negash and Swinnen, 2012).

Negash and Swinnen used a detailed questionnaire (476 households from 24 villages, a third of whom were participants in the programme), and showed that:

- households headed by women were less likely to participate;
- adoption was not influenced by distance from towns or by education;
- participants were more likely to rely on formal sources of information with regard to prices, markets and agricultural practices;
- participants used on average double the amount of fertilizer, with positive spillover effects for food production, pointing to complementarity rather than competition between food and fuel production.

To capture food security impacts the research compared the "food gap months" (months when households run out of stocks and have no money to buy food), between participants and non-participants to the programme, and the per capita food consumption in energy kilocalorie (kcal) equivalents. Both of these indicators were significantly better for participants. Gap months declined to 1.02 months as against 1.58 months for non-participants. For participants as compared to non-participants, food insecurity was down from 63 to 51 percent and chronic food insecurity from 42 to 36 percent. While a long way from guaranteeing food security, this field study points to the possibility of complementarities between food and fuel production.

5.4 A gender perspective on the impact of biofuels

A growing number of studies have tried to bring to the attention of policy-makers the importance of taking gender into account in biofuels development (Arndt *et al.,* 2010ab; Cotula, Dyer and Vermeulen, 2008; Karlsson, 2008; Nelson and Lambrou, 2011a, 2011b; Rossi and Lamrou, 2008). An understanding of the gender dimension is important since "to achieve equitable and socially sustainable development requires an understanding of how women, men, and social groups may be affected differently by biofuel innovations" (Nelson and Lambrou, 2011b).

These studies highlight the issue of the security of access to and ownership of land as one of the key factors determining whether the expansion of biofuel feedstocks could potentially benefit the rural poor, women in particular. To the extent that biofuel expansion often involves the establishment of large-scale plantations, it can accelerate the takeover of land by large investors on the basis of

plantation permits provided by the State. In these cases, women and those from the poorest groups in the rural society are often the most severely affected. Women traditionally have less secure access rights to their customary land. Even when women own land through inheritance or purchase, the patriarchy system often excludes them from the village decision-making process. In addition, government programmes generally place men as the decisions-makers on behalf of the household.

When biofuel expansion increases the price of feedstock crops, it promotes land-use change from previously forest lands or food crop agriculture to cash crops. The effect of such land-use change on women can be observed in the case of oil palm expansion in West Kalimantan, Indonesia (White and White, 2012). According to White and White (2012), as the result of the development of oil-palm plantations on customary lands, women's land rights have been seriously eroded. Although traditionally women in this village in West Kalimantan had rights to land, it was the men who negotiated with the oil-palm company concerning the decision to surrender the customary lands to the oil-palm company. Women's exclusion from the political process can have devastating impacts. In the West Kalimantan case, according to White and White, women's land rights were eroded even further when government programmes designated only the husband (or another male family member) as "the head of the family." When the palm-oil plantation company distributed two hectares plots to each household as a compensation for the villagers having surrendered their customary lands, this land was mostly registered under the husband's name on behalf the family rather than as a joint ownership between husband and wife.

The disappearance of forested areas or fertile land previously used for food crops or agroforestry and its transformation into palm-oil monoculture has also had a great impact on women. The women lost a portion of their income derived from collecting forest products, and also lost the raw materials from which they made handicrafts for sale. According to White and White (2012), this also led to an increase in the feminization of smallholder agriculture since women now work both on the palm-oil plantation and on the subsistence plot. The gender balance of labour that was traditionally more equal has been upset and women now work more in agriculture than men. In addition, in some palm-oil areas, clean water sources are also harder to find as water is often contaminated and small creeks become dried up.

In many societies collecting water for drinking and cooking is considered a job for women and children, and so the changes brought by biofuels have increased the burden on women (See section 5.5). Nutritious and cheap protein sources, such as fish, have also disappeared with forest clearance and the shift from diversified crop farming to monoculture plantation. Women and children tend to be the worst affected from the ensuing malnutrition and hunger when compared with men, since, according to widespread cultural practices, the best food often tends to be served first to the husband and adult son before the women and children.

In addition to large-scale plantations, a wide range of other biofuels schemes have also been identified, including contract farming and varied village-based schemes (Nelson and Lambrou, 2011a). Further study is required to explore the differential impact of these schemes on gender relations. Nelson and Lambrou (2011a, 2011b) have proposed a first map of these gendered impacts, and possible policy implications (see Appendix 3).

5.5 What are the benefits of modern bioenergy for cooking, heating and local power generation?

Access to energy is often key to improving food security. Energy is often a crucial factor to improve agricultural productivity, for instance providing power for irrigation. It is also essential for rural development and income generation in general. Finally, and especially where it is scarce, it is essential for food conservation and preparation.

Over one-third of the world's population (2.4 billion people) relies on fuelwood, agricultural residues, and animal wastes for their primary energy needs (Tilman *et al*., 2009). For many communities "off the grid", with no easy access to energy, a majority in Africa, parts of Asia, but also in some areas of Latin America, biomass is the first or only source of energy, as the BEFS study on Peru mentioned above shows. In these areas the development of more efficient and cleaner uses of biomass for energy purposes can have a huge impact, to reduce the drudgery of agricultural work (see HLPE, 2013), offer income-generating opportunities and especially ease the workload of women. Many women spend up to 3 to 4 hours a day collecting fuel for household use, sometimes travelling 5 to 10 km a day. In many African, Asian and Latin American countries, rural women carry approximately 20 kg of

fuelwood every day. This work burden limits time available for food production and preparation, household-related duties, and women's participation in income-generating activities and educational opportunities (Tilman *et al*., 2009).

NGOs, private foundations, international organizations and cooperation programmes have been promoting a wider approach to biomass use within the framework of sustainable development – local, rural and urban. Initiatives such as COMPETE,[58] Probec,[59] Re-impact,[60] have focused on the multiple uses of biomass for electricity and power generation, for alternative sources of heating and cooking and also for local transport (German *et al*., 2010; UNDESA, 2007; Maltitz and Stafford, 2010). Of particular significance are adaptable technologies for cooking, heating and water management, that can be rapidly replicated, and whose use and maintenance can be readily assimilated (FAO, 2010c). These address themselves to the central issues of health and the subordinate position of women. New cooking technologies have the wider significance of applying equally to the urban population, a large proportion of whom continue to rely on wood and charcoal for cooking (Slaski and Thuber, 2009; Rai and McDonald, 2009; WHO, 2006; World Bank, 2009).

Box 13 Gender division of labor, transport tasks and time poverty in SSA

The gender division of labor in transport tasks, as revealed in time allocation data, leaves women with by far the most substantial burden in rural areas, with in average adult females spending from 1 hour to 2 hours 20 minutes every day. Water, firewood, and crops for grinding are transported predominantly by women on foot, the load normally being carried on the head. Village transport surveys in Ghana, Tanzania, and Zambia show that women spend nearly three times as much time in transport activities compared with men, and they transport about four times as much in volume. What would happen if all households in SSA were no more than 400 m (about a six minute walk) from a potable water source—a national target once set by the Government of Tanzania—or if woodlots or other sources of household energy were no farther than a 30-minute walk? In the Mbale district in Eastern Uganda, if these proximity targets were met, a considerable outlay of household time and energy could be saved, predominantly for women, amounting to the equivalent of a half year of 40-hour work weeks.

Source: Adapted from Blackden and Wodon, 2006

More strategically, these approaches are promising to address the central problem (that we have identified in discussions of large-scale land investments) of the use of communal lands for fuel and water. In many cases, such lands, as we have seen, are also central for grazing and complementary food supplies. Nevertheless, the development of local energy options from biomass, in alleviating household's and especially women's time and walking constraints, could allow rural communities more flexible conditions for negotiations of new land uses, including more commercially organized biofuels to attend wider energy needs (see Box 13, Kes and Swaminathan, 2006).

Such a vision converges towards the four principles as identified by Von Maltitz and Setzkorn (2012) to orient biofuels policies in SSA: (i) be designed for the promotion of rural development; (ii) be geared to the objectives of energy security; (iii) develop the ability to attract appropriate investments; and (iv) be based on sustainable land use.

5.6 A range of tools for decision-making at various levels

As shown in Chapter 4 and throughout this chapter, the potential impact of biofuel policies and projects can differ widely according to national and local conditions. As shown in Chapter 2, the choice of specific technologies and feedstocks can also play a crucial role.

This is why various tools have been designed to facilitate and orient decision by the various actors. Academics have attempted to design typologies of countries to help governments and their partners select the best options for developing national production policies. Some tools are aiming to assess *ex-ante* potential effects of biofuel production at project level, or at the level of policy at country and/or local level. Finally, certifications aim to assess the impact of biofuel production in a given context and

[58] http://www.compete-bioafrica.net

[59] http://www.probec.net

[60] http://research.ncl.ac.uk/reimpact

transmit the information to importing countries and consumers, providing operational tools to linking policies and related criteria to the biofuel products.

5.6.1 Typologies for projects, programmes or policies

Pingali, Raney and Wiebe (2008) propose a 2 x 2 matrix country-level typology based on the potential to respond to increased demand biofuel production along intensification or extensification pathways. The former is defined as the weight of agriculture in GDP and the latter as the availability of additional agricultural land per capita. This typology distinguishes:

1. Land-scarce, low-income countries. An example here would be Bangladesh, which would have to adopt an intensification strategy given its land scarcity but whose low income means that it has very little technical or infrastructural conditions to carry this out. Any additional biofuel investment could therefore be prejudicial.
2. Land-abundant, middle-income countries. Brazil would be the key example, with enough land for extensive agricultural growth and sufficiently developed to also adopt intensification.
3. Land-scarce middle-income countries. Thailand would be a case in point where an intensification strategy would be a clear option with biofuels being just another commodity within its agro-industrial profile. Here, however, its economic growth increases the opportunity cost for land and labour as agriculture declines as a proportion of its GDP.
4. Abundant land and associated resources but low-income countries. Such countries with available land, water and inputs are attractive to investors but the lack of infrastructure and appropriate institutions means that investments tend to concentrate where these are present, creating competition and conflict with existing populations and agricultural production. The United Republic of Tanzania would fit this category as would a number of Latin American countries.

Ewing and Msangi (2009) for their part have developed a country typology based on the following four dimensions: the share of traditional biomas in all energy sources (linked to the time needed for collecting traditional biomass), the share of the energy expenditures in the import bill, the share of food expenditures in the import bill, and land availability from land scarcity to abundance.

A recent United Nations University–Institute of Advanced Studies (UU–IAS) study on biofuels in Africa by Gasparatos *et al.* (2012) also develops a useful typology for biofuel production, this time at the level of individual production systems, insisting in a similar fashion on the need to go beyond aggregate considerations. Also using a 2 x 2 matrix, they distinguish on the one hand between the scale of production (smallholders and/or outgrowers x large-scale farms) and the motives for production (national blending mandates/exports x local fuel production). Four types of production system are identified: (ii) small-scale biofuel projects for electrification; (ii) commercial firms or mines producing biofuels for own use; (iii) outgrowers or smallholders linked to commercial farms or biofuel processing plants; and (iv) large-scale commercial plantations. On this basis, the study identifies different types of investments and investors in the African case, with type (iv) predominating in the case of private investors and type (i) in the case of NGOs and foundations geared more to rural/local development.

Von Maltitz and Setzkorn (2012) have elaborated a similar but project level typology to explore the different ways by which bioenergy projects can be integrated into development strategies, crossing two dimensions: (i) the project scale (smallholders and outgrowers versus large industrial farms) and (ii) the targeted outlet (local fuel use versus national/international biofuels blends).

The BEFS project, as we have seen, has elaborated an analytical framework and developed a methodological toolkit to capture differences at country and regional levels. Their proposal for economic feasibility studies is specifically based on a typology of different production systems, particularly those which involve smallholders as outgrowers.

In conclusion, a number of studies have proposed typologies to capture different outcomes and guide policy formulation. This has led to a “profusion” of typologies, without any one of them clearly emerging. Here also the scientific community could gain from improving exchange of information on methods, tools and data used, especially focusing on the distributional impacts of biofuels by country and by production.

5.6.2 Certification schemes

Efforts directed at national governance have been complemented by the promotion of sustainable certification at the level of individual product supply chains. Biodiversity and climate change concerns had already promoted movements to ensure the sustainability of the major agricultural commodities. These have typically taken the form of multistakeholder roundtables, promoted by civil society and business with varied public participation, and now cover all the biofuel feedstocks, in addition to a roundtable specifically for biofuels, the Roundtable on Sustainable Biofuels (RSB).

FAO, through the BEFSCI Project,[61] has reviewed 17 such initiatives (including legislative frameworks, voluntary standards and certification schemes, and scorecards), against their environmental, socio-economic, food security relevance, and governance performance. The EU has resorted to such schemes to ensure that its carbon emissions and environmental criteria are respected by would-be exporters of biofuels to its markets. For the importing member country, the certification schemes are virtually obligatory, since only certified products count for the mandatory renewable fuels' targets. The EU does not explicitly demand the inclusion of social criteria and, of the 13 schemes already recognized (with dozens more in the pipeline), the majority have no detailed social clauses.

Internationally, the GBEP[62] has been active in the promotion of sustainability criteria and indicators for biofuels, under three pillars: economic, social and environmental (GBEP, 2011).[63] The GBEP sustainability indicators do not feature directions, thresholds or limits and do not constitute a standard, nor are they legally binding on GBEP Partners. The current set of 24 sustainability indicators of the GBEP includes eight environmental indicators, eight economic indicators and eight social indicators (GBEP, 2011).

One interesting feature of the GBEP sustainability indicators is the inclusion of social criteria, a move which is also followed by the multistakeholder Roundtable Sustainable Commodities initiatives – which, as we have mentioned, include soybean, palm oil and biofuels: for example, the principles and criteria of the Roundtable on Sustainable Biofuels (RSB) incorporate the following social concerns (RSB, 2010):

- human and labour rights;
- rural and social development;
- local food security;
- land rights.

Important progress is, therefore, being made to ensure that social criteria are included in certification schemes that qualify for access at least to European markets. The RSB's ambitions, however, are much broader. Its membership is individual, but is based on seven chambers representing positions in the production chain and distinctive stakeholders – farmers, industry, retail, rights based groups, rural development/food security organizations, environmental and intergovernmental groups – from all continents.

Certification schemes are a key complement and advance on regulation to the extent that they operate at the level of the firm and can incorporate specific features not contemplated in general regulations.

61 http://www.fao.org/energy/befs.

62 On 11 May 2006, ten nations and seven international organizations signed the Terms of Reference to create the Global Bioenergy Partnership (GBEP) and begin to implement the wish expressed by G8 Leaders in the 2005 Gleneagles Summit Action Plan to support "biomass and biofuels deployment, particularly in developing countries where biomass use is prevalent". As of December 2011, GBEP includes 23 partner countries and 13 partner international organizations, along with 23 countries and 11 international organizations that participate as observers. http://www.globalbioenergy.org

63 http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf

Table 8 GBEP sustainability indicators

Environmental	Social	Economic
1. Lifecycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and requalification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

Source: Adapted from GBEP (2011).

There are, however, some limitations with regard to this profusion of certification schemes. First, not all are multistakeholder, and their governance is always ad hoc. Second, not all include social or food security criteria. Third, there are always difficulties in terms of costs and logistics to ensure enforcement. All of this favours the adoption of less stringent standards.

In many instance, for example, the social criteria are reduced to observance of the national legislation of the exporting country. Certification schemes, in addition, are applied at the level of the individual farm or firm and therefore one challenge is how to integrate these schemes in a national framework. (Harrison *et al*., 2010).

5.6.3 Towards internationally coordinated guidelines?

The profusion of standards and certification schemes comes with its own challenges. It can lead to increase cost for compliance, and hinder policy outcomes. How to better use these tools at international level to help reconcile the inherent trade-offs?

In addition to food security concerns and socio-economic impact considerations, one other issue is whether standards generate barriers for trade and result in discrimination. Sanchez *et al.* (2012), noting ILUC gaining importance in biofuel regulations, have recommended the adoption of compatible and comparable accounting frameworks for ILUC between the USA, the European Union, South East Asia, Africa, Brazil and other major biofuel trading blocs to avoid distortion and improve policy outcomes, especially the compatibility with food security objectives.

The harmonization of sustainability criteria has been a challenge identified by the Global-Bio-Pact[64] research project for the “Development and harmonization of global sustainability certification systems for biomass production, conversion schemes, and trade in order to prevent negative socio-economic impacts”, involving an international consortium of research institutions, financed by the EU and coordinated by WIP Renewable Energies, Germany. This project had its concluding conference in January 2013. Among its publications, detailed socio-economic impact studies can be found related to the United Republic of Tanzania, Mali, Indonesia, Costa Rica, Brazil, Argentina and Canada to

[64] http://www.globalbiopact.eu

capture second-generation socio-economic impacts. It has also developed a proposal on socio-economic indicators to be adopted in certification systems.

Finally, everything taken into account, the certification of biofuels cannot, alone, lead automatically to sound biofuel and bioenergy policies in developing countries, as Diop *et al.* (2013) have also recognized in their report to the European Commission.

This is why we suggest here that the CFS launches, with support of FAO and GBEP, the development of guidelines to be adopted by countries and used to evaluate the impact and viability of biofuels policies. These guidelines should include: (i) the prior existence of technical, social and environmental zoning to delimit “available land” and accompanying resources; (ii) the prior existence of “responsible land investment” practices; (iii) the prior existence of mechanisms to ensure the capacity to react quickly to food price spikes and problems of food availability (price triggers, waivers, “minimum” levels of food stocks); (iv) the prior evaluation of the implications for the origin of feedstock provision (domestic/imported), and for trade; and (iv), last but not least, a prior evaluation of the implications of the policy for domestic and international food security.

CONCLUSION

Some major conclusions can be drawn from this report. A first group of conclusions regards the role of policies to develop a biofuel sector. Biofuel policies have been successful in developing an economic sector and a market. There are now more than 60 countries that have developed biofuel policies. Given the increasing price of fossil fuels and more efficient production, biofuels, or at least some of them, will be competitive even without public support. Increasingly it will be the market rather than policies that will drive the development of the sector. Which means that the role of policies will change.

A second group of conclusions relates to the impacts of biofuels and biofuel policies on food security. Biofuel development has both global and local effects, positive and negative, short and long term. Many of these effects take the form of increased competition, for food, for land, for water. There are links between biofuels and food security. Therefore biofuel policies have to integrate food security as a major concern. Their main focus could now be to orient the development of biofuels in order to limit their potential negative impacts and strengthen their potential positive impacts.

There is a general agreement on the fact that biofuels played an important role in the recent food price increase, even if its extent depends on feedstocks and is still discussed. And, to a certain extent, in countries and at periods when supply was abundant, it could have a positive impact on food producers. It is the very expansion of the consumption of biofuels, their beginning to have an impact outside the frontiers of the major producers, either by reducing exports of food or by increasing imports, driving the increase of international prices, which can have a negative impact on food security, on poor importing countries, poor consumers. These considerations call for a form of international coordination of policies, first of all by establishing regular exchanges of information on biofuel actual and projected production, towards the establishment of ways to use biofuel policies to limit excessive impacts on prices.

Biofuels and more generally bioenergy compete for land and water with food production. Experience shows that this competition can rarely be totally avoided. The notion of available land often does not take into account uses other than crop production, which often play a crucial role to ensure the food security of local populations. As for any agricultural production, the efficiency of the feed and technology, the yield, is crucial to better use land and reduce the need for additional land. This calls for more research and especially for research more adapted to the needs and possibilities of least developed countries and local communities.

Competition for land and water has to be appraised and managed at local level. The issue is not only food availability. It is access to resources in order to be able to make a living, produce or buy food. The implementation of the *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests* is key to ensuring the proper recognition of all tenure rights, of all types, including those of women.

There is not much hard evidence on the economic and social consequences of the development of biofuels, mainly because these impacts take longer to manifest themselves. Some examples show that they can have a positive impact on employment and livelihoods in rural areas, including, in some cases and with appropriate policies, on small farmers.

Over one-third of the world's population (2.4 billion people) relies on biomass for energy. For these communities the development of more efficient and cleaner uses of biomass for energy purposes can have a huge impact, to reduce the drudgery of agricultural work, increase agricultural productivity, increase income-generating opportunities and especially ease the workload of women.

The potential impact of biofuel policies and projects can differ widely according to national and local conditions and to the choice of specific technologies and feedstocks. This calls for careful *ex-ante* policies and projects, taking into account all potential direct and indirect effects. Such tools, along with the certification schemes aiming to assess the impact of biofuel production in a given context and to transmit the information to importing countries and consumers, have a transnational dimension, given the increasingly international dimension of biofuel policies.

Biofuel policies have been successful in developing biofuels; they now have to orient this success towards food security, which requires taking into account its various dimensions and to recognize and integrate all the potential impacts of national policies, internally and abroad.

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The HLPE also acknowledges the important feedback received from the peer-reviewers on a pre-final draft of this report. The global list of peer-reviewers is available at the HLPE website.

APPENDICES

A1 Summary of commodity price effects of major biofuel policies

Source	Coverage and key assumptions	Effects
Roberts and Schlenker (2010)	US biofuel policy + 5% of world harvest for biofuel; no policy.	30% increase in food price (20% if a third of feedstock is used for livestock).
Carter and Smith (2011)	2001–2007; US biofuel policy *vs.* no policy.	20–25% contribution (corn price rise) 7–8% contribution (soybean price rise).
National Research Council (2011)	2007–2009; US biofuel policy; using a review of several studies.	20-40% on food commodity prices.
Banse *et al.* (2008)	2001–2010; Reference scenario without mandatory biofuel blending , 5.75% mandatory blending scenario (in EU member states), 11.5% mandatory blending scenario (in EU member states).	Price change under reference scenario, 5.75% blending, and 11.5% blending, respectively: Cereals: -4.5%, -1.75%,+2.5% Oilseeds: -1.5%, +2%, +8.5% Sugar: -4%, -1.5%, +5.75%
Baier *et al.* (2009)	24 months ending June 2008; historical crop price elasticities from academic literature; bivariate regression estimates of indirect effects.	Global biofuel production growth responsible for 17%, 14% and 100% of the rises in corn, soybean and sugar prices, respectively, and 12 % of the rise in the IMF's food price index.
Lazear (2008)	12 months ending March 2008.	US ethanol production increase accounted for 20% of the rise in corn prices. US corn-grain ethanol production increased global food prices by 3%.
IMF (2008)	Estimated range covers the plausible values for the price elasticity of demand.	Range of 25-45% for the share of the rise in corn prices attributable to ethanol production increase in the US.
Collins (2008)	2006/07–2008/09; Two scenarios considered: (1) normal and (2) restricted, with price inelastic market demand and supply.	Under the normal scenario, the increase in ethanol production accounted for 30% of the rise in corn price; Under the restricted scenario, ethanol could account for 60% of the expected increase in corn prices.
Glauber (2008)	12 months ending April 2008.	Increase in US biofuels accounted for about 25% of the rise in corn prices; US biofuels production accounts for about 10% of the rise in global food prices IMF global food commodity price index.
Lipsky (2008) and Johnson (2008)	2005–2007	Increased demand for world biofuels accounts for 70% of the increase in corn prices.
Mitchell (2008)	2002-mid-2008; ad hoc methodology: impact of movement in dollar and energy prices on food prices estimated, residual allocated to the effect of biofuels.	70-75% of the increase in food commodities prices was due to world biofuels and the related consequences of low grain stocks, large land use shifts, speculative activity and export bans.

Source	Coverage and key assumptions	Effects
Abbott, Hurt and Tyner (2008)	Rise in corn price from about USD2 to USD6 per bushel accompanying the rise in oil price from USD40 in 2004 to USD120 in 2008.	USD1 of the USD4 increase in corn price (25%) due to the fixed subsidy of USD0.51 per gallon of ethanol.
Rosegrant (2008)	2000–2007; Scenario with actual increased biofuel demand compared to baseline scenario where biofuel demand grows according to historical rate from 1990–2000.	Increased biofuel demand is found to have accounted for 30% of the increase in weighted average grain prices, 39% of the increase in real maize prices, 21% of the increase in rice prices and 22% of the rise in wheat prices.
Fischer *et al.* (2009)	(1) Scenario based on the IEA's WEO 2008 projections; (2) variation of WEO 2008 scenario with delayed 2nd generation biofuel deployment; (3) aggressive biofuel production target scenario; (4) and variation of target scenario with accelerated 2nd generation deployment.	Increase in prices of wheat, rice, coarse grains, protein feed, other food, and non-food, respectively, compared with reference scenario: (1) +11%, +4%, +11%, -19%, +11%, +2% (2) +13%, +5%, +18%, -21%, +12%, +2% (3) +33%, +14%, +51%, -38%, +32%, +6% (4) +17%, +8%, +18%, -29%, +22%, +4%
IEEP 2012	EU biofuel policy.	8–20% on oilseeds 1–36% on vegetable oils 1–22% on cereals/corn 1–13% on wheat 1–21% on sugar[65]
IEEP 2012	Global/multiregional biofuel mandates.	2–7% on oilseeds 35% on vegetable oils[66] 1–35% on cereals/corn

Source: Compilation by the authors based on Timilsina and Shtrestha (2010) and IEEP (2012).
WEO = World Energy Outlook; IMF = International Monetary Fund

[65] The ESIM model (Blanco Fonseca *et al.*, 2010) projects an increase in corn prices of 22%, in sugar prices of 21%. The remaining studies project increases in corn or cereal prices of ≤8%, sugar price increases of ≤2%.

[66] OECD (2008) is the only "global" study providing a figure for vegetable oils.

A2 Land deals in Africa

Country	Type of investment	No. of invest-ments	Land (ha)	Feedstock type	Annual production targets (litres/ha)	State of investment			Total (ha)
						Operational	Project stage	Abandoned	
Democratic Republic of the Congo	Foreign	2	154 000	Jatropha, palm oil	No data				154 000
	Domestic	0							
Zimbabwe	Foreign	1	14 000	Sugar cane	44 000	1			164 000
	Domestic	5	150 000	Sugar cane, jatropha	58 400	4		1	
Mozambique	Foreign	27	624 162	Jatropha, sugar cane, sweet sorghum, palm oil	No data	24	1	2	645 162
	Domestic	1	21 000		No data				
Malawi	Foreign	2	>7 000	Jatropha	No data				>7 000
	Domestic	2	No data	Sugar cane	42 000	4			
Zambia	Foreign	12	827 483	Sugar cane, jatropha, palm oil	No data	9	3	1	827 483
	Domestic	1		Jatropha	No data	1			
Angola	Foreign	6	92 600	Sugar cane, jatropha, oil palm	No data	5	1		206 600
	Domestic	3	114 000	Sugar cane, sorghum	No data	1	2		
Namibia	Foreign	3	460 000	Jatropha, sugar cane	No data	2		1	460 000
	Domestic	0			No data				
United Republic of Tanzania	Foreign	17	407 622	Palm oil, jatropha, sugar cane, croton, sweet sorghum	No data	13	2	2	409 622
	Domestic	1	2000	Jatropha	No data	1			
Madagascar	Foreign	18	1 249 600	Jatropha, sunflower, palm oil, sugar cane, woody biomass	No data	14	1	2	1 249 600
	Domestic	0			No data				
Kenya	Foreign	3	161 000	Jatropha, sugar cane	No data	3			211 000
	Domestic	1	40 000	Sugar cane	No data	1			
Uganda	Foreign	1	10 000	Palm oil	No data	1			10 000
	Domestic	0			No data				

Republic of the Congo	Foreign	3	110 000	Palm oil	No data	3			110 000
	Domestic	0			No data				
Gabon	Foreign	1	300 000	Palm oil	No data	1			300 000
	Domestic	0			No data				
Ethiopia	Foreign	13	496 500	Castor, jatropha, oil palm, sugar cane	No data		1	1	610 490
	Domestic	4	113 990	Castor, jatropha, oil palm, Sugar cane, pongamia, various vegetable oils	No data		1		
Sudan	Foreign	1	600 000	Jatropha	No data	1			660 000
	Domestic	2	60 000	Jatropha, sugar cane	No data	2			
Cameroon	Foreign	3	97 168	Oil palm, jatropha	No data	3			97 168
	Domestic	0			No data				
Nigeria	Foreign	3	61 292	Sugar cane, cassava, sweet sorghum	No data	2	1		103 292
	Domestic	3	42 000	Oil palm, cassava, sweet sorghum	No data	2	1		
Benin	Foreign	2	293 488	Jatropha	No data	2			293 488
	Domestic	0			No data				
Ghana	Foreign	19	1 050 950	Jatropha, woody biomass, sugar cane, rapeseed, oil palm	No data	18	1		1 202 200
	Domestic	5	151 250	Jatropha, sugar cane	No data	5			
Mali	Foreign	6	142 432	Sugar cane, jatropha	No data	6			242 432
	Domestic	1	100 000	Jatropha	No data	1			
Liberia	Foreign	1	168 748	Oil palm	No data	1			168 748
	Domestic	0			No data				
Sierra Leone	Foreign	6	314 500	Sugar cane, oil palm, jatropha	No data	6			314 500
	Domestic	0			No data				
Senegal	Foreign	2	150 000	Jatropha	No data	2			158 700
	Domestic	2	8 700	Sugar cane, jatropha	No data	2			

Source: German, Schoneveld and Mwangi (2011)

A3 Biofuels: gender impacts

Gender and power dynamics

Gendered power relations

Gendered participation in biofuel policy-making and planning

Traditional gender roles (domestic, production, reproduction, trade, community)

Gender specialist knowledge

(e.g. of different crops)

Gendered livelihood resource entitlements

Schemes → Livelihood and environmental impacts → Gendered impacts → Entry points

Model 1

Schemes

Large scale company owns land (for export and national markets)

e.g. large oil palm, sugarcane or soy bean plantations

Livelihood and environmental impacts

- Loss of biodiversity, agrobiodiversity, natural resources, ecosystem resilience, resource dispossession risks and no compensation when investors not given capital.
- Impacts on household food security, increased mitigation.
- Some job creation – but often fewer than projected. Cases of poor quality labour standards.

Gendered impacts

- Women have fewer resources to cope with impacts of large schemes, weaker tenure security and secondary use rights – so more at risk of dispossession, more vulnerable to environmental impacts.
- Traditional subsistence gender roles, so women more reliant on natural resources (which may be depleted or taken over).
- Gendered economy (women excluded from work, lower paid positions, poor conditions, informal economy).
- Women less likely to be consulted about land transfers and in compensation negotiations.

Entry points

- Caution over large-scale, export oriented schemes. Give more priority to local energy autonomy, ecosystem resilience and consider alternative value chain model opportunities.
- Policy and project screening to mainstream gender.

  Increase governmental regulation of gender-sensitive labour standards and enforcement.
- Build worker/civil society capacity on labour rights.
- Seek climate finance to support livelihoods and protect forests and strengthen women's empowerment.

Model 2/3

Schemes

Contract farming, outgrower schemes, upgrading of smallholder roles (for export/national markets)

e.g. Brazil Social Fuel Seal, Tanzania outgrower schemes

Livelihood and environmental impacts

- Similar types of impacts as model 1, if linked to large-scale schemes. Smallholder production mainly but also mixed ownership, roles, management innovations.
- Better access to technical advice, credit, inputs.
- Smallholder dispossession risks over time, plus productivity / technical issues, unclear and unfair contracts, sustainability standards may exclude smallholders.

Gendered impacts

- Similar types of impacts as above if linked to large-scale schemes.
- Potential for labour and increased incomes for women and men, but needs education and skills-training, especially for women.
- Female farmers less able to participate (lesser access to resources, extension gender biases).

  Insufficient knowledge of alternative value chain models.
- Lack of participation of women in developing contracts, but chance for women's group projects.

Entry points

- Identifying promising ways of involving smallholders along the value chain especially women. Identify opportunities for targeting and supporting women's participation.
- Mainstream gender impact analysis. Provide gender training for professionals in biofuel companies. Support independent facilitation of contract negotiations / legal advice for communities.
- Strengthen women's land tenure security, resource and inputs access.
- Increase gender-sensitivity of extension services, women's education/skills training.

Model 4

Schemes

Small-scale, decentralized projects

e.g. Mali, Jatropha programme; Brazil PROVENAT programme

Livelihood and environmental impacts

- Clean energy access (can improve education and health). Income generation (sale of feedstock seeds and electricity, diversification).
- But, dispossession risks, environmental risks with scaling up, technical and scaling up challenges.

Gendered impacts

- Opportunity to work with women's groups in increasing access to energy services, energy enterprise and income generation (sometimes with health/education benefits).
- Not all projects target women's groups.
- Risks fall disproportionately upon women when participating in experimental projects.
- Potential for unequal distribution of benefits (e.g. increased income) and costs (e.g. extra work, lack of control of income).

  Reductions in drudgery especially for women, but new tasks in cur extra work.

Entry points

- Give greater priority to tackling energy poverty. Prioritize small-scale, community based biofuel.

  Integrate gender analysis through project cycle (distribution of impacts/participation).
- Promote participation of women's groups.
- Take specific steps to support women's participation in decision-making.
- Support women's entrepreneurial capacity building and access to resources.

  Provide technical support to women's biofuel groups and conduct research on good practices.

Source: Adapted from Nelson and Lambrou (2011a, 2011b).

A4 The HLPE project cycle

The HLPE has been created in 2009 as part of the reform of the Committee on World Food Security (CFS) to assess and analyze the current state of food security and nutrition and its underlying causes; provide scientific and knowledge-based analysis and advice on specific policy-relevant issues, utilizing existing high quality research, data and technical studies; Identify emerging issues, and help members prioritize future actions and attentions on key focal areas.

The HLPE receives its mandate from CFS and reports to it. It produces its reports, recommendations and advice independently from governmental positions, in order to inform and nourish the debate with comprehensive analysis and advice.

The HLPE has a two-tier structure:

- A Steering Committee composed of 15 internationally recognized experts in a variety of food security and nutrition related fields, appointed by the Bureau of CFS. HLPE Steering Committee members participate in their individual capacities, and not as representatives of their respective governments, institutions or organizations.
- Project Teams acting on a project specific basis, selected and managed by the Steering Committee to analyze/report on specific issues.

To ensure the scientific legitimacy and credibility of the process, as well as its transparency and openness to all forms of knowledge, the HLPE operates with very specific rules, agreed by the CFS.

The reports are produced by time-bound and topic-bound Project Teams, selected and appointed by the Steering Committee, following its guidance and under its oversight.

The project cycle for the reports, in spite of its being extremely time constrained, includes clearly defined stages separating the elaboration of the political question and request by the CFS, its scientific formulation by the Steering Committee, the work of a time bound and topic bound project team, external open consultations to enrich the knowledge base, an external scientific review (Figure 14).

The process promotes a scientific dialogue between the Steering Committee and the Project Team throughout the project cycle, with the experts in the HLPE Roster, and all concerned and interested knowledge-holders worldwide, thriving for the involvement of diverse scientific points of view.

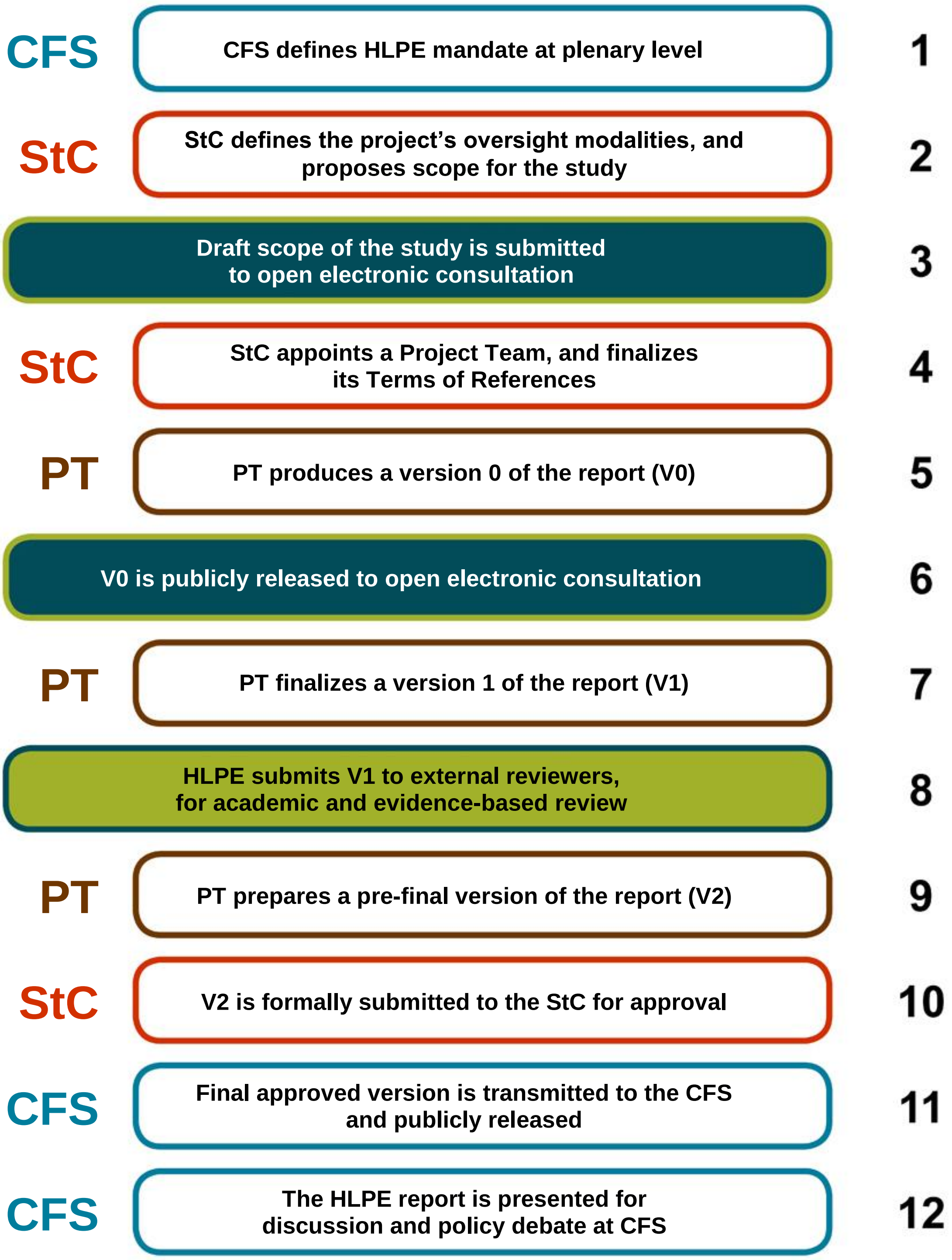
This is why the HLPE runs two external consultations per report: first, on the scope of the study; second, on a first draft (V0). This provides an opportunity to open the process to the input of all experts interested and towards the experts HLPE roster (there are currently 1200 of them), as well as to all concerned stakeholders. The input provided, including social knowledge, is then considered by the Project Team and enriches the knowledge base.

The draft report is submitted to independent evidence-based review. It is then finalized and discussed, leading to its approval by the Steering Committee during a face-to-face meeting.

The report approved by the Steering Committee is transmitted to the CFS, made public, and serves to inform discussions and debates in CFS.

All information regarding the HLPE, its process, former reports is available at the HLPE website: www.fao.org/cfs/cfs-hlpe.

Figure 14 HLPE project cycle



CFS Committee on World Food Security
HLPE High Level Panel of Experts on Food Security and Nutrition
StC HLPE Steering Committee
PT HLPE Project Team

Source: HLPE, 2012.

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CFS
Committee on World Food Security

HLPE
High Level Panel of Experts

Secretariat HLPE c/o FAO
Viale delle Terme di Caracalla
00153 Rome, Italy

Website: www.fao.org/cfs/cfs-hlpe
E-mail: cfs-hlpe@fao.org