

Committee on World Food Security

High Level Panel of Experts on Food Security and Nutrition

Biofuels and Food Security

V0 DRAFT

A zero-draft consultation paper

9 January 2013

**Submitted by the HLPE
to open electronic consultation**

This V0 draft has been produced by the HLPE Project Team under guidance and oversight of the HLPE Steering Committee.

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This V0 draft is put online by the HLPE as part of the its report elaboration process, for public and expert feedback and comments

from 9 January until 30 January 2013

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This consultation will be used by the HLPE Project Team to further elaborate the report, which will then be submitted to external expert review, before finalization by the Project Team under Steering Committee guidance and oversight.

According to the provisions of the Rules and Procedures for the work of the HLPE, prior to its publication, the final report are to be approved by the HLPE Steering Committee, This is expected to take place at the 7th meeting of the HLPE Steering Committee (May 2013).

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FOREWORD

(...)

EXECUTIVE SUMMARY

If 10% of all transport fuels, to date, were to be achieved through biofuels, this would absorb 26% of all crop production. At present, if we would use the totality of the world's crops to produce biofuels, it would represent at most only 13% of the world's primary energy, which, if inefficiencies in appropriation were included, would realistically be closer to 9%, and which in 2050 would only correspond to 4-6% world's energy. This would further mobilize 85% of the world's fresh water resources.

This Report starts with outlining the main policies taken at national and regional level for the promotion and creation of biofuels markets. While Brazil, the US and the EU clearly dominate production, more than 50 countries have adopted biofuels targets and/or incorporated transport fuels mandates for the development of biofuels. In addition, while policies have been elaborated at national or at most regional level these have led to trade and investment in biofuels on a global scale.

Agricultural and agro-industrial lobbies have been influential in the adoption of biofuels policies in the currently major biofuel producing countries. National energy policies have also been an important factor. At the same time, global international negotiations, including climate change and biodiversity conventions, have played roles both in how the formulation, promotion and evaluation of these policies.

Civil society organizations have also played a role. In the 1990s, their general support for biofuels, was based at the time, on their assumed greater efficiency than existing liquid fuel options, whether in terms of energy, or greenhouse gas emissions. As the evidence-base in terms of energy and greenhouse gas efficiency of first generation biofuels has narrowed, the impact of biofuels on food security has become an increasing concern. CSOs increasing role in policy (re)formulation is particularly evident in the decision to reduce the participation of first generation biofuels from ten to five per cent in the EU renewable fuels mandate. They are similarly also in evidence in the pressures to modify current mandates in the US.

The central concern of this report is to analyze the implications for food security of global and national biofuels markets, as they were put in place in the first decade of the current millennium, through an evaluation both at the aggregate level of macro data and through field research carried out in different regions and localities.

We consider also analyze recent major changes which have occurred with regard to targets and mandates focusing particularly on the EU Directive which limits biofuels blending to half the original target and effectively establishes existing levels as a ceiling for first generation biofuels. The US is also coming up against the limits of its established blending target as it too is reaching the 10% and/or 15 billion gallon ceiling for first generation corn ethanol. The shifts in trade and investments consequent on this new phase in the development of food crop biofuels and the food security implications of these measures are identified, together with the degree to which they are provoking similar changes in policies in other countries and regions.

The development of country typologies can provide a starting point for the elaboration of biofuels policies and an illustration of this approach is presented which shows how basic criteria such as land availability and per capita income can aid in the identification of the type of policies which would make sense in a given country context.

While biofuels is a global phenomenon, its impacts are very much influenced by the characteristics of the country involved and the type of production activities undertaken. The FAO Bioenergy Food Security (BEFS) project has developed an analytical framework which

gives priority to the specific context in which biofuels are developed, and has applied this framework in individual country studies in Latin America, Africa and Asia (BEFS, 2010).

The second chapter begins with a review of the discussions on the technological justifications for biofuels, which are grounded on the fact that they are the most readily available liquid fuel for confronting the fossil energy dependency and greenhouse gas emissions challenges posed by the current use of fossil fuel. A quarter of global emissions are attributed to transport, a globally fast growth sector and a special challenge to policy given the way transport is locked into the existing technology paradigm from “well to wheel”. We examine here the different technological trajectories.

First generation biofuels are understood as those which use fuel crops and traditional fermentation, distillation and esterification technologies.

Second generation biofuels use non-edible crops or the non-edible parts of food crops which require the use of lignocellulose technology¹.

Third generation biofuels are associated with algae production which while relieving land and food crop pressures are not themselves immune to environmental consequences and potential threats to food security. In addition, scale-up challenges places 3rd generation biofuels well into the second decade of this century if not beyond.

While much of the literature has centered on the delay in coming on stream of second and third generation biofuels there has also been considerable concern over the implications of their adoption. Attention is given to the formidable logistical problems and to the possible negative consequences of withdrawing soil nutrients in the case of using straw and residues. These factors, together with the scale and complexity of the processing technology suggest that second generation biofuels might lead to a more radical “division of labor” between developing and developed countries creating greater dependence on food imports particularly on the part of the European Union and greater pressure for cash crops exports from developing countries.

The production of energy feedstock (mainly wood) has been a traditional function of agriculture and land-use, and it still is in a variety of forms in many parts of the world. The introduction of biofuels however changed market dynamics since the products of agriculture can now be used for very different functions (food, energy etc) depending on relative demand and relative prices. The term “flexible agricultural products”, whose markets often depends on relative prices, has been introduced to capture this phenomenon. On the other hand, multi-purpose crops have to compete with the opposed strategy of developing dedicated crops for specific market demands. The notion of flexible crops is aligned with a broader concept, that of biorefineries which can already be foreseen in the emerging sugar/ ethanol/ electricity/ bioplastics complex in Brazil. Here the interchangeability of feedstocks and outputs approximates agroindustry to the model of the chemicals industry. This model also obliterates a vision where there is a strong separation between primary and secondary processing, foreclosing one of the most favored avenues for value added farming strategies, and posing specific challenges linked to the involvement of small scale producers and smallholders.

¹ The *Jatropha* plant for biodiesel which has at different moments assumed central importance and been the object of great expectations is an anomaly in the classification between first and second generation biofuels. It is a non-edible crop, which would place it with the second generation, but its oil is produced by the traditional processing techniques of the first generation. The scientific challenges with regard to *Jatropha* are more located in the genetic and agronomic improvement of the plant for biodiesel production. *Jatropha* has been a major object of investment in China, India and Africa, involving varied relations with traditional communities and different production systems whose implications are discussed in the final two chapters where we pull together the land related and social impacts of biofuels which are directly relevant for food security considerations.

Technology trajectories for biofuels cannot be seen in isolation from concerns with the broader issues of energy security, but must be situated within a consideration of other renewable fuel alternatives and the degree to which these are in a position to compete with biofuels. Waste has become a key concern in international discussions of food security, and is now on the agenda of the CFS. Biogas produced from rural and urban waste could be used directly as a transport fuel or in liquefied form, either option involving massive changes in distribution and refilling systems. Further down the road is research geared, through diverse pathways, including biological, chemical, solar cells and others, to “transforming” solar energy ultimately, into, liquid fuel, going beyond the inefficiency of photosynthesis which in energetic terms has a very low 3% conversion yield for solar energy, against a 10% conversion rate for solar cells. This includes the search for viable solutions to the electric car, which has been the object of research strategies since at least the 1970s.

The chapter concludes with a discussion of the R&D priorities for biofuels when these are integrated into bioenergy strategies as key components of rural development policies. Here in addition to, and more important than, the provision of renewable transport options is the development of appropriate biomass energy for lighting, cooking, water use and the running of local productive facilities, technologies often equally applicable in urban settings.

Chapter three addresses the role of biofuels under five headings. The first distinguishes the impacts of biofuels on poverty from those on malnutrition and discusses potential impacts of biofuels on malnutrition. Biofuels cause poverty to the extent that they force the poor to pay more for their food and less for other necessities and that turns on price increases. But they are also a cause of hunger and malnutrition to the extent that the poor are not able to eat as much as before, and if the poor eat less as prices rise, that actually holds down price increases. There is significant evidence that a substantial fraction of each ton of crops diverted to biofuels comes out of consumption by the poor, and that could greatly exacerbate malnutrition if biofuels grow to 10% of the world’s transportation fuel.

The second section evaluates the dominant role of biofuels in the recent agricultural commodity price increases. Because corn has become a substitute for fossil fuel, producers will bid up the price of corn to make ethanol at high oil prices, and this fact explains by itself most of the rise in crop prices since 2004. Overall, that rise is not related to any drop-off in production or yields prior to 2012, but is primarily related to the challenge of supply in keeping up with high rate of growth in demand due to biofuels. . .

The third section introduces two further factors that have also influenced prices. To some extent, crop price increases expressed in dollars reflect a lowering of dollar values on international exchanges. China’s large increases in imports of soybeans and its management of inventories have also played a role in tightening demand.

The fourth section discusses factors and arguments that have inappropriately clouded the discussion of the role of biofuels on food prices. These factors include confusion between the impacts of prices on food retail prices and on agricultural commodities, the exclusive focus on policy rather than the broader relations with oil prices, and the failure of explanations to focus on the incremental role of biofuels in triggering price increases. They also include an exaggerated emphasis on the importance of increased agricultural input costs and of the role of speculation. Perhaps most importantly, explanations have relied on models that are primarily directed at estimating the price consequences of biofuels in a long term equilibrium to explain price rises that reflect the shorter term inability of supply to keep up with demand and therefore to achieve that equilibrium.

The last section focuses on the future and estimates that providing 10% of the world’s transportation fuel from biofuels would require roughly a quarter of all present crop production

and therefore will keep prices high. It also argues that the new relation between corn and oil prices, which cellulosic options is unlikely to radically modify, implies that high oil prices will both keep biofuel production growing and crop prices both high and volatile in the absence of new policies to limit their growth.

Chapter four discusses two basic issues - the competition for land given food, feed, fuel, fiber and urban needs, and the role of biofuels in the recent rush for land investments, dubbed as "land grabbing."

FAO's projection of the need for a 60% increase in food crops and a 70% increase in livestock production by 2050 imply a need for additional cropland and pastureland, even if crop yields continue to grow at high rates and even accounting for a massive increase in the productivity of pasture. Although large potentials for new cropland have been reported, high-end estimates of up to 445 Mha include areas currently covered by dense forests, or by savannas with large carbon content, as well as by already highly productive pastures. The need to preserve productive lands for food crops and pasture, the need to preserve carbon-rich ecosystems such as savannas and forests, the need to find lands for urban expansion and the need to expand managed forests for timber, all these factors are likely to place large demands on the world's land by 2050, and this even without accounting for a significant growth in biofuels.

Any biofuel growth would exacerbate that challenge. At present, 100% of the world's crop represents a raw chemical energy potential equal to only 13% of the world's primary energy. When considering its relative efficiency with fossil fuels, its realistic maximum potential would be closer to 9% of primary energy today and only 4-6% in 2050. And this would consume 85% of the world's freshwater diverted from rivers and aquifers.. As cellulosic ethanol is not necessarily more land or water efficient than crop-based biofuels (after accounting for feed by-products of grain-based biofuels), the use of productive land for cellulosic biofuel crops would not substantially alter this equation. The fundamental problem lies in the relative inefficiency of biomass for energy as plants are unlikely to transform more than 0.5% of solar energy into biomass energy, with a the final fuel energy yield down to only 0.1-0.2%. When food, feed, energy and carbon storage demands have to be considered jointly, given the orders of magnitude at stake, one can assume that bioenergy cannot provide a significant source of the world's total energy.

The second section of this chapter deals precisely with the enormous and rapid expansion in land investments, which have assumed global proportions, although they would seem to be primarily focused on the identified "available" lands, particularly on the African continent. NGOs have been largely responsible for the data on this phenomenon, which they have baptized as "land grabbing". The dimensions of this phenomenon are subject to quite divergent estimates with figures varying from 83 to 44 million hectares, although it is argued that the real figure could double this higher calculation. A recent estimate puts land deals at 10 million hectares a year. A wide range of investors are involved including- investment funds, States and private "speculators", in addition to the biofuels and broader agro-industrial sector. Africa is a key target, accounting for 56 million of the higher figure mentioned above which is equivalent to 4.8% of the continent's agricultural land, and many African countries have mobilized to facilitate investments in their lands. The chapter analyses in some detail these investments including case-studies which confirm the analysis that these lands tend to be under traditional, often communal, forms of land occupation and tenure. Current initiatives to ensure responsible land investments are clearly inadequate and measures are needed urgently to defend the rights of those traditional communities occupying and using these lands.

In the final chapter, we focus on some of the key social implications of the above considerations for the rural and urban poor faced with problems of food (in)security. As we have seen, negative effects are associated with biofuels given their share of responsibility in creating higher

and more volatile prices. In parallel fashion, biofuel's feedstock investments have been accompanied by land/crop displacements in many countries.

The scale of their operation, the speed with which they have escalated and their global reach have brought current land investments projects up against millions of rural families and communities living according to customary and often communal rights of access to land. For a variety of acceptable and unacceptable motives these rights have been placed massively in question, undermining the sustainability of these peasant, often pastoral, communities and threatening the basis of their precarious food security. A series of international initiatives to discipline land investments (Principles for Responsible Agricultural Investments, Voluntary Guidelines on Land Tenure) and the Convention on Biodiversity include provision for consultation and the "prior, informed, consent" of the communities involved. However these have to be put in action. Further measures are needed, combined with social inclusion, participation and democracy, for the effective recognition of customary rights to land.

Initially a neglected issue, a series of studies has recently been carried out on the impact of biofuels for the position of women which we review in this chapter. These studies show that, although women are the family anchor when it comes to food security, they have been the most negatively affected by the advance of large-scale biofuels investments. Their rights to land have been less recognized, their access to forest products for complementary food and raw material for production has been prejudiced, and their role as water provider has become more onerous as traditional sources dry up or are expropriated and they are forced to cover longer distances to access supplies. Women, on the other hand, stand most to gain from locally oriented bioenergy strategies which are assuming greater importance in national and regional policies.

Central to the initiatives to confront the varied critiques of currently designed biofuels mandates has been the development of voluntary, public/private, forms of governance of the supply chain in the form of certification systems. These have been primarily promoted within the EU and have now assumed virtually regulatory status to the extent that non-certified biofuels cannot count as contributing to fulfilling mandated targets (EASAC, 2012). The criteria governing the very varied range of certification schemes are heavily oriented to energy efficiency, carbon emissions and environmental factors. Indeed, the inclusion of social factors can incur retaliation within the terms of the WTO. Nevertheless, the GBEP Task Force has been building consensus on the inclusion of social criteria under the team leadership of the FAO since 2008 (GBEP, 2008). The Roundtable on Sustainable Biofuels (RSB) also includes social criteria and we examine whether such criteria are present in other certifications and review the literature on their effectiveness in promoting and/or defending food security.

At the level of local and business-driven biofuel investments, the type of production systems adopted can lead to very different results for the social and economic in(ex)clusion of farming families and rural laborers. Special care is needed to ensure that bio-energy policies, including biofuel components, are protected from perverse or unattended consequences, since biofuels have often been promoted for specific purposes but the outcomes have been very different.

Negative, unintended consequences can be mitigated when biofuels options are conceived as part of a broader concern with the development of bioenergy for rural development in more isolated regions, and where bioenergy is geared to improving the "use" and nutrition aspects of food security in rural and urban cooking practices important for nutrition and food safety. In addition to macro energy concerns, policies in developing countries are increasingly including these objectives, and the recourse to typologies of different production systems provides an important tool for the evaluation of different outcomes for income and employment and the multiple aspects of food security

DRAFT POLICY RECOMMENDATIONS²

In 2011, a joint recommendation to the G20 summit in Paris by the FAO, IFAD, IMF, OECD, UNCTAD, WFP, World Bank and the WTO, called for the adjustment of biofuels mandates when food markets come under pressure. In 2012, the FAO called for the suspension of biofuels targets in the light of pressure on food commodity prices. The UN Special rapporteur on Food Rights has put out a call: “to abolish mandates on biofuels”. International NGO’s campaign for “scrapping the mandates”. The 2011 HLPE Report on price volatility also called on the CFS to demand of governments “the abolition of targets on biofuels and the removal of subsidies and tariffs on biofuels products and processing”.

1. Our Report has confirmed the central role of biofuels in provoking high and volatile food prices, and therefore, we point to the fact that there is enough evidence to call in question the use of mandates/targets together with subsidies and tariffs where these artificially stimulate biofuels production. Our Report concludes, however that in the context of persistent high oil prices, biofuels from maize in the US and from sugar-cane in Brazil can be, for different reasons, market competitive. In this situation, **we must advance beyond the discussion of mandates and subsidies to include mechanisms for controlling the growth of biofuels markets.** The recent EU Directive has moved in this direction, and while the EPA in the US has rejected the suspension of targets, maize/ethanol has almost reached its current allocated share of the biofuels market. **Policies should now be directed at ensuring that domestic ceilings are not made innocuous by the emergence of a global biofuels market.**

2. The 2011 HLPE report on land tenure identified biofuels as a major factor in the acceleration of such land investments with adverse consequences, and for this reason also called for an end to mandates/targets and subsidies. Our report reviews the evidence on land foreign direct investment and confirms the importance of biofuels objectives. It is not only through prices, therefore, that biofuels threaten food security. Case-study evidence accumulated primarily by NGO networks has confirmed the massive displacement of traditional communities as the result of land investments which also replace varied sources of food with monocultures further aggravating food and nutrition insecurity. **The principle of prior, informed consent and full participation of all concerned in land investment deals must be effectively implemented as preconditions for any land deals.**

3. The negative experience with jatropha has shown that the pressure on land provoked by biofuels is equally a pressure on water resources. Investments in land are increasingly being understood as simultaneously investments in water. **Policy must now catch up with analysis and integrate land and water so that land concessions cannot be made without an evaluation of the impacts of land use on water resources.**

4. The expansion of biofuels has revealed key gender consequences. Case-studies show that women are generally marginalized in negotiations over land investments, lose access to forest foods and raw material, suffer from more difficult access to water, and are nutritionally worse affected than men by any reduction in food supplies. **Policies must ensure that women participate fully in land negotiations and that their land ownership rights are recognized.**

² Note: The current V0 draft contains a short summary and, intentionally, very first tentative recommendations : these are to be seen NOT as the final recommendations of the HLPE, but as a work-in-progress, part of the process of their elaboration: it is therefore to be seen as a *scientific and evidence-based invitation* for their enrichment, for being screened against evidence, as well as for further suggestions on their operationalization and targeting.

5. As in the case of prices, many international organizations have recognized the negative impacts of such land investments on food security. At its 2010 summit, the G20 called for “all countries and companies to uphold the Principles for Responsible Agricultural Investment”, and requested “UNCTAD, the World Bank, IFAD, FAO and other appropriate international organizations to develop options for promoting responsible investment in agriculture (RAI).” The FAO has adopted “Voluntary Guidelines for the responsible Governance of Tenure of Land, Fisheries and Forests in the context of National Food Security”. The CFS has also launched an inclusive consultation process for the development and broader ownership of the principles for responsible agricultural investments (RAI) which enhance food security and nutrition, to be endorsed in October 2014. **Adhesion to the broadly-owned RAI principles, envisaged in the CFS consultation process, and to the voluntary guidelines should be established as a precondition for participating in land deals involving biofuels production plans.**

6. One way to ensure compliance with or to implement international guidelines such as these, particularly in the case of investments in weak or failed States has been the conditioning of market participation on the adhesion to a recognized certification system, accounting for environmental, social, energy and food security considerations. The EU has taken the lead here and has so far recognized thirteen such schemes with many more in the pipeline. Given the proliferation of certification schemes there is a danger that this strategy for ensuring compliance becomes innocuous. **We urge that only certification schemes which are multi-stakeholder, fully participative and transparent be recognized for access to the biofuels market.**

7. Our Report has further noted that separate biofuels certifications schemes may have the negative effect of locating biofuels on lands which most easily comply with certification requirements, pushing food production onto less favorable lands. In addition, the same lands and the same crops can be used interchangeably for biofuels or for food. Indeed in our discussion of the technology frontier we have suggested that flexible biomass, bio-refinery supply chains may emerge as the corresponding agro-industrial model. **The conclusion here and the corresponding policy proposals point to the need for all land investments and all agricultural production to be socially and environmentally sustainable. While it might be difficult to request all agricultural production to be subject to sustainable criteria ratified by recognized certifications schemes, the question should be raised of how to improve sustainability in agriculture at the macro aggregate level, including through the development of sustainability criteria testified by certification schemes for farming activities and products. .**

8. We have suggested in our Report that **the elaboration of typologies of countries' situations based on land availability, population density and per capita income can provide a preliminary orientation on the advisability of developing a biofuels policy** and the type of policies which would be most appropriate. Similarly, **typologies of production models can identify the trade-offs of different production systems and their positive/negative implications for food security.**

9. In biofuels discussions, the developing world is often seen in the role of biomass supplier for Northern markets. Our Report has shown that biofuels for the domestic market are also a central concern of major developing countries, and that these biofuels demands are also creating regional markets. The majority of these countries have an explicit commitment to non-food biofuels and the use of “marginal” lands, with Jatropha as the banner product. The evidence now suggests that there is no current magic bullet which can ensure adequate production from non-food crops on marginal lands **and no policies should have this as their presupposition. Non-food-competing crops for biofuels should, therefore, be assessed with the same rigor with respect to their direct and indirect food security impact as food-competing feedstocks, since they also compete for land, water, labor, capital and other food-related inputs and investments.**

10. In reviewing the technology frontier for biofuels our Report confirmed the improbability of being able to count on second generation biofuels within the current decade. It further concluded that the skill, scale and logistics necessary for second generation biofuels made them inappropriate for most developing countries today. The reduction of oil based transport fuels and their GHG emissions point, therefore, to the need for alternative policy measures – improvements in fuel efficiency and a transition to collective transport and priority for the development of non-biomass renewable fuels, according to the specificities of both developing and developed countries.

11. On the other hand, **the wealth of biofuels case-studies reviewed in our Report shows the importance of shifting from a narrow biofuels to a more comprehensive bioenergy policy approach.** In developing countries with vast hinterlands, the mobilization of biomass for different forms of bioenergy can be the most effective development strategy to provide electricity and alternative power for cooking, water management, and local productive facilities in addition to transport fuel.

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”.

Following on these recommendations the present study is dedicated to a policy oriented literature review of the food security implications of biofuels. To understand the threats/opportunities which biofuels pose for food security we must understand the dynamics and impacts of the biofuels market within the liquid transport market and the broader framework of the energy market. At the same time, we must define the understanding of food and nutrition security which underlies this report and identify the different ways in which such security may be affected by the development of the biofuels market.

Food security will be analyzed in the light of the four components comprising the FAO definition, adopted by the HLPE, namely: access whose principal determinant is the ratio price of food /income; availability which is associated with the resources for food production, basically land and water; stability meaning that access and availability are guaranteed through time and predictable; and finally use, which involves access to the resources which enable food to be appropriated with security, especially water and energy.

It should be further noted that food security includes the question of nutritional security. The report will be sensitive therefore to land use changes which replace mixed farming systems with mono-crop plantations or modify labor relations which prejudice the maintenance of food plots, a key source of micro-nutrients. Both in relation to nutrition and the use aspects of food security – water and energy - women are the key actors and therefore a gender understanding of the impact of biofuels is essential to the definition of food security policies.

Biofuels can affect food security negatively through prices, through land and water use and by public policy and private strategy responses to the perceived effects of biofuels in the form of trade and investment. They can also be seen to have a positive effect on food security to the extent that they open up the possibility for new sources of income and employment, and provide alternative sources of energy for rural communities and for rural and urban food preparation. At this point biofuels become components of broader bioenergy policies and strategies.

Biofuels are currently almost exclusively produced from internationally traded edible crops and any pressure, therefore, which they exert to higher or more volatile prices directly affects global food prices. At the same time, the national/regional targets and mandates which have promoted biofuels have stimulated the growth of a global market both for biofuels and biofuels feedstock. As a consequence, land in many countries, which may have neither domestic targets/mandates nor large transport fuel demands, has also become the object of biofuels investments.

At current levels of technology two basic categories of biofuels are distinguished. Bioethanol is produced from the fermentation and subsequent distillation of starches and sugar and can be made from a wide variety of cereal and sugar products. Biodiesel is produced through the refining and esterification of a wide range of oil crops, animal fats and used cooking oil. At more sophisticated levels of technology, not yet in commercial operation, both bioethanol and biodiesel can be produced from the same feedstock.

The relation between biofuels and food security is strongly influenced by the choice of feedstock and land-use. What are known as first generation biofuels are equated with the use of

food crops as feedstock based on established process technology. Second generation biofuels are identified with the non-edible parts of crops, with certain grasses and wood products and their transformation into fuel using cellulose technology whose scale-up is at an early stage. In principle, this second generation would have different food security implications both from the standpoint of prices and land-use.

Further down the line, a third generation of biofuels is identified with the industrial production of biofuels from algae. Here food security would be limited to possible consequences for fisher communities. Beyond this point technology routes merge with research to transform a range of renewable energy into liquid fuels. Other options via the transformation of urban and rural waste are also being explored for the production of biogas. These would in principle be either neutral, or in the case of waste food recycling, highly positive for food security.

Of the world's poor and food insecure some 70% are to be found in rural areas although within a trend to increasing urbanization in all countries. In addition, many in rural areas depend partially or primarily on food purchases. Both land and prices are therefore central to the discussion of biofuels and food security.

The world's poor and food insecure are heavily concentrated in South East and South Asia and Sub-Saharan Africa. 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). An exclusive North-South view of biofuels-food security would, therefore, be inappropriate. While for many of these countries biofuels may be a question of the opportunities /threats of land investments for external markets, the issue of liquid transport fuels has also become a vital question for the domestic markets of the leading countries in these regions. Indeed as from 2012, the South is now consuming more transport fuels than the OECD countries dramatically confirming this shift to the South (Nelder, 2012).

Conversely the issue of food security has begun to be raised in connection with biofuels in the North. In the EU, this is associated with increasing levels of food imports in conditions of climate uncertainty (EASAC, 2012). In the EU and in the US it is expressed in the conflict which pits the food industry against the proponents of biofuels using food crops. The pressure of higher priced agricultural inputs on final food prices has become particularly acute in 2012 in the US, where the tightness of corn markets was exposed by the prolonged drought and led to the unprecedented import of corn into the US from Brazil. The current surge in the production of alternative fossil fuels, especially natural gas and shale oil is creating expectations for options other than biofuels to replace traditional oil and may accelerate changes in the rules of the game. The United States is centrally concerned here but many other countries are contemplating similar options.

Through prices, policies and land effects, biofuels have both global and local impacts on food security, which will be the object of analysis and policy proposals in the Report. Dependence on world prices for access to food was dramatically revealed in the food riots affecting some 28 countries in the light of the price hikes of 2007-8. Nevertheless, the transmission of global food prices at local level depends on a range of factors from exchange rates, to crop substitutes, trade access and local consumption practices. Similarly, different forms of land investment have varied social and economic implications relevant for food security. We will analyze the evidence on social and economic implications of biofuels adoption using typologies identified in the literature to characterize both countries and production systems. In this light we will consider to what extent regulation and voluntary forms of governance, in the form of certification systems take into account food security related criteria.

Much of the literature under review is primarily concerned with the energy, climate change, and biodiversity impacts of the adoption of biofuels targets and mandates. In this report we highlight the factors specific to an appreciation of the food security aspects of biofuels. Nevertheless, one of the findings and the recommendations arising from this report is the need to understand and design policies which recognize the intimate connection between energy, climate change and biodiversity concerns and those of food security.

1. BIOFUELS POLICIES

1.1. The Rise of Policy-based Biofuels Markets – Ethanol in Brazil and the US

Modern biofuels 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 which created a biofuels ethanol market and a biofuels productive sector in this period were Brazil and the US, the former using sugar-cane and the latter corn. In both cases the defense of the interests of powerful agricultural and agro-industrial sectors was key, but these interests coincided with broader strategic goals to reduce levels of energy dependence.

Biofuels were not the result of policies to regulate a market but involved the policy creation of these markets via obligatory or highly stimulated blending targets/mandates coupled with a range of tax exemptions, subsidies and favorable credit. After a decade Brazil was producing 12 billion liters a year and, in addition to a blending demand of some 20% with gasoline, 90% of new car sales were 100% ethanol (Wilkinson & Herrera, 2010).

In the US, an initially regional response to farming pressure for the development of new markets became integrated into the Federal goals of the Carter administration for greater energy independence. The California Clean Air Act and the banning of the oxygenate MTBE further stimulated ethanol blending. The production of flex-fuel vehicles was also encouraged by the CAFE benefits provided to automobile makers. Tax breaks were tied to E10 blending targets and domestic ethanol was protected from imports by a 54 cent tariff (Glozer, 2011).

In both countries, the '90s, with more favorable oil prices, saw an interruption in the development of the ethanol markets. In Brazil, the alcohol car virtually disappeared although compulsory blending maintained the ethanol market at more modest levels. In the US, lower oil prices and the lack of policy support measures by the Clinton administration also led the ethanol market to hibernate during the '90s, increasing only from 1.0 billion liters in 1992 to 1.7 billion in 2001. With no overall mandate, and blending targets dependent on the stimulus of tax exemptions, the market was maintained primarily through the substitution of ethanol for the banned MTBE (Glozer, 2011).

Nevertheless when the surge in biofuels promotion took off in the early years of 2000, the policies of these two countries had already consolidated both a biofuels market and a biofuels industry. In the course of the first decade of this century the Brazilian ethanol sector was now able to operate under market conditions, and analysis has suggested that US ethanol, given continuing high oil prices could also survive without mandates (Babcock, 2011).

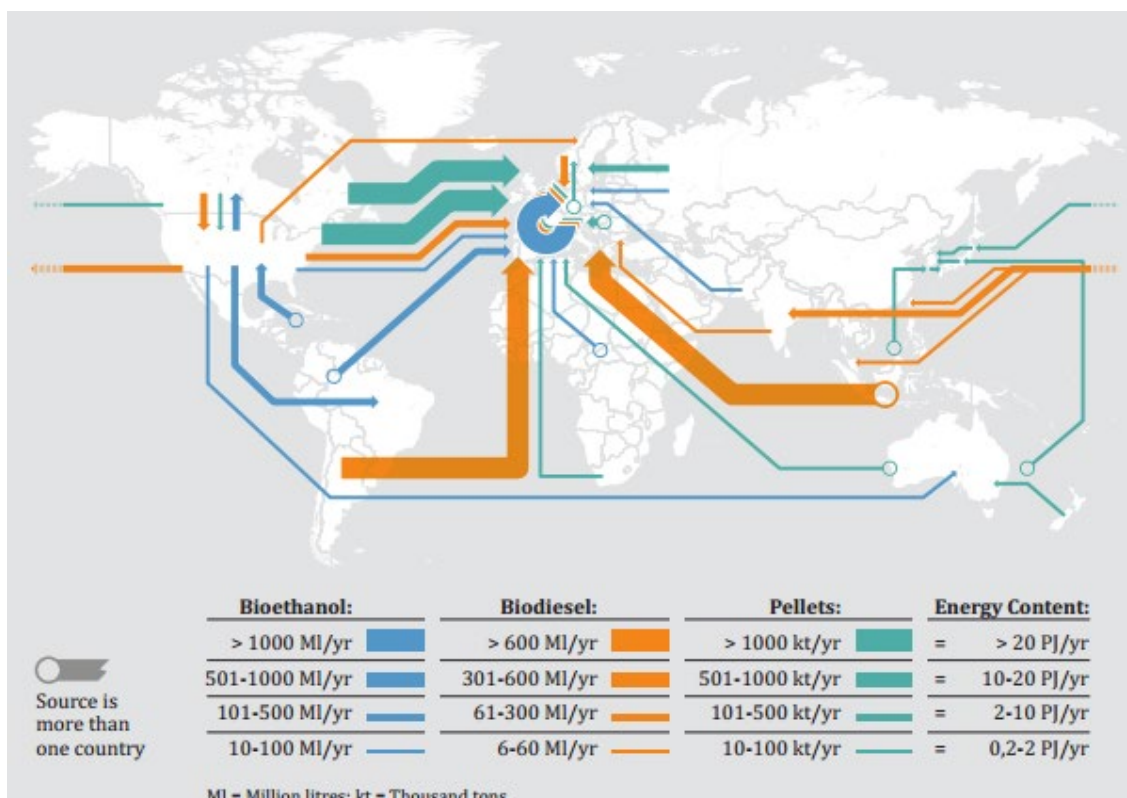
1.2. The Entry of the EU and Biodiesel

In the first decade of this century the EU emerges center stage and introduces three new elements into biofuels policies:

1. Differently from Brazil and the US where farm lobbies and energy concerns predominated, the principal driver in the EU was the fulfillment of commitments to the Kyoto targets (European Directive, 2003). This has made EU policy, and biofuels more globally, highly sensitive to positions adopted within the scientific community and civil society.
2. In the EU, a biofuels policy had to give priority to biodiesel which represents half the light vehicle fleet in Europe and in some countries well over half of all new car sales. From a feedstock perspective this involves a shift from cereals to oil crops where

- Europe is traditionally in deficit, and the promotion of oil crop expansion involving much direct land use change (DLUC).
- Given the traditional dependence on imports of oil crops and the rapidly expanding mandates, the EU becomes structurally dependent on imports, either of biofuels, or feedstock, to meet its targets. This is true for ethanol imported first from Brazil and later from the US, and even more so for biodiesel where over 40% of feedstock is currently imported, variously from Latin America, Africa or Asia. By 2020, the EU would be importing annually some 15.9 billion liters equivalent (Bowyer, 2010, German & Schoneveld, 2011). The EU biofuels policy, therefore, implies also the creation of an increasingly global market and the involvement of developing country agricultures.

Figure 1. Net trade streams of wood pellets, biodiesel, and ethanol, 2011



Source: REN21, 2012.

The European Parliament in 1998 proposed the adoption of a biofuels program with a 2% blending target. This was endorsed by the European Council in 2001 where biofuels were clearly identified with an option for sustainable development and Kyoto commitments. This position was also in line with the *Green Paper on Transport* which proposed a 20% target for alternative transport fuels by 2020. In Europe, transport was responsible for 30% of final energy consumption and 30% of total CO2 emissions with road transport accounting for 84% of these (European Commission, 2012). In the 2003 EU Directive, a target of 2% blending was established for 2005 and a 5.75% mandatory target fixed for 2010. The Directive also called for biannual evaluations to assess the development and impacts of the program (EU Directive, 2003).

In 2009, the EU Climate and Energy Package and the Fuel Quality Directive, the EU/RED Directive, were adopted by the European Council. This package increased mandated blending of renewable transport fuels to 10% by 2020.

1.3. New Dynamics to Biofuels in US and Brazil

The first decade of this century also sees a leap forward in biofuels in both the US and Brazil. Biofuels in the latter country experience a remarkable comeback with the launching and rapid diffusion of the flex-fuel car, where fuel decisions can now be taken at the pump and not, more irrevocably, at the point of vehicle purchase. The deregulation of the sugarcane sector in this interval meant that ethanol in Brazil became largely market driven, with primacy for the rapidly growing domestic market of flex-fuel vehicles.

In addition, and in counterpart to the large-scale monoculture model of sugar-cane ethanol production, the Brazilian government launched a biodiesel program formally justified in terms of social inclusion and rural development. The idea was to base the program on the family farm production of biodiesel feedstock using regionally appropriate oil-crops which could be integrated into existing farming systems. Blending targets were originally fixed at 2% but rapidly evolved to B5 by the end of the decade. Although the product of a sophisticated policy of market construction to ensure predominantly family farm participation in feedstock supplies, Brazilian biodiesel is currently overwhelmingly dependent on soy with animal fats making up most of the rest (Wilkinson & Herrera, 2010).

In the US, the first decade of this century also saw a dramatic surge in biofuels as a result of the mandatory policies adopted by the Bush administration. The Energy Policy Act of 2005 required that 7.5 billion gallons be incorporated into transport fuels by 2012. Two years later in the Energy Security and Independence Act the figure for corn ethanol was set at 15 billion gallons by 2015, with a further 21 billion gallons of advanced biofuels added progressively up to 2022. Ethanol production in the US shot up from 1.7 billion gallons in 2001 to 13.9 billion gallons in 2011, overtaking Brazil whose ethanol sector only produced 5.5 billion gallons in 2011 after being severely hit by the 2008 financial crisis. A host of policy support measures have facilitated these targets, (Schnepf & Yacobucci, 2012).

US biodiesel, using largely soy as its feedstock, is still well under 1 billion gallons reflecting its share in the transport matrix. In the renewable fuels legislation some 1 billion gallons of biodiesel are included in the advanced fuels category to the extent that they show a 50% reduction in GHG lifecycle emissions.

1.4. The Generalization of Policy Promoted Biofuels Markets

While a number of other countries initiated biofuels policies in the '70s 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. By the end of the decade over 50 countries had mandates or targets in place (see Table in Annex), motivated variously by the attraction of the emerging global market and the associated perceived perspective for new sources of income, employment and rural development, by the return of sustained high oil prices and concerns over GHG emissions. If we calculate an average mandate of 10% blending 26% of the world's total cropland would be required (see Chapter Four).

1.4.1. China's Biofuels Policy and Food Security

China, in spite of its sustained three decade record of high growth, accounts for 25% of the world's poor and food insecure. It is also now the world's number one emitter of GHG. Its car sales market, at 18.5 million in 2011, is now the largest in the world and is expected to increase to 30 million a year by 2020. Even so only 3% of the population are car owners compared to 80% in the US, which makes biofuels targets more modest with regard to the agricultural resources which will need to be mobilized, but at the same time points to a huge future increase in this source of GHG emissions.

China is also dependent on oil imports for over 50% of its needs, a figure estimated to increase to 75% by 2030. China initiated its renewable energy policies in 2000 and set a renewables target of 10% of total energy demand by 2010 increasing to 15% by 2020. For liquid biofuels the target set was for 10 million tons of ethanol and 2 million tons of biodiesel and five large-scale plants capable of producing 1.87 million tons were constructed. According to Qiu et al (2011), the ethanol target represents only 14% of total gasoline consumption, but would use 20% of China's maize production, some 32 million tons, and 6.6% 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, L et al, 2010)

In the light of these figures and their food security implications, China changed its biofuels policy and in its "Development Program for Renewable Energy" in 2006-7 decided on the use of non-cereal crops and the incorporation of marginal lands. (We will consider the discussions on marginal land in the chapter 4). 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, 2011)

Sweet sorghum, sweet potato and cassava then became the preferred crops and the ethanol targets were lowered to 4 million tons in 2010 and 10 million in 2020. China has a cassava plant with a capacity for 150,000 tons 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 feedstock competes with food crops for land, and intercropping seems to be the guiding strategy.

Jatropha is being promoted for biodiesel through the incorporation of marginal lands. Official calculations put marginal land at 130 million hectares but the above authors (Qiu et al, 2011) suggest that only 7 million are effectively available. The targets for biodiesel, which is little used in transport, are much more modest: 0.2 million tons in 2010 and 2 million tons in 2020. China is heavily dependent on imports for oil crops 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, the authors 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. India: Biofuels and Food Security

India imports 75% of its crude oil consumption. It is the third largest emitter of CO₂ after China and the US. Its vehicle fleet was 90 million in 2005 increasing to 140 million in 2011. With vigorous economic growth between 6-8%, annual transport growth is currently around 8-10%. 51% of petroleum consumption goes to transport as against only 4% for agriculture (Gain, 2012).

Both as a response to energy dependence and emissions in the light of a rapidly increasing transport sector India has adopted the EU norms on emissions which involve the promotion of clean and green fuel. In 2003, it decided on a 5% Ethanol Blending Program but

by the end of the decade only 2% blending had been achieved and biodiesel was insignificant (Gain, 2012). India's bioethanol comes principally from molasses although favorable harvests may permit use of the sugarcane 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% and later to 10% although these figures have not been met. Nevertheless, a target for 20% for all biofuels has been set for 2017.

Although for many reasons ethanol has not advanced as planned as a transport fuel, electricity from sugarcane biomass is an important factor in power generation for many plants in the sector and in other industries.

The policy for biodiesel, as in the case of China, has been to plant jatropha on marginal lands. An ambitious program for reaching a 20% blend by 2012 through the incorporation of between 11.2-13.4 million hectares was launched in 2003. 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% blending would require 18.6 million hectares of marginal land. Although 100% FDI is permitted for biofuels projects oriented exclusively to the domestic market, non-edible plantation investments for biofuels are not allowed.

The first four objectives of India's Biofuel's Policy approved in 2009 are as follows:

- 1) Meet energy needs of India's vast rural population, stimulating rural development and creating employment opportunities;
- 2) Address global concerns with emissions reductions through environmentally friendly biofuels;
- 3) 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;
- 4) 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 which 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.

1.4.3. Biofuels in other Asian Countries

Of the other major Asian countries, Japan and South Korea meet their targets through imports coming from the US, Brazil, and Argentina. Indonesia and Malaysia, in spite of being responsible for nearly 90% 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 NGOs have associated deforestation in Indonesia and Malaysia with European demand for biofuels. In practice only small quantities of palm-oil or biodiesel is exported to Europe and the deforestation can be understood better as an indirect land use change (ILUC) effect as more palm-oil is used in the food industry (Sanders et al, 2012). Thailand has the most ambitious biofuels targets and has been studied by the BEFS-FAO bioenergy team (2010). It recently also became the major regional exporter of cassava to China and is discussing limiting these exports for food security reasons (Rosenthal, 2011)

1.4.4. South Africa Biofuel's Policy

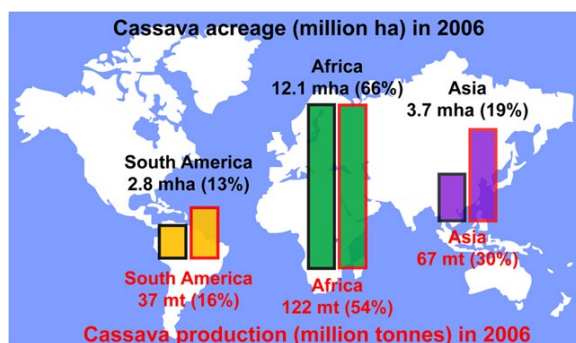
In a very different context, South Africa has also focused its biofuels program on “under-utilized land”, a concern evident both in India and China, and on excluded small producers, which recalls the Brazilian biodiesel program. The results have so far, however, been very unpromising. One fundamental 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 maize should not be acceptable as a feedstock at least until the program was consolidated.

The objectives of the program were not inspired by either energy dependence or concern with CO₂ emissions, and 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 program to promote rural development, alleviate poverty and focus on non-cultivated lands, more specifically “new and additional lands” and/or “currently under-utilized lands”(Sparks & Ortman, 2011).

Cassava: a “new” biofuel feedstock

There is a growing interest to use Cassava (*Manihot esculenta* Crantz) as a feedstocks for ethanol-based biofuel (Jansson, 2009). 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).

Cassava is grown in many countries in the tropics. In 2006, total world production of cassava was around 226 Million tons with Africa as the main producer region (http://www.pb.ethz.ch/research/cassava_projects/cassava_facts). Country wise, Nigeria, Brazil, Thailand, Indonesia, and the Democratic Republic of Congo are the main producing countries, accounting for almost 70 percent of the world’s cassava (FAO, 2000).



Data from FAO (2008). Picture: H.Vanderschuren (ETH Zürich) (available at http://www.pb.ethz.ch/research/cassava_projects/cassava_facts).

The first important use of cassava is for human food. It ranks as the fourth most important source of calories after rice, maize, and potatoes (FAO, 2000) or fifth if we add wheat to the list. Cassava as daily food serves approximately 600 million people in the world (http://www.pb.ethz.ch/research/cassava_projects/cassava_facts). Cassava is important as a staple food in Africa. In Sub-Saharan African regions, in particular, “more than 200 million—about one-third of the population—get more than half of their calories from foods made from cassava roots” (Manyong, 2000). Besides the root, young leaves are also used as greens. Since it is easy 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 particularly poor farmers, many of them are women (Rossi & Lambrou, 2008).

The second important use of cassava is as a feed ingredient for pork, poultry, cattle and fish farming. 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). In terms of trade, Thailand supplies around 80 percent of cassava on the market (FAO, 2001). Thailand, Viet Nam, China, and Nigeria are among the countries that are considering using cassava for bioethanol. Among these countries, China is where cassava as a feedstock is being mostly used today. China’s increased demand for cassava imports for feedstock contributed to the increase in the price of cassava in 2008 (Rosenthal, 2011). Originally, China used corn and wheat as a feedstock. Corn accounted for 82 percent and wheat 18 percent for crops used as feedstock for bioethanol production in 2012 (Scott & Junyang, 2012). 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. To reduce the amount of grain-based feedstock, the government has directed the new plants to use cassava and sweet sorghum as alternatives. Cassava is favorable because it has a higher conversion rate to bioethanol compared to sweet sorghum and sugarcane (Jansson, 2009), and is considered a non-food crop in China (Jikun et al., 2008). However since domestic cassava production (and sweet sorghum) is not enough to support the capacity of biofuel industries (Fengxia, 2007), some of the cassava raw material for bioethanol is imported from Thailand. Thailand, the largest cassava exporter in the world, sent nearly 98 % of its cassava production to China to make biofuel in 2010. Cassava exports to China from Thailand has increased fourfold since 2008 (Rosenthal, 2011; Sidhu, 2011).

The initial target was for an overall voluntary 2% blend (broken down into B2 and E8 given the overwhelming dominance of diesel-driven vehicles), which it was claimed would only occupy 1.4% of cropland and would create over 25,000 jobs (Funcke, Strauss & Meyer, 2009). The land envisaged was in the homelands where it was calculated that 14% of the land was under-utilized. A further goal was to focus the program on products which had been grown previously in the homelands, and on small farmers prejudiced by apartheid. In this respect the program echoes the Brazilian biodiesel program which similarly tried to base itself on the family farmer, choosing the feedstock in accordance with different regional farming practices.

To date the results have been quite negative. Some have attributed this to lack of compulsory mandates; others to the exclusion of maize. Letete and Blottnitz (2010), whose account we have largely followed, would give more importance to the ambiguity of the notion of "under-utilized" land, 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 are three times diesel prices and the only biodiesel currently being commercialized come from small plants recycling used vegetable oils.

1.4.5. An Emerging Biofuels Strategy in Sub-Saharan Africa (SSA)

With the exception of the long established domestic biofuels policies of Malawi and Zimbabwe, biofuels in Sub-Saharan Africa in the middle years of the last decade were largely dominated by responses to the bio-diesel demand created by the EU mandate, and by Brazil's championing of a global ethanol market. The former largely took the form of foreign investment proposals for re-export, benefitting from the "All but Arms" conditions of access to the EU market, and might also be accompanied by CDM or RED benefits. Brazil, on the other hand, promoted more ambitious "government-to-government" policies for the development of biofuels strategies, including technology transfer and agricultural research and assistance.

National and SSA regional policies have largely developed as a reaction to the perceived problems arising from the pressure for the incorporation of the region as a raw materials supplier directly to Europe on the basis of foreign investments. Maltitz and Stafford (2011) capture this process well in their recent analysis which identifies the subsequent emergence of commonalities among SSA policy formulators on the need for biofuel policies to:

- 1) Be designed for the promotion of rural development;
- 2) Be geared to the objectives of energy security;
- 3) Develop the ability to attract appropriate investments; and
- 4) Be based on sustainable land use.

1.4.6. Biofuels in Latin America

The development of biofuels policies in Latin America were very much influenced by Brazil, particularly in Central America which was seen as a potential platform for exporting to the US without having to pay the 54 cents tariff. Argentina, for its part developed a vigorous biodiesel program, quickly reaching B10 for the domestic market. For the powerful Argentinian soy farming sector, however, the key motive was access to the European market in the wake of the negative reputation acquired by South-east Asian exports of palm oil.

While Brazil was seen to be exceptionally endowed in land, studies by the FAO and the ECLA (2008) characterized Latin America as a whole as having abundant available land which

could be incorporated into biofuels production without prejudice to food production. This provided a green light for the development of national targets and mandates both for ethanol and biodiesel (see Figure). The Inter-American Development Bank (IDB) was likewise a key promoter of biofuels investments in the middle years of the decade.

1.5. “Land-Use Change” provokes Changes in EU targets and Influences US Policy

In the chapters on Prices and Land we will discuss in detail the growing critiques of the impact of biofuels on prices, on land displacement in developing countries, and most decisively on land use change (LUC), and the consequences of direct (DLUC) and indirect land use change (ILUC) on the levels of carbon emissions. Here, we will only draw attention to the consequences of these critiques on the EU Biofuels Policy, and to the parallel questioning of the US mandates once it became clear that second generation biofuels were in no position to take over from food-crop biofuels as imagined in the policy mandate.

In October 2012, after almost two years of discussions, the EU issued a directive radically modifying its mandated targets, capping biofuels based on food crops at 5%, a level virtually reached by that time for Europe as a whole and which some countries had already exceeded. While the overall targets remained they would now have to be achieved with non-food biofuels or alternative renewable fuels. In addition Europe’s cooperation for development programs would no longer support biofuels investment projects.

In the US, at the same time, maize based ethanol was nearing the “blending wall” of E10 and was close to its allotted share of 15 billion gallons. It was clear, however, that second generation biofuels were still far from commercial scale and would not be able to fill the remaining 16 billion gallons. As the perspective of biofuels exports to Europe declined the way was opened for Brazilian ethanol to occupy the 4 billion gallon window of advanced biofuels, along with 1 billion gallons of US biodiesel.

Biofuels policies in the North are now at a turning point which promises to put a ceiling on food-based biofuels at around their existing levels. Regional ethanol exports will probably increase from Brazil, while the US will be looking to export markets for its maize ethanol. The 2012 change in EU mandated targets looks likely to freeze the emerging global market created by the expectations in relation to its demand. This market had already been shaken by the food price hikes of 2008, and the “food x fuel” debate which they provoked. Many foreign investment projects had already been abandoned or put on hold and the EU’s new directive will certainly accelerate this process.

For developing country biofuels policies this means that much needed investment capital will be more difficult to mobilize but it will also allow space for the redefining of national and regional policies around the four principles formulated by Maltitz and Stafford (2011) which we have reproduced above.

What is less clear is the impact of future demand by China and India both on biofuels investments in Africa, where both countries are active, and on the development of a regional biofuels trade, as in the case of cassava exports from Thailand to China. It remains to be seen whether other countries will be led to revise their biofuels targets/mandates in the light of the EU decision.

A recent development in the EU which 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.

1.6. Country-based Typologies as Guides to Biofuels Policymaking

The establishment of country typologies can be a useful first step in the elaboration of biofuels policies. Pingali et al (2008) establish a 2x2 matrix based on the potential to respond to increased demand for agricultural (biofuels) 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. In such a matrix we could distinguish: 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 investment is therefore likely to 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 labor 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. Tanzania would fit this category as would a number of Latin American countries.

2. BIOFUELS AND THE TECHNOLOGY FRONTIER

2.1. Technology Trajectories at a Crossroads

The wide support that biofuels recently enjoyed has become contested as studies began to emerge connecting their rapid growth to rising food prices, challenging their credentials both in terms of their capabilities to displace fossil energy and reduce emissions of pollutants (including greenhouse gases), and 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). Together, these critiques and challenges have created a sense of urgency with regard to the commercial development and distribution of biofuels produced from non-food biomass, which are less resource (e.g., land and water) intensive, and have better sustainability and environmental credentials. These biofuels, which have been envisioned to augment and displace existing food-based feedstocks, have received the broad name of second generation biofuels.³

Despite massive efforts in terms of investments in research and development and the progress made in recent years, significant hurdles still need to be overcome before second generation biofuels can be produced at commercial scale (IEA 2008). Additionally, uncertainty remains about their likely contribution to extending global energy supplies. In particular, the technical potential for biofuel production depends critically on both the amount of land that would be available, and the biomass productivity. While biofuels could technically make significant contributions to the global energy supply, their market potential is likely to be more limited due to the amount of feedstocks that can be economically produced and harvested as well as their costs relative to those of liquid fossil fuels (Carrquiry, Du, and Timilsina 2011). We provide here a summary comparison of the performance of several first and second generation biofuels, based on their estimated costs, energy balances, and greenhouse gas emissions when compared to the fossil fuels these would displace.

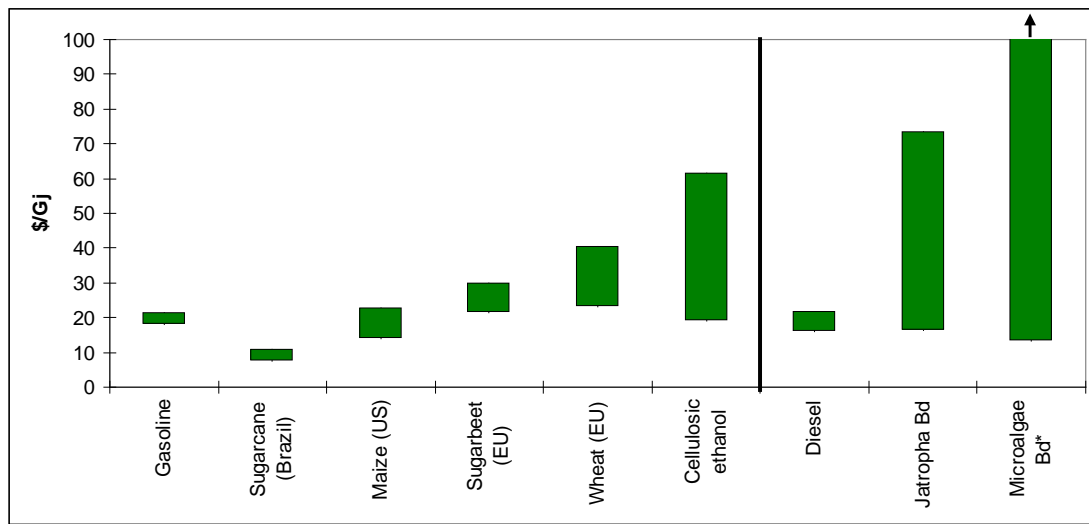
2.2. Costs and Efficiencies of First and Second Generation Biofuels

A comparative review of the cost of biofuel (first and second generation) production against those of the fossil fuels they could displace was conducted in a study by Carrquiry, Du, and Timilsina (2011), a figure of which we reproduce here (see figure Y). While most sources calculate the cost of second generation biofuels above those of fossil fuels, their estimated costs vary widely across studies. However, these numbers can be partially used to explain the current lack of commercial scale deployment of biofuels other than first generation. They are still too expensive to be produced based on market forces and recent policy support. The International Energy Agency (IEA), together with a range of other research, now considers that second generation biofuels will not be commercially viable before 2020.

³ To the best of our knowledge there is no strict technical definition for the terms first and second generation biofuels. The main distinction between the two seems to hinge on the feedstock used in production (Larson 2008). In broad terms, first-generation biofuels are those mainly based on sugars, grains, or seeds, and generally requiring relatively simple processing to produce the fuel. Second generation biofuels are those made from non-edible and/or lignocellulosic biomass, including residues of crops or forestry production (corn stover, rice husks, forest thinning, sawdust, etc.), and dedicated energy crops such as fast growing trees and grasses (e.g. poplar, willow or switchgrass). Biofuels obtained from vegetable oils produced from sources that do not directly compete with crops for high quality land (e.g., jatropha, microalgae) have also been labeled as second generation biofuels. More on this below.

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 centered on the processing stages. Although the technology is more complex and some aspects require new solutions both technology routes are well known and mature. At their current stage of development, however, they can be many times the costs of first generation options and fossil fuels.

Figure 2. Biofuel production cost (\$/Gj) from various feedstocks



Source: Figure 3 in Carriquiry, Du, and Timilsina (2011).

Two common ways of assessing a fuel's energy balance are their fossil energy balances and their energy return in investments (EROI). The former is defined as the total energy provided by the biofuel over the fossil energy needed to produce them. EROI is calculated using total energy used for biofuels production (in the denominator) and not only fossil energy. Results greater than 1 indicate the biofuel is a net energy provider. We should also expect the EROI to be lower than the fossil energy balance since the denominator of the latter only includes fossil energy usage.

The table indicates that biodiesel tends to have better energy balances when compared to grain ethanol. However, sugarcane ethanol performs better than the other first generation biofuels. It is worth noting both the wide range and potentially high fossil 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 to attain desirable energy balances. The large uncertainty surrounding the EROI estimates, reflecting early stages of the development of this technology, should also be highlighted.

Table 1. Fossil energy balance of a sample of the fuel types.^a

Fuel	Approximate fossil energy balance ^b	EROI ^c
Cellulosic ethanol	2-36	-
Corn ethanol	~1.5	0.8-1.7
Wheat ethanol	~2	1.6-5.8
Sugar-beet ethanol	~2	1.2
Soybeans biodiesel	~3	1.0-3.2
Sugarcane ethanol	~8	3.1-9.3
Rapeseed biodiesel (Europe)	~2.5	2.3
Waste vegetable oil biodiesel	~5-6	-
Palm oil biodiesel	~9	2.4-2.6
Jatropha	-	1.4-4.7
Algae	-	0.01-7.01 ^{d,e}

Source: WWI (2007). ^a For the full list of fuels/feedstocks and references see table 10.2 in WWI (2007) ^b Ratio of energy contained in the fuel to the fossil energy used to produce it. ^c Energy return on investment. It is the ratio of energy in the biofuel over all the energy used for its production. Obtained from tables 1.1 and 1.2 of Stromberg and Gasparatos (2012). ^d Beal et al. (2010), Beal et al. (2012). ^e National Academy of Sciences (2012)

Another goal allegedly pursued by the production of biofuels is a reduction in the emission of greenhouse gases (GHG). 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 Y). The different pathways involve different combinations of feedstocks, conversion, process technologies, and type and nature of co-product handling. Some consensus seems to emerge from Table Y that biofuels, and in particular second generation 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 is the treatment of land use and land use change including both direct and indirect (Searchinger et al., 2008).

Table 2. GHG Emission reductions of select biofuels compared to gasoline and diesel excluding land use change impacts

Biofuel	Emission Reductions (%) ^a
Sugarcane ethanol	65 – 105
Wheat ethanol	-5 – 90 ^b
Corn ethanol	-20 – 55
Sugarbeet ethanol	30 – 60
Lignocellulose ethanol	45 – 112 ^c
Rapeseed biodiesel	20 – 80
Palm oil biodiesel	30 – 75
Jatropha biodiesel	50 – 100 ^d
Lignocellulose diesel	5 – 120

Source: OECD (2008), WWI (2007), Wang et al. (2007) and Whitaker and Heath (2009) data. ^a Values are approximate, as some reports only reported results in graphical form. ^b Negative numbers mean increases in GHG emissions. ^c Includes forest residues, energy crops (such as short tree rotations (e.g., poplar), and switchgrass), and crop residues (e.g., corn stover). ^d Whitaker and Heath (2009), their base base resulted in 62% GHG emission reductions when compared to diesel.

2.3. Second Generation Biofuels: Are they an Alternative?

While, however, discussion was originally focused on the maturity of second generation options, it is their appropriateness which is now increasingly being questioned. The defense of first generation biofuels as paving the way for the deployment of second generation biofuels is also being challenged. The discussion of a few examples and the challenges encountered should clarify these points. Some potential opportunities for paradigm changes are also discussed (Taylor, Sims & Saddler, 2008, IIASA, 2009).

The conception that first generation biofuels may pave the way for the second generation has considerable plausibility in the case of Brazil's sugar-cane ethanol. Ligno-cellulose technology is being applied to the components of the sugar-cane plant not previously used for biofuels. More advanced technology routes are exploring alternative fuels derived from sugarcane, and even the direct production of bio-diesel. In addition the bio-refinery model is being explored in the co-production of both bio-electricity and biopolymers (Zab, R., C. Binder, S. Bringezu, J. Reinhard, A. Schmid & H. Schnitz, 2010).

2.3.1. Synergies and Drawbacks

For other crops, however, the synergies are tenuous or inexistent. In the goal of reducing competition for resources, crop residues are increasingly being regarded as the most promising candidate. Waste products generally coincide with the lignocellulose components of crops. There are three potential disadvantages of crop remains:

1. They are less energy intensive than the original crop and their transport can be as much as five times more expensive.
2. They are more dispersed than traditional crops and therefore pose formidable logistical challenges.
3. They are often used to re-nourish the soil and so would have to be collected in much smaller quantities, exacerbating the former two limitations, or substituted by fossil energy nutrients.

While these critical considerations do not rule out their use, it is clear that biofuels from residues would only be viable in especially favorable scenarios, such as wood chippings, or crop residues that are densely located.

2.3.2. The Promise and Limitations of Biorefineries

These challenges posed by biomass within traditional production chain perspectives reinforce the position of those who argue for a paradigm shift towards the bio-refinery model of agro-industrial production (King, 2010). This would have the advantage of whole plant processing making possible the development of co-products and an increase in flexibility in the appropriation of biomass for different market conditions and opportunities. The development of bio-refineries, however, demands major advances in conversion techniques and feedstock processing and implies the reorganization of existing supply chains around a broader biomass conception. Hess et al (2010) have designed a biomass supply system consisting of a preprocessing depot which would furnish biomass to a central blending terminal. Local communities could use the preprocessing terminal for a variety of bioenergy requirements. The biomass would then be forwarded to a central blending terminal into "a variety of consistent, uniformly formatted and aerobically stable products" (p107). The biomass is then available as a commodity for the bio-refineries, and distributed along the lines of the grain industry.

2.3.3. Jatropha: so far a failure

Jatropha was seen by many as an ideal solution to the fuel-food dilemma, since it was identified as an oil crop which could flourish in poor soils and conditions of hydric stress. Mostly grown in Asia, less so in Africa and almost not at all in Latin America, jatropha has been the object of a considerable number of projects and policy goals. Particularly high hopes were placed on its potential for biofuels development on the African continent (Diaz-Chavez, 2010). It soon became clear, however, that, while jatropha had the agronomic advantages initially identified, its economic viability demanded high productivity levels which in turn required better quality soils and greater water inputs. It provided no ready solution, therefore to the competition for resources which has been the main source of criticism of first generation biofuels (Gasparatos, 2010).

2.3.4. Algae: still long in the future

Algae has been focused on as possibly a major or even in some scenarios the major component of second generation biofuels. Cost effectiveness, however, demands that these be large-scale operations (around a thousand hectares), and differently from other options it is the biomass which poses most technical challenges. In addition, the advantage of using water and even seawater rather than land, must be balanced by the considerable concern over environmental impacts of using coastal marshland. Second generation algae biofuels are therefore unlikely to be other than an exceptional option for developing countries (FAO, 2010; Subhadra & Grinson-George, 2010).

2.4. Second generation biofuels and developing countries

Given their technological complexity second generation biofuels pose enormous problems for less developed countries. The logistics, the transport and the engineering and scientific requirements are exactly those which are most at a premium. As a result, if they were to be attempted they would likely assume an enclave format occupying the most favorable locations. Second generation biofuels are, therefore, more likely to become consolidated in developed countries, or countries such as Brazil. The low energy content of second generation biomass, its general dispersion, and the tendency to occupy more grassland, would lead to land displacement of food crops to developing countries, reproducing the ILUC effect which would have to be incorporated into the efficiency calculations

If on the other hand, biofuels are situated within the broader category of bioenergy and seen in terms of their potential for contributing to development both in the urban and the rural context a new technology frontier unfolds harnessing biomass for the diverse energy needs of local communities – transport, lighting, cooking, water-management and the powering of local productive activities.

3. BIOFUELS, FOOD PRICES, HUNGER & POVERTY

A wide variety of papers have found that biofuels have increased crop prices and played a major role in triggering price increases but have disagreed about the magnitude and have less often directly addressed impacts on malnutrition. This part addresses the role of biofuels in four subsections. The first section distinguishes the impacts of biofuels on poverty and the impacts on malnutrition and discusses potentially impacts of biofuels on malnutrition. The second section evaluates the dominant role of biofuels in the recent agricultural commodity price increases. The third section introduces two other factors – exchange rates and Chinese stock management – which have also contributed meaningfully to price increases as measured in dollars. The final section discusses factors and arguments that have inappropriately clouded the discussion of the role of biofuels on food prices.

3.1. Understanding the Distinction between Impacts on Price & Impacts on Hunger & Poverty

It is important to distinguish the food price impact which biofuels exerts on malnutrition from its implications for poverty. Although the effects are intertwined, they are not the same and the failure to understand the distinction can lead to an important underestimation of the potential consequences of higher prices for malnutrition.

Relation to Poverty: Rising food prices lead directly to poverty impacts by causing the poor to spend more of their incomes on food. Equally important is the increase in the depth of poverty as the shifting of money to pay for food leads to less money for other necessities. On the other hand, some poor people who are small farmers with surpluses to sell may also benefit. For these reasons, the role of biofuels in increasing food prices is directly relevant for discussions of poverty, and we discuss that role below.

Relation to Hunger: As prices rise, some people will consume less, and that will be disproportionately the poor. For these reasons, price increases also contribute to poorer nutrition. However, the reduction in nutrition depends on how much the poor are able to pay higher prices, or put another way, it depends on how rapidly they must reduce consumption as prices rise. The more people reduce consumption for each 1% increase in price, the less prices will rise. For this reason, some models that predict relatively modest price rises due to biofuels, far from implying less of a problem from biofuels, actually predict a large effect on nutrition, and it is that effect that helps to hold down the rise in prices.

Few papers have directly attempted to estimate the different responses of supply and demand but one exception is an analysis by the European Commission's Joint Research Centre (Edwards et al, 2011). It analyzed the results of several different world agricultural models that were attempting to estimate the amount of land use change due to biofuels. The JRC study found that several models estimated large decreases in demand for each ton of grain dedicated to biofuels⁴. Analyzing the GTAP model used by researchers at Purdue University, the IMAGE model used by researchers at IFPRI and the FAPRI-CARD model used by researchers at Iowa State, the JRC found that from 34% to 52% of maize or wheat diverted to ethanol would not be replaced due to reduced food consumption. (Edwards et al, 2011, p. 89, Table 39).⁵

⁴ Because biofuels trigger changes in different types of commodities, the study used weight as the proxy for measuring changes in consumption versus changes in supply. The study also credited biofuel feed by-products as part of the food supply. In other words, if one third of the grain diverted to ethanol resulted in a feed by-product, that feed was not treated as a diversion into ethanol and instead treated as part of the food supply.

⁵ The models at issue were all run to estimate the land use change associated with biofuels. Problematically, some modeling papers attempt to estimate the role of reduced food consumption by running their models with food consumption constant and estimating the change in land use compared with model runs that allow food consumption to decline. This method does not accurately estimate reductions in food consumption because many intervening model effects hold down land use change even when food consumption is held constant. The differences are striking and the significance of the JRC paper is that it directly calculated the reductions in food consumption from the output tables.

These models include an enormous range of elasticities and functions, many of which are not known with precision. One alternative approach attempted to estimate directly the supply and demand responses of calories for the world's major crops due to recent price increases. It generated a range of estimates, but the central values implied that roughly one third of calories diverted to biofuel production were not replaced (Roberts 2010).

These models attempt to estimate only what could be called a "quantity effect." An alternative consequence might be a shift in food quality. In effect, when grain crops for biofuels displace other types of cropland, such as that used for fruits and vegetables or vegetable oil, they may result in a more modest reduction in food calories but a larger reduction in food quality. The MIRAGE model developed by IFPRI for the European Commission has estimated that maize for ethanol would displace a large quantity of other crops that have high nutritional value, such as oilseeds and fruits and vegetables, but lower caloric supply⁶.

In general, these models or other analyses tend to use short term rather than longer term elasticities. (It is very difficult to estimate long-term elasticities.) Over one or two years, the capacity of farmers to increase supply is more modest than over the long-term, which implies that declines in demand will have to take up more of the response. In the longer term, if demand does not continue to grow rapidly, supplies might catch up and the reduction in consumption might be lower.

According to the best UN estimate there were 870 million food insecure people in the world in 2011 (FAO 2012). They plausibly consumed roughly 5.5% of ⁷ world calories.⁸ As of 2010, biofuels used 5.9% of all the energy contained in crops.⁹ If one third of those crops were not replaced, the food insecure experienced even one third of that reduction, the world's food insecure on average would reduce their consumption by 9.5%. Because some people would face smaller reductions, others would face larger reductions.

This discussion also helps to identify potential impacts on food consumption by 2020 if the world were to achieve a commonly accepted target of producing 10% of its transportation fuel from biofuels by that date. That would require 25% of all the energy in world crop production as of 2010.¹⁰ Again, if one third of the crops were not replaced, and if even one quarter of that reduction were experienced by the food insecure, their reduction in food consumption would reach 40%.

In truth, we do not know what percentage of reductions in consumption the food insecure experience when crops are diverted to biofuels and prices rise. Yet these very rough figures provide reason to believe the effect is substantial and could be extremely substantial.

⁶ The model results are reported in Al-Riffai,(2010). For maize-based ethanol, the estimates are that to generate one MTOE of ethanol from maize, maize area will expand 6.52 hectares, but only 0.88 hectares occurs in new cropland for the remainder, maize displaces 5.64 hectares of other crops. That results in a reduction in total calories, but it also results in a shift in calorie consumption away from higher value crops.

⁷ This calculation assumes that the food insecure had "available" to them 2034 kilocalories per person per day. (That is based on the assumption that they consume 15% fewer calories than the recommended average daily calorie intake for people in developing countries (1819) plus average losses and wastes of 24%. That results in Total world crop calorie production as of 2006 was ____).

⁸ This calculation assumes that the world's hungry consumed 1637 kilocalories per person, based on the assumption that they consumed 90% of the FAO's recommended average daily energy intake for people in developing countries of 1819 kilocalories. That results in 520 trillion kilocalories per year, and 684 trillion kilocalories accounting for their share of world losses and wastes of food production. World total crop production was 9,500 trillion kilocalories in 2006 according to FAO data obtained from the authors of Alexandratos 2012, which makes the food insecure's share of world crop production by calories 7%.

⁹ This figure results from authors' calculations based on total energy in crops and the world energy contained in crops used for biofuels (excluding the energy that is later contained in by-products). Authors' calculations used world crop production based in 2000 from FAOSTAT, and the energy in crops (HHV) from Wirsenius (2000). Biofuels used the same after adjusting for by-products. Energy in crops used for biofuels are based on reports of world biofuel production and consumption for 2010 from the U.S. Energy Information Agency at (<http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=79&pid=80&aid=2&cid=regions&syid=2005&eyid=2010&unit=TBPD>), and determination of crops used for these biofuels based on various sources but primarily US Foreign Agricultural Service.

¹⁰ These figures are from author's calculations using the methods described above but also assuming that the biofuels in 2020 result from the same mix of feedstocks as those in use today. The calculation would only modestly change with different crop feedstock assumptions because they are based on the energy content in crops, not the quantities of crops.

Although price increases are the method by which biofuel demand translates into poorer nutrition, the ultimate facts that matter for hunger and malnutrition are how much of each ton of crops diverted to biofuel production is replaced by additional production and how much resulted in reduced consumption. That does not depend on the absolute size of the price increase but only in relative size of the response that is supply versus demand. We have reasonable evidence that the fraction that results from reduced demand is substantial. We also have good evidence that the poor cut back on consumption far more than the rich (HLPE 2011). We can therefore estimate that biofuels probably have had a meaningful effect on hunger and have the capacity to have much larger consequences if biofuel production continues to rise.

3.2. The Role of Biofuels in Increased Food Prices and their Volatility since 2000-2004

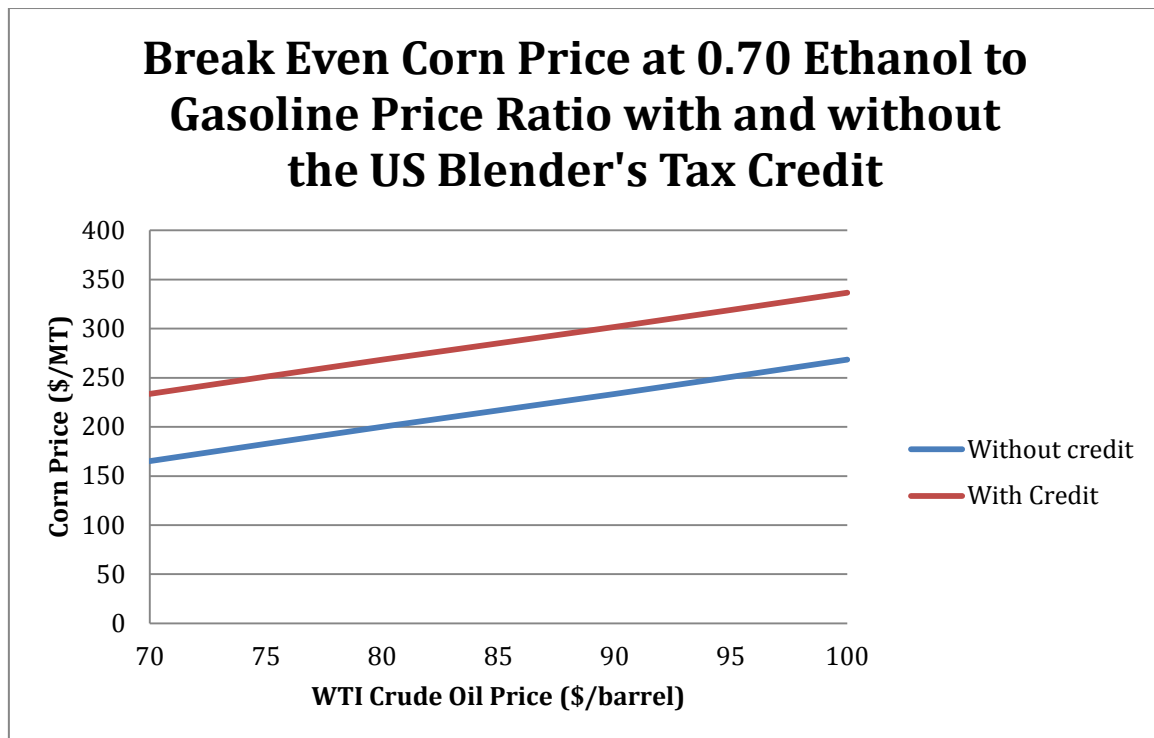
In line with the HLPE report on this theme (2011), our analysis indicates that biofuels have played a predominant role in the increases in food prices and volatility since 2004. Two basic reasons can be identified. In the first place, with the rise of oil prices, it has been economically feasible for ethanol manufacturers to bid up the price of maize (and through it the price of other crops) from roughly \$2.25 per bushel (\$88.6 per metric ton) to levels 2.5 to 3 times higher for much of 2008 and since 2010 (prices ranging from \$6-\$8 per bushel, or roughly % per bushel, or roughly \$235 to more than \$300 per metric ton) for much of 2008, and since 2010. Secondly, the production and supply of grain, vegetable oil and sugar supplies since 2004 have not been growing as fast as the demand for them, which is due in large part to the rise in demand for biofuels.

3.2.1. Linkage of Ethanol Demand, Grain Prices and Oil Prices

The simplest reason to believe that biofuels have driven large increases in grain prices is that it has made economic sense for biofuel producers to drive up grain prices dramatically. There is a relationship between oil and maize prices that determines whether ethanol is economically feasible to produce. As calculated by Bruce Babcock of Iowa State University, and assuming that ethanol sells for 70% of the price of gasoline, the relationship is shown in Figure 3.1. What this relationship means is that so long as the price of crude oil is \$80.00 a barrel, it is economical for ethanol producers to expand ethanol production so long as maize prices are \$200/ton (\$5.10 per bushel) even without any ethanol subsidies. With a \$0.45/gallon tax credit for ethanol in the U.S., which prevailed until the end of 2011, the break-even price for maize rises to \$268/ton (\$6.80 per bushel).

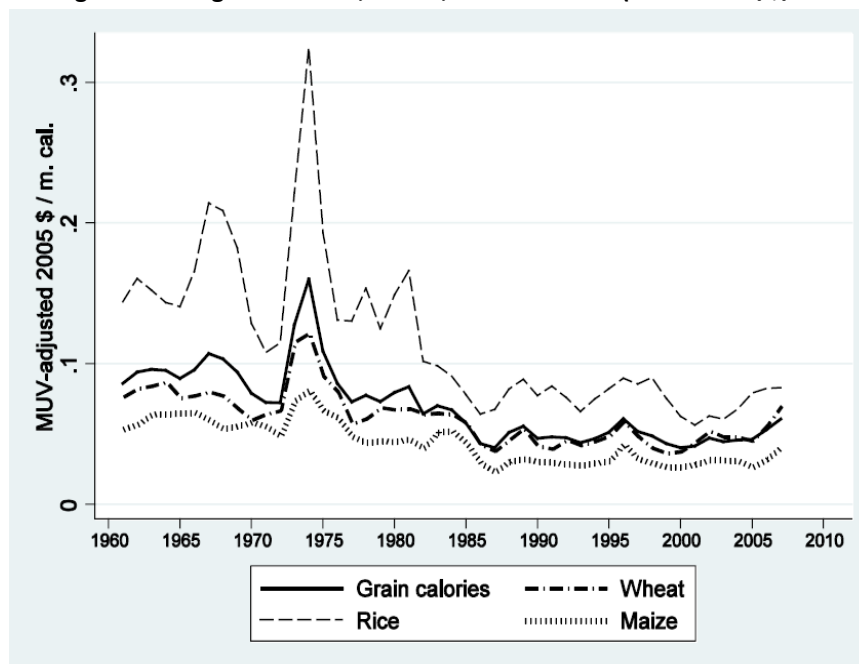
From 2000 through 2004, the world maize price averaged \$83.40 per metric ton. Crude oil prices were above \$80/barrel for much of 2008 (reaching close to \$100/barrel), plummeted with the recession, and have once again been over \$80/barrel since 2010. During this period, there has been ample production and distribution capacity to make and sell ethanol in the U.S. In the light of these conditions, demand for ethanol (including the additional incentive from the U.S. tax credit) by itself is capable of explaining a tripling of world maize prices for much of this period.

Figure 3. Relationship of Oil to Maize Break-Even Price for Ethanol With U.S. Tax Credit in Place Through 2011



The rise in maize price should also have driven a large rise in the prices of other grains. As figure 3.2 shows there is a close historical relationship between the price of maize and the price of wheat, and rice is also correlated although less perfectly (Figure 3.2 from Brian Wright (2012); Baffes (2010) includes a more thorough statistical correlation). These prices track each other because a substantial number of consumers are able to shift from one grain to another if the price of one rises, and because substantial numbers of farmers are able to shift production from one grain to another in subsequent years. (A recent paper from economists of University of California at Berkeley even shows that low world inventories for aggregate grains (maize, wheat and rice) better explain changes in prices than world inventories of individual grains (Bobenrieth, 2012)). The markets anticipate the substitution of one grain for another, and the tightness in one market is likely to translate immediately into tightness in others.

Some papers have downplayed the role of biofuels in triggering price increases because biofuels only directly consume some grains and because it is difficult to trace a temporal path between increased consumption of maize for biofuels and subsequent price increases for other grains (HM Government 2009 p. 20; Pfeuderer 2009). This position, however, fails to take into account the way markets anticipate the co-movement of different grain prices.

Figure 4. Market linkage between grain calories, wheat, rice and maize (1960 - 2010/\$/m.cal.)

Source: Brian Wright.

Any effort to explain why ethanol would have an effect on crop prices other than the doubling and tripling which we have identified, has to start by offering a cogent explanation of why ethanol producers would not have bid up the price of ethanol near to these amounts as oil prices rose.

3.2.2. The Role of Supply and Demand:

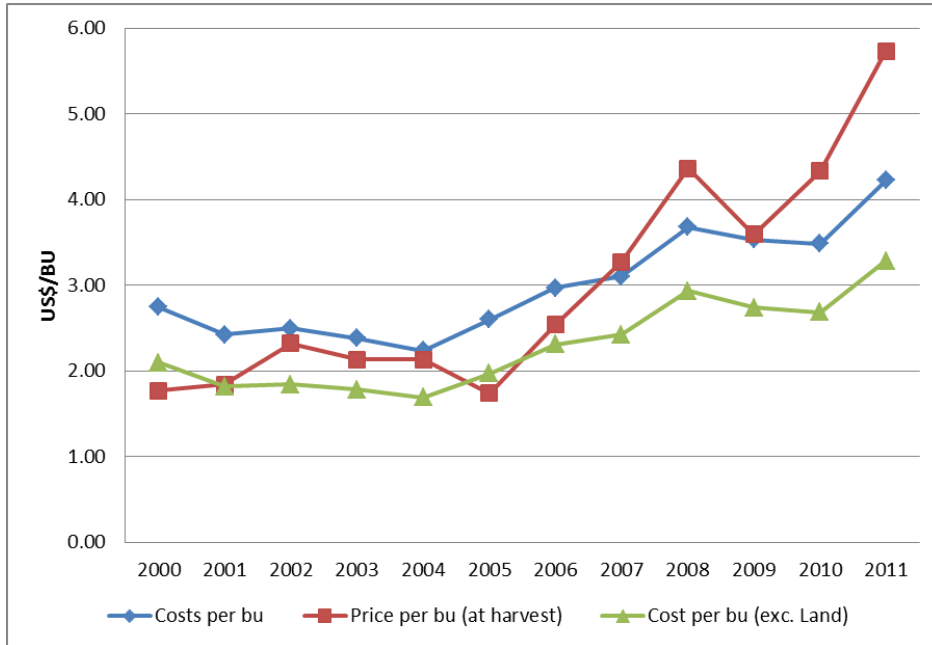
Although the rise in oil price has helped to increase demand for ethanol triggering price increases for maize, these price increases have only been one of the factors driving ethanol demand and grain demand. Other factors include government mandates and subsidies for biofuels, and as we discuss below, changes in Chinese imports. The rise in prices reflects the difficulty of supply in keeping up with rapid rising demand. Biofuels are a dominant part of that increase because they have had a large role in increasing demand for grain and because their increase comes on top of these other factors.

Although some papers have suggested that rising costs, particularly energy costs, explain the rise in crop prices, price rises have far outstripped the increase in costs. As one analysis by IFPRI economists in 2010 showed, the rise in oil prices which had already been substantial by 2007 could only explain 8% of the increase in maize prices in the US and 20% of the increase in wheat prices even on the assumption that farmers were able to pass on 100% of their cost increases (Headey, 2010, p. 27). Figure 3.3 presents the differences in the U.S. costs and prices for maize as estimated by the Economic Research Service of the U.S. Department of Agriculture : production costs increased 34% between 2000 and 2008, while prices increased by 146% in the same period. At the same time, land values have soared (Federal Reserve Bank of Chicago 2012). These rising returns to farming and land values demonstrate that rising costs of production have not been driving crop price increases; if costs were the driving factor, both land values and net returns to farming would have declined.

The price increase implies that supply has not been keeping up with demand, which has allowed farmers to charge prices above the costs of production. Estimates of the long-term

costs of production are unanimous that production costs for agricultural commodities should not rise much once farmers have full opportunities to increase production (see discussion of models below). The rise in prices therefore reflects not the absolute growth in demand but the rate of that growth, which has exceeded the rate of growth in supply.

Figure 5. Changes in production costs for maize versus prices in the U.S.



Source: based on data from Economic Research Service of US Department of Agriculture.

The question then becomes whether this imbalance is due to an increase in the rate of demand or some kind of shortage of supply. Many papers have blamed droughts and floods for food price increases, but as Figures 6 e 7 show, both global grain yields and production from 2005 through 2010 were generally above the trend line: only in one year, were yields below the trend line by roughly 1%, which is a modest deviation. As a result, higher than average grain yields have helped to hold down prices in a few years, in particular after 2008 and 2009. But not all years can be above average, and in more normal years, production has not kept pace with demand.

Figure 6. World Grain Yields and Production in Recent Years in Relation to a Trend Line from 1980-2004

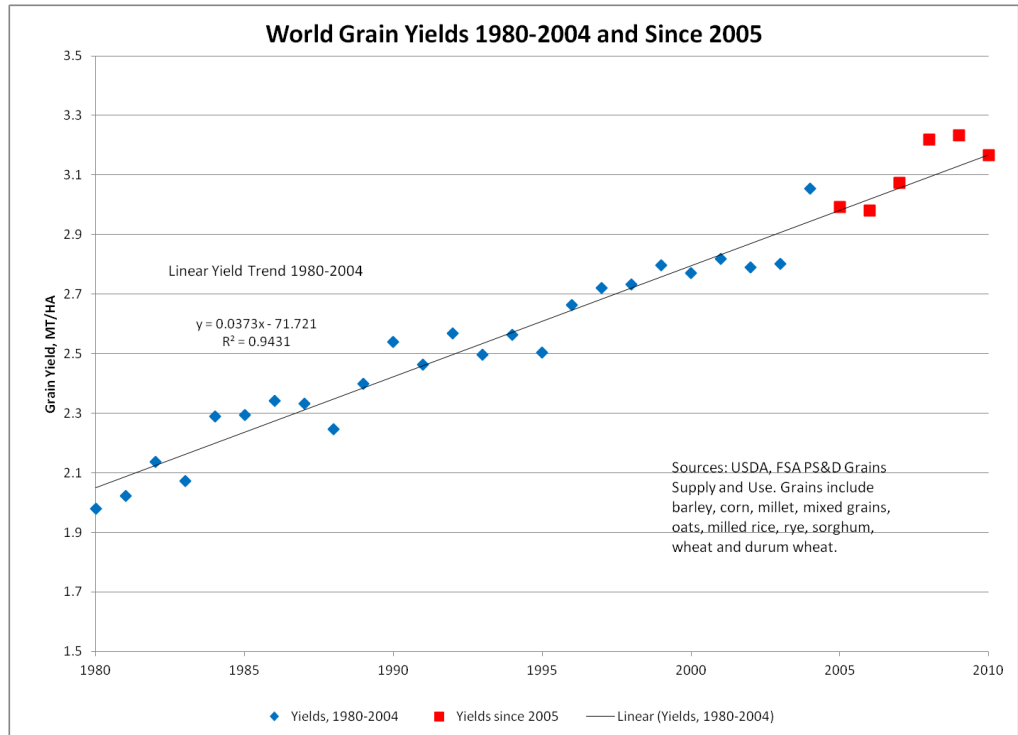
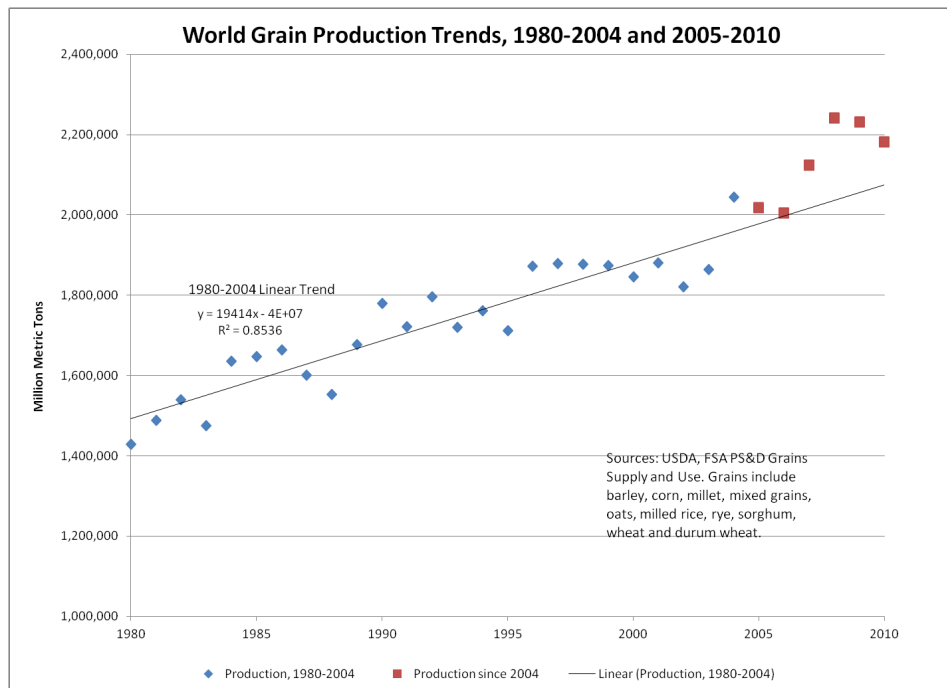


Figure 7. World Grain Yields and Production in Recent Years in Relation to a Trend Line from 1980-2004



Biofuels have been the dominant factor increasing demand (although the rise in Chinese demand for soybeans also plays a role as discussed below). In figures 6 through 7, we

present the increase in consumption of various crops since 2005, showing the quantity of the increase going into biofuels versus alternatives. (For grains, we separate out the portion devoted to ethanol that contributes to feed consumption using the simplifying assumption that ethanol by-products replace 30% of the grain and consider those by-products part of the increase in food supply.)

* Between 2005 and 2010, increasing demand for ethanol (after fully accounting for by-products) consumed 32% of the growth in grain consumption. Viewed another way, for every additional ton of grain (or by-product) for food and feed which farmers have had to produce since 2005, they have had to produce an additional 0.46 tons for fuel.

* Growth in demand for vegetable oil for biodiesel during this period (2005-2012) consumed 29% of the cumulative growth in demand for vegetable oil. Put another way, for every one ton increase in vegetable oil for food and feed, biodiesel required an addition 0.41 tons.

* Growth in ethanol devoted to sugar has consumed all of the increase in demand for raw sugar.

These charts show that the growth in consumption due to biofuels is a substantial fraction of the total growth rate. The increases in prices well above the costs of production indicate that price increases are due to an imbalance of supply and demand, and until 2012, supply was not falling below trend lines. The necessary conclusion is that the rate of growth in biofuels is playing a dominant role in triggering price increases.

Figure 8. Change in use for food and feed versus use for biofuel, grains (2005-2012)

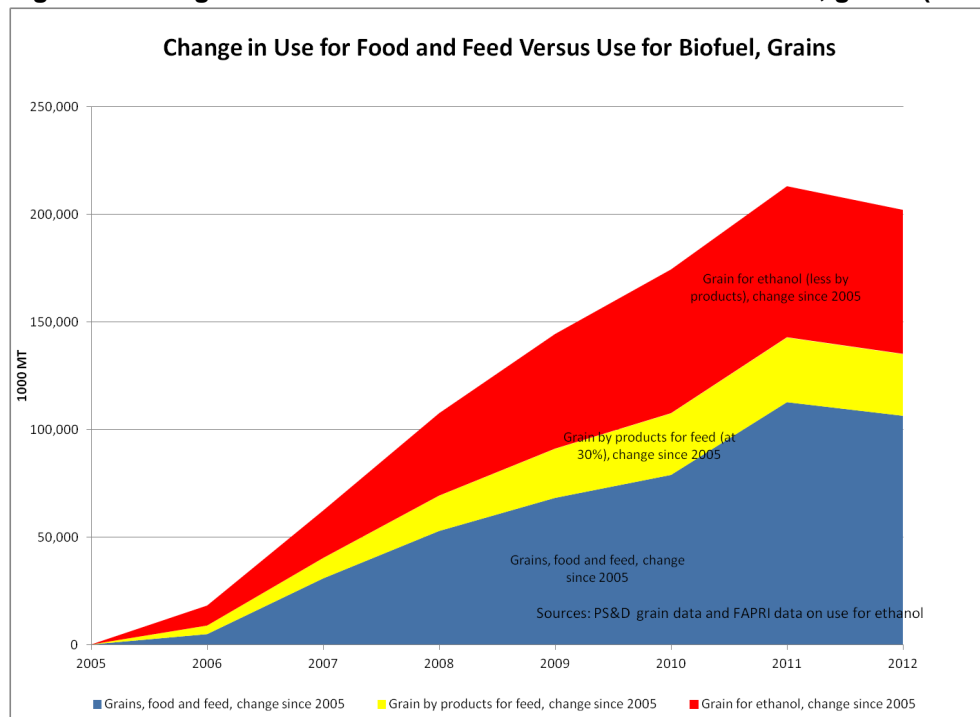


Figure 9. Change in use for food and feed versus use for biofuel, vegetable oil (2005-2012)

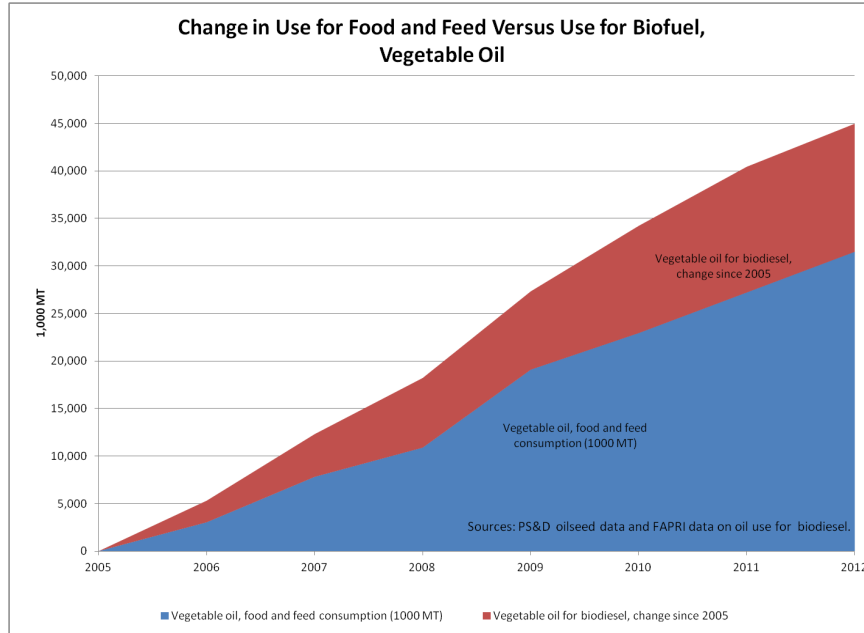
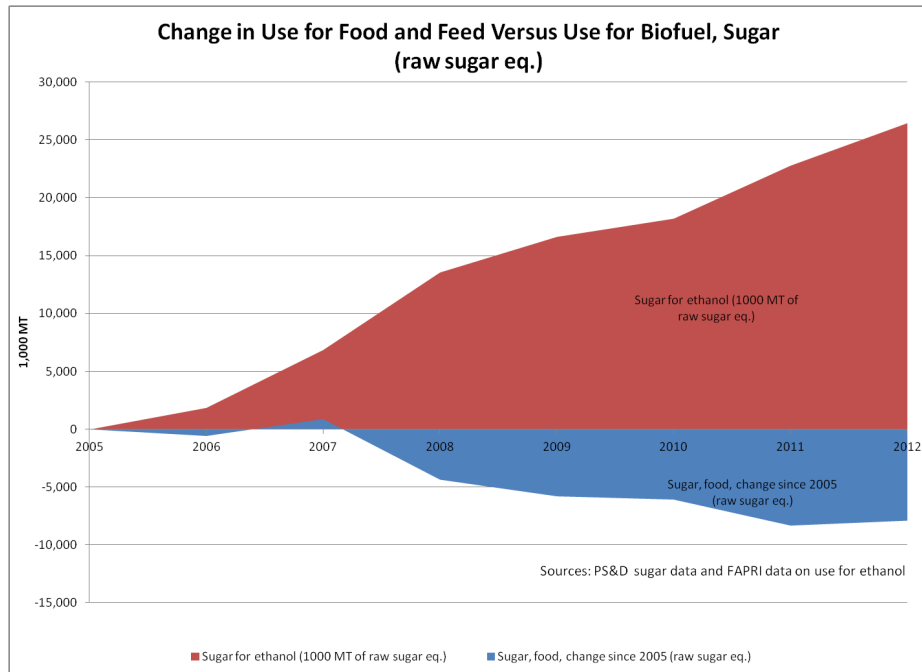


Figure 10. Change in use for food and feed versus use for biofuel, sugar (2005-2012)



3.3. Other Factors That Have Led to Higher World Crop Prices Measured in Dollars

On the above evidence and arguments the rise in demand for biofuels has played the largest role in price increases. At the same time, two other factors help to explain some of the rise in prices in recent years: changes in currencies, and the rising demand for soybean imports in China.

3.3.1 Exchange rates imply that world food price increases in recent years have not been quite as large as commonly reported.

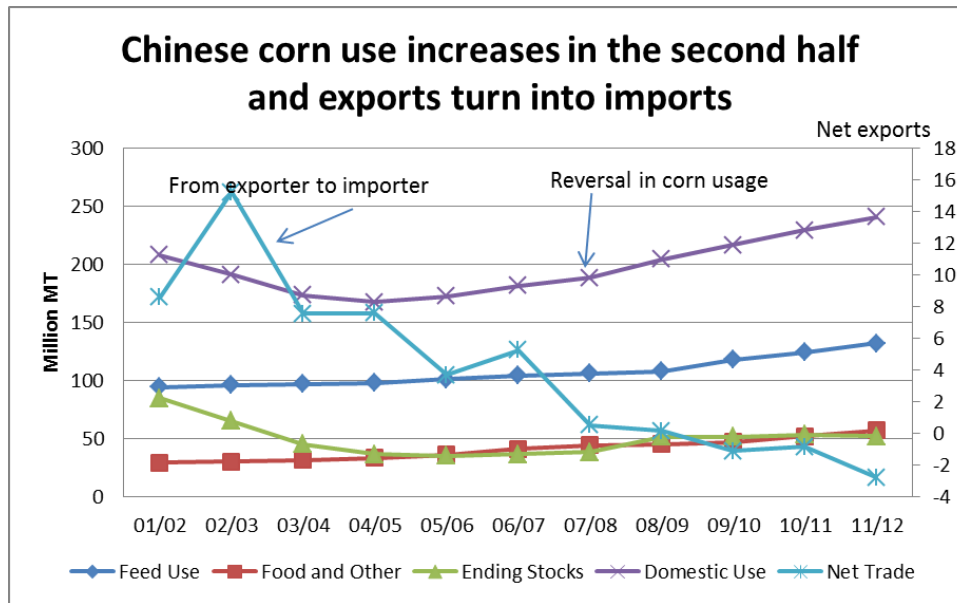
World price increase estimates generally use one or more of the FAO commodity price indices, which are denominated in dollars. They also tend to compare prices in the early 2000s with prices since 2006. The dollar was strong, however, compared to other currencies in the first period, whereas it weakened in the latter part, (Trostle, 2011). World crop prices measured in other currencies, therefore, indicate substantially smaller price increases. While maize prices in 2011, for example, are more than three times higher than prices in the early 2000s, they are only a little more than double when measured in Euros, Abbott (2011). The implication is not that a declining U.S. currency boosted prices (although they definitely did in countries with currencies that track the dollar) but rather that the world price did not really increase as much as the dollar-denominated indices would indicate.

There is no clearly preferable currency for measuring world crop prices. To the extent prices are set by potential exports from countries with the strongest currencies, then world crop prices should reflect those currencies. But crop prices are more a reflection of the interaction of crops available in multiple countries, and the U.S. is such a larger exporter of maize and many other commodities that it is a major market maker. It can be concluded, therefore, that some world average crop part of the price increase has been overestimated by focusing on dollars in the period under consideration.

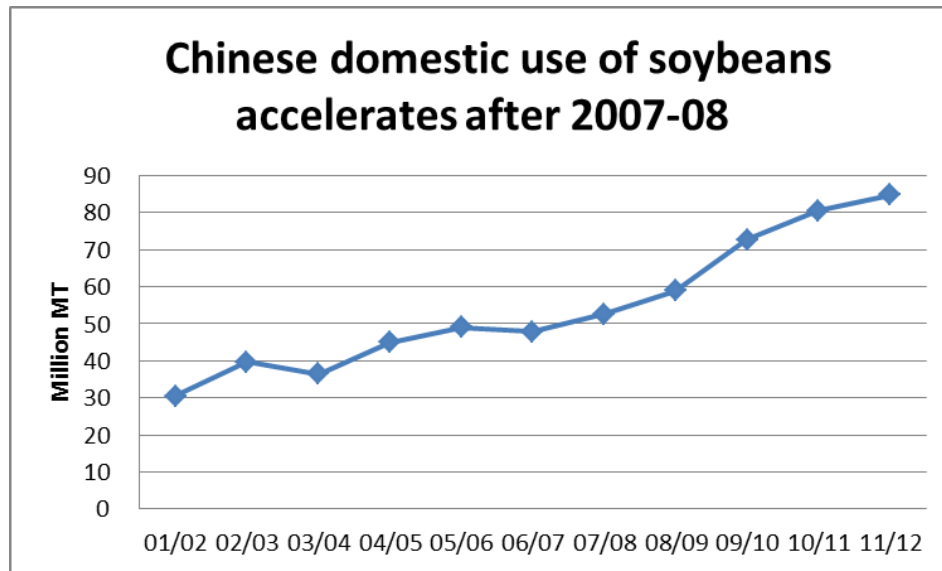
3.3.2. Chinese Stock Management and Increased Demand for Soybean Imports

In the early 2000's, the Chinese were reducing their inventories. For the first four years of the decade, they sold 38.7 million metric tons of maize, contributing roughly 13% of world exports in those years (305.6 million mt). Those exports probably helped to lower world crop prices. By 2008, those exports ceased. Replacing that supply (i.e., the former Chinese exports) required the equivalent of 1.090 million U.S. hectares of maize (at the 2012 U.S. yield of 8.879 MT/ha) (Authors calculations based on FAOSTAT). Since then, Chinese use and imports have continued to grow modestly (see Figure 11 below).

Figure 11. Chinese domestic use, imports and exports of corn



At the same time, China’s reliance on imports for soybeans increased. During this period, there is no evidence that either China or India increased its consumption of food in general, or livestock products in particular, more rapidly than in the past (Alexandratos, 2009; Headey, 2010). For the 2008 price shock, the role of soybeans also seems less substantial as the increase of soybean imports was only 7 million metric tons. But between 2005 and 2011, the increase in yearly imports grew by 26.46 million metric tons responding to accelerating usage (see Figure Y below). Of course, soybean imports had already been rising rapidly even prior to this period without leading to large price increases. But the persistence of this large increase and the acceleration after 2006/07 must have contributed to tightness in world markets for all commodities as land committed to soybeans competes with use of cropland for other crops. The persistent increase in usage of feed and livestock products also contributes to the tightness.

Figure 12. Chinese domestic use of soybeans (2007-2008)

Land use demand provides one way to compare the scope of this increasing demand with the scope of increasing demand for biofuels. Producing that many additional soybeans at U.S. yields requires roughly 9.6 million additional hectares of U.S. croplands. By comparison, the increase in biofuel production since 2004 has commandeered roughly 22.7 million hectares of additional, similarly high yielding lands.¹¹

In summary, the growing Chinese demand for soybean imports would probably have created some pressure on crop prices even without biofuel growth. Yet biofuel growth is both more than twice as substantial as this growth in soybean demand and comes on top of that growth.

3.4. The Inadequacy of Alternative Explanations for the Rise in Agricultural Commodity Prices.

The rise in agricultural commodity prices, measured in dollars, is, therefore, well explained by changes in the value of the dollar and the rapid rise in demand primarily but not exclusively due to biofuels. An array of alternative causes have been adduced but prove to be unsatisfactory for one of three reasons: some explanations focus on issues other than the incremental effect of biofuels on world wholesale crop prices; some explanations are based on inappropriate interpretations of models; and some explanations are simply not supported by the evidence.

¹¹ The growth of 26.46 million metric tons of soybean imports in China between 2004 and 2012 would require 9.6 million hectares of U.S. soybean land at 2012 yields (26.46 million mt divided by 2.75 MT/ha U.S. 2012 soybean yield). During this period, total grain used for ethanol increased 95.6 million metric tons, which implies a net increase of 66.9 million mt after accounting for by-products at 30%. Vegetable oil for biodiesel increased by 13.483 million metric tons and raw sugar used for ethanol increased by 26.444 million metric tons. That can be roughly translated into 7.542 million hectares of U.S. maize land net of by products (66.9 million mt/8.879 mt/ha), 8.57 million hectares of U.S. soybean land based on the caloric value of vegetable oil in the soybeans (13.483 million mt soybean oil/0.2 crush ratio*.35 caloric ratio/2.75 mt/ha U.S. 2012 soybean yield); and 6.6 million hectares of Brazilian cropland for sugarcane (26.444 million mt of raw sugar eq. /.048809 raw sugar to sugar cane ratio in Brazil in 2012/81.64 mt/ha sugarcane yield in Brazil in 2012).

3.4.1. Focusing on Different Issues

Retail Food Prices in Developed Countries rather than Wholesale Prices of Agricultural Commodities: Several biofuels studies have focused on their contribution to price increases at the retail level in developed countries.¹² Such studies correctly view this role as modest. Wholesale crop prices represent a minor part of retail food prices in developed countries so even their doubling alters retail food prices, only modestly. Food security is overwhelmingly an issue for poor countries and the linkage of prices in these countries to wholesale prices is far more direct.

Focus on the Role of Public Policy rather than the Overall Role of Biofuels: Several studies focus in whole or in part only on the role of specific government policies in driving biofuels and therefore in driving food prices, rather than the rise in biofuels as a whole (Babcock 2012; Abbott 2010). At times, other drivers of biofuel growth have included clean air standards and rising energy prices. The different drivers are important for policymakers, but the broader focus on biofuel increases is central.

All Influences on Supply and Demand rather than the Incremental Effects of Biofuels taking the Rest of the World as a Given

Every event has a limitless number of causes, and when prices rise because of a shortage of supply to meet demand, every factor that in any way limits supply or contributes to demand could be called a cause. Were population and meat consumption not growing globally, world agriculture could more easily accommodate growing demand for biofuels. Had governments maintained larger stockpiles of grain, the demand for biofuels would have had a more modest effect. Some studies have focused equally on every possible factor that continues to boost demand or could limit supplies (Trostle 2011), and each of them can accurately be viewed as a cause of rising prices. Indeed, if biofuels are taken as a given, then the cause of price increases can only be the continued growth in demand for food by people, or the failure of governments and producers to take more aggressive measures to boost supply. When we focus on the influence of biofuels, we focus on the incremental effect of biofuels and assume all other factors remain equal.

3.4.2. Evaluations with methodological flaws

Inappropriate Use of Economic Models: Many papers have used the estimates of global agricultural models to estimate the role of biofuels in recent price increases. Such papers include those by the U.S. National Research Council, by the UK Government (HM Government, 2009), and by economists at the World Bank (Baffes 2010). Modeling analyses have tended to estimate that government biofuel goals for 2015 or 2020 will increase world crop prices from 5% to 25%.¹³ Because recent crop price increases have been much larger, these papers infer that other factors must be responsible for most of the recently observed price increases.

Unfortunately, this use of the models is often inappropriate. Many of the models cited are general equilibrium models that by design 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. By contrast, as we have discussed above, the evidence is abundant that the rate of demand growth has created agricultural markets that are well out of long-term equilibrium, with prices in excess of production costs.

¹² One example is CBO (2009)..

¹³ For example, in 2008, the Organization for Economic Cooperation and Development (OECD) estimated that if biofuel production remained at 2007 levels, rather than doubling over the next decade as projected, prices for coarse grains (primarily corn) would be 12% lower in 2017 (OECD 2008). The International Food Policy Research Institute (IFPRI) estimated earlier this year that global biofuels expansion would boost the export price of corn by 17.7% in 2020 (IFPRI 2012a).

Such models, however accurate over the long-term, have little to say about these short-term increases.

In theory, partial equilibrium models could assess shorter term changes. But many of the analyses using those models, have also attempted to estimate effects in long-term equilibrium. These outputs therefore cannot be used to predict the short-term impacts.

More broadly, many of the elasticities driving even these partial equilibrium models use data from periods with relatively modest changes in supply and demand conditions. As such, the results of these models should be interpreted with care in front of rapid, large changes in supply and demand conditions. For the same reason, analyses that extract elasticities from the literature or from these models and simply apply them to biofuel demand, are not appropriate ways of measuring the consequences of these rapid increases in demand for biofuels. (Examples include Baier [2009] and CBO [2009]).

Some modelers also run these models while assuming no other supply and demand shocks in an effort to interpret long-term effects. For example, the models typically assume that future yields in each year will grow at predicted trend lines. In the real world, other shocks to the system also occur – such as yields modestly below trend lines in some years, or the large unexpected rise in Chinese soybean demand. Biofuel shocks will have disproportionate or compounding impacts whenever they come on top of these other shocks. For this reason also, partial equilibrium model predictions for an average future should not be used to interpret what has happened in the case of the rapid, recent run-up in demand.

These observations are not critiques of these models as such. Some of these models may turn out to be accurate predictors of long-term consequences for biofuels. We believe that models are important for exploring the complex interactions between many commodities and sectors that are affected by the rise of biofuels. However, the use of many of these models to explain the price rises of the last few years has been many times inappropriate.

3.4.3. Overstated Factors

Energy costs and speculation appear to have played a role in the price rises but cannot be considered the primary causes.

Effect of Energy Costs on the Costs of Production: Energy costs can increase crop prices in two different ways: one, by pushing up the costs of producing agricultural products, and two by increasing demand for biofuels. As we explained above, the rising costs of oil made it economical in the U.S. to produce biofuels even above mandated levels and did help drive up crop prices. But as we discussed above, the rising costs of production did not match the rising prices (Headey, 2010, p. 27). In fact, much of the rising costs of production came in the form of non-fuel input costs, which were probably driven more by rising demand than by rising energy costs.

Speculation: The prices of any commodity are in part speculative because expectations about future prices determine what owners of crops are likely to demand for those crops. Particularly when markets are tight, guesses about future supply and demand will sharply influence prices. These guesses can be termed speculation, are presumably not perfectly rational at all times, and can explain why prices should in fact fluctuate. In this sense, speculation is inherent in commodity markets.

The core new concern is that agricultural markets are now fluctuating not because of changes in agricultural markets but because of broader markets, such as those for stocks and bonds. There has been a five-fold increase in commodity index funds and the number of players in agricultural markets who are not producers or consumers of agricultural commodities dwarfs the real producers and consumers, (HLPE, no. 1., 2011). These investors are likely to move money in and out of commodity markets based on developments in broader financial markets that have nothing to do with the supply and demand for agricultural products.

One theory in particular could explain how agricultural prices become tied to energy prices. As Wise (2011) explains, there has been a large growth in commodity index funds that hold a minority of their value in agricultural commodities and that are required to keep their share of agricultural commodities in value constant. This fact means, according to Wise, that when oil prices rise, index fund managers are required to purchase more agricultural crops, driving up their prices (Wise, 2001).

In both case, however, we are dealing with short term phenomena which might increase the volatility around prices but cannot be seen as the main drivers. Unlike company shares, crops are either consumed or they are not consumed and since speculators do not consume more crops, they can only drive up prices by withholding more crops from the market. That means that for speculators to drive up the prices of stocks there must be an increase in stocks.

Data on crop stocks is far from ideal, particularly month to month, but the basic experience since 2005 has been of low stocks, which are best measured not in absolute terms but in stock to use ratios. By the end of 2006, stocks of corn, wheat and rice were all low compared to historic figures, both including China and excluding China. They remained low by the end of 2007. Wheat stocks increased significantly after the harvest of 2008 and 2009, but have declined again since then. As we explain in Appendix II, the increase in stocks after 2008 and 2009 is explained by the bumper crops in those years, not by speculation, and those increases in stocks corresponded with declining prices, not increases as a theory of speculation would suggest.

Speculation may possibly have played a secondary role. The changes in annual stocks could obscure changes in monthly stocks and short-term price volatility that might be triggered by speculation. Stocks by end of year in 2008 could have grown less but for speculation. Yet studies that attempt to correlate prices with flows in and out of commodities exchanges have also not been successful (Aulerich, 2012). Speculation may very well be increasing volatility in the short term, but the behavior of grain stocks over the last five years make clear that speculation has not driven the rise in prices since 2005.

3.4.4 Summary explanation of recent price rises

Our analysis concludes that a decline in the value of the dollar since the early 2000's plus a strong rise in Chinese imports of soybeans have been contributing factors to the world price rise for commodities. On the other hand, an increase in production costs due to the rise in the cost of energy, poor weather (prior to 2012), and speculation have not played a significant role. Explanations that identify modest price effects for biofuels have used the results of economic models outside of their proper context. Finally, the rise in prices largely reflects the difficulty that supply has had in keeping up with demand, and because the rise in biofuels has greatly increased the scope and rate of that rise in demand, it has played a predominant role in driving up prices.

3.5. Future Biofuel Demand and Price Effects

As of 2010, biofuels provided 2.7% of world transportation fuel,¹⁴ equivalent to roughly 0.5% of all delivered energy, but used 5.9% of all crops (measured by their energy content). If biofuels rise to provide 10% of world transportation fuel in 2020 – which is consistent with many current world policies -- they will consume the equivalent of 26% of all 2010 crop energy.¹⁵ In other words, total crop energy production would have to rise 20% from 2010 to 2020 just to

¹⁴ This figure is based on the energy content of all biofuels as a percentage of the energy content of all gasoline and diesel.

¹⁵ This calculation assumes the present mix of biofuels continues, which rely heavily on maize and sugarcane. However, because we measure this percentage in energy terms – and it takes very roughly the same quantity of crop energy to make each exajoule of biofuel – the mix of crops would not greatly vary this percentage.

generate biofuels before rising yet again to meet demands for increased food consumption. All this would provide roughly 2.5% of all global delivered energy as of 2020 (ignoring the energy necessary to produce the biofuel).

Present policies encourage the participation of cellulosic biofuels in these supply targets. Such policies do not, however, generally mandate that they do so. In the United States, for example, the renewable fuel standard requires 15 billion gallons of biofuels to be met by maize, another six billion gallons of “advanced biofuels” to be supplied by almost any other feedstock, and then 15 billion gallons of cellulosic ethanol. But the government can waive the requirement for cellulosic ethanol if it is not available, and any other non-maize feedstock can then supply these 15 billion gallons, including sugarcane ethanol.

One likely result is that Brazil will export ethanol from sugarcane, recognized as an “advanced biofuel”, to the United States to help meet that supply while the U.S. ships ethanol from maize to Brazil. (In the first ten months of 2012, Brazil shipped 336 million gallons of ethanol to the U.S., and one source projects such shipments to reach 600 million gallons in 2013.) Yet, the U.S. exported more than 300 million gallons of ethanol to Brazil in 2011 (CRS 2011 p. 31). This apparently strange behavior reflects the premium price paid for “advanced ethanol” to meet U.S. mandates, which include sugarcane, and the limited capacity of Brazil to produce ethanol both for its own market and the U.S.

Cellulosic production also does not necessarily imply less need for land. For example, even at extremely optimistic yields of 18 tons of dry biomass per hectare per year, and 90 gallons of ethanol per ton, a hectare of cropland in the U.S. would produce 1620 gallons. By contrast, an average hectare of maize in the U.S., after accounting for by-products, produces around 1600 gallons per hectare.¹⁶ In fact, the U.S. EPA has projected yields for switchgrass of less than half that yield even in its most productive locations, so actual cellulosic yields per hectare could be less than half of those of maize.

Cellulosic ethanol may also derive from a variety of alternative sources, including wastes and wood. Many of these alternatives have other land use implications, which we discuss in the following chapter, but would avoid direct competition for food and would therefore have less consequences for food security.

Biofuel policies could change, and there are already some signs. For example, the U.S. eliminated its tax credit for ethanol at the end of 2011, and the European Commission recently proposed to cap biofuels from food crops at roughly their present levels of 5%. As biodiesel production is not economical even at high energy prices, it is driven by government policies and changed policies would eliminate its growth.

Yet, the linkages between energy prices and food prices could continue to drive demand for ethanol and maintain high food prices. As we discussed above, so long as oil prices remain high, ethanol production for maize is economical at prices from \$200 to \$300 per metric ton. In 2012, crop prices exceeded the price at which ethanol production was economical. Yet, as supply catches up with the recent rise in demand for biofuels and crop prices sink, it will be economical to increase ethanol production again. In effect, long-term high oil prices would appear to set a floor on crop prices.

This linkage suggests that a crucial policy question will be the limitations on blending ethanol into crops, the so-called blend wall. In the U.S., this blend wall is now scheduled to rise from 10% to 15% as new vehicles replace older vehicles in the market. So long as the ethanol mandate remains in place, this capacity to use ethanol will probably be absorbed by “advanced biofuels,” and in particular sugarcane, but that in turn may drive more exports of maize-based ethanol to Brazil and elsewhere.

This linkage between biofuels and oil prices now provides a source of demand and volatility in crop markets that are unrelated to crop conditions. Whenever oil prices rise, demand for crop-based ethanol is also likely to rise and increase crop prices until crop prices

¹⁶ This figure assumes a present average yield of 395 bushels per hectare (160 bushels per acre) or hectare (395 bushels per hectare), 2.8 gallons of ethanol per bushel, and a 30% by-product. That results in 1581 gallons per effective hectare, i.e., treating 30% of the by-product as remaining in the feed supply.

are so high that additional ethanol production becomes unattractive. That also implies that crop prices will reflect speculative judgments not merely about crop conditions but also oil prices.

The linkage to oil prices also means that high oil prices are likely to guarantee high crop prices going forward so long as other obstacles, such as blending requirements, do not limit uses of biofuels. If oil price remain high, only affirmative government policies to limit biofuel production, including tight blend walls, are likely to allow crop prices to return to their previously much lower levels.

4. BIOFUELS AND LAND

4.1. Biofuels and Land Competition

The potential competition between biofuels and food production turns not only on the scale of increasing demand for biofuels, but on broader demands for bioenergy, and on the growth in demand for land generally. As the world's population grows and more people enter modern consumer circuits, demand for food and timber products grows, and more land is converted to urban areas. As important, concerns over climate change (and recognition of dwindling areas available for wildlife) provide a direct and tangible worth to the preservation of forests and savannas because of their carbon storage. The result is great and growing pressures on land resources. We first set forth demand for food and feed, demands for land for other purposes, and finally the potential significance of biofuels and other forms of bioenergy.

4.1.1. Food and Feed Demand

According to the latest FAO projections, meeting food demand by 2050 will require roughly a 60% increase in output from the world's cropland and a 70% increase in the output of meat and dairy (Alexandratos & Bruinsma 2012).¹⁷ These figures represent the growth in crops in calories. They also correspond to a projected 70% rise in total animal products, including a 70% rise in ruminant meat and dairy products.

These increases in production, which do not account for significant growth in biofuels, reflect both a rise in population and a growing middle class. This growing middle class will demand proportionately more meat and dairy, as well as vegetable oil, fruits and vegetables. The rise in consumption of animal protein per person is actually relatively modest on a global basis. The FAO assumes that people in sub-Saharan Africa will still be able to afford only extremely limited quantities, and that people in India will choose to eat little meat. If meat consumption rises for the whole world with income in the same way in the future as in the past, the rise in demand will be substantially larger and the challenge of feeding the world all the greater (D. Tilman et al. 2011).

To meet this demand, the FAO projects that total world cropland will expand by 69 million hectares from 2006 through to 2050. This figure will actually be hard to achieve. It assumes that the corresponding hectares of extra cropland will become available from double-cropping or other improvements in cropping intensity without expanding cropland area.

It also assumes that future crop yield growth will roughly match yield growth in the previous fifty years, a period of staggering productivity gains. Overall, FAO projects food increase per year over each of the next 40 years to exceed the annual growth in the period from 1961 through 2006. For example, annual cereal growth is projected to grow 6% more per year, oilseeds 29% more and root crops 46% more. Yet the period from 1961 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 from 250 to 300 million hectares from 1961 through 2006 (Alexandratos 2012; Bruinsma 2003, Table 4.7).

Grazing land probably expanded even more (Steinfeld 2006). Researchers in Brazil and Colombia have demonstrated great potential to increase output of milk and meat on the tropical grazing lands carved out of forest. Yet the FAO projections implicitly rely on a 70% increase in the quantity of meat and milk generated by the world's grazing land to meet a 70% increase in milk and dairy. (The FAO projects feed from crops will increase but not more than

17

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, but these assumed increases are ambitious. If they are not met, the consumption must result from more conversion of forest.

In addition to increases in food demand, a growing population will also demand more timber supplies with a common estimate of 70% (Smith et al. 2010). One assessment for the OECD by the Netherlands Environmental Agency projected that would require an increase by 1 billion hectares in the quantity of managed forest either through new plantings or by manipulation of natural forests (OECD 2011).

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 hectares (Lambin 2011). Not all of that will be arable land, but much 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.

In short, without any additional bioenergy, the world faces large pressures on agricultural production and land.

Confusion over the degree of land competition results in part from confusion about the estimates of potential cropland. The principal estimate comes from FAO, based on modeling by IIASA using the Global Agroecological Zone model. This estimate places potential unused cropland at roughly 1.3 billion hectares, representing a net of all suitable lands of 2.8 billion hectares minus roughly 1.5 billion hectares already cultivated, (Bruinsma 2003 p. 13). Yet, the FAO has itself warned that these estimates are overly generous for a variety of reasons. They ignore land with major soil constraints, which according to FAO includes 70% of all the otherwise suitable land in sub-Saharan Africa and Latin America. In addition, as early as 2003, the FAO warned that 60% of this land was covered by forests, protected areas or human settlements.

Even with these caveats, substantial lands remain. A recent assessment found cropping potential of 445 million hectares after excluding denser forests, protected areas, and areas that show up on global maps with obvious other physical constraints (Fischer (2011), discussed in Lambin (2011),). But these remaining lands still include land already devoted to grazing, whose removal from grazing not only will sacrifice soil carbon but also forage production.

What remains rarely receives much mention, but, by process of elimination, the remainder consists of wetter savannas (those savannas capable of crop production) and sparser woodlands. It has become common to view these lands as somehow surplus (Lambin 2011). One joint World Bank/FAO study actively encourages their conversion to food production or bioenergy in sub-Saharan Africa (Morris 2009; Deninger 2011). But tropical savannas and sparse woodlands have large quantities of carbon and high levels of biodiversity (Searchinger 2011b; Gibbs 2008). Their conversion would result in substantial environmental losses.

In short, the next four decades will see a large, growing competition for land for food, feed, timber and urban uses even without any increases in bioenergy. Although the prospect probably exists to expand agricultural land if necessary to meet food needs, that would run counter to global goals to maintain carbon stores to resist global warming.

Biofuels and Indirect Land Use Change

One policy question under debate is whether calculations of the greenhouse gas implications of biofuels should count emissions from so-called "indirect land use change" or "ILUC." These are the emissions that occur when biofuels divert crops from existing cropland and farmers elsewhere plow up forests or grasslands to replace the crops, which releases the carbon stored in plants and soils. Some people argue that these emissions should not be counted either because their quantity is too uncertain or because farmers and biofuel producers should not be held responsible for the harmful behavior of others.

This whole discussion assumes that biofuels start by reducing greenhouse gas emissions, and then ILUC cancels out some or all of those gains. Lifecycle greenhouse gas accounting for biofuels prior to 2008 generally worked this way because those analyses ignored the carbon dioxide released by burning the biofuel. Ignoring this carbon dioxide is what leads to the finding that biofuels often reduce greenhouse gas emissions. But burning ethanol and biodiesel releases carbon just like burning gasoline and diesel. So the question should be: what justifies ignoring that carbon.

The reason usually offered is that the production of a biofuel starts with plant growth, which absorbs carbon, and that carbon balances and therefore offsets the carbon released by burning the fuel. In fact, if a farmer takes otherwise fallow land and grows a crop for biofuels, that offset is real. The additional plant growth absorbs additional carbon, which offsets the carbon released by burning the biofuel. But what happens when biofuel producers use crops that farmers were growing anyway. In that event, there is no direct additional plant growth. Because there is no additional carbon absorbed, there is no direct offset for the carbon released by burning the biofuel.

Any greenhouse gas reductions have to follow a different path in the reactions to the diversion of crops away from food and feed and into fuel:

One possibility is that the crops are not replaced. In that event, people or livestock consume fewer crops and they therefore emit less carbon through their breathing and through their waste. That generates a greenhouse gas reduction although it is obviously not desirable.

A second possibility is that farmers replace the crops by producing more crops on the same land. That absorbs more carbon and generates a greenhouse gas reduction in a desirable way.

The third possibility is that farmers plow up more forest or grassland. In that event, they grow crops that absorb more carbon, but they also emit carbon by plowing up of forest or grassland releases carbon.

All these responses occur because the diversion of crops increases prices and spurs further reactions. The only possible way to generate greenhouse gas benefits by diverting crops to biofuels is if the reactions that reduce greenhouse gases exceed the reactions that increase greenhouse gases. In some way, a proper greenhouse gas accounting cannot simply ignore the carbon released by burning biofuels as if the carbon did not exist. It should count that carbon and then examine all of these indirect effects to determine the extent to which that carbon is offset by net carbon absorption by plants or reduced consumption of plants by people and livestock.

When lifecycle calculations count ILUC they in effect assume that the carbon in plants is free by ignoring the carbon released by vehicles but then estimate and count the degree of emissions from land use change. That gets the calculation correct mathematically but it does so backwards.

One of the consequences of doing the calculation backward is that it obscures the role of reduced food consumption. ILUC models do in effect estimate that, but it is hidden in the inside of the models. In effect reduced food consumption results in greenhouse gas reductions.

In this report, we do not call for ILUC calculations in public policy because we instead call for abandoning mandates and incentives to divert crops to biofuels in the first place. But this analysis helps to explain why. Diverting crops to fuel by itself does not generate any additional plant growth. It just competes with food needs for the crops and drives up prices. Biofuels made this way could only contribute to public goods if the overwhelming response was that farmers produced more food on the same land. Yet, the incentive for farmers to do so is a higher price, and that same higher price encourages farmers to plow up new land and encourages the poor to eat less. As we have shown, the competition is steep: any meaningful contribution of biofuels to energy supplies requires a very large quantity of crops, which implies unacceptable consequences for food

4.1.2. Bioenergy

The best way to appreciate the potential scope of bioenergy demand is to appreciate the relationship between potential bioenergy production and the existing harvest of crops and biomass for other human purposes.

- Today, if 100% of world crop production were diverted to bioenergy, it would provide 13% of world primary energy¹⁸. This calculation counts 100% of the chemical energy present in all the world's crops. It therefore unrealistically assumes that people could use biomass as efficiently as fossil fuels. From the standpoint of net contributions to the world's true energy supply, a more realistic figure would be around 9%. What's more, energy demand is growing. By 2050, 100% of today's crop production would yield around 4-6% of world net delivered energy.
- As discussed above, producing 10% of the world's transportation fuel by 2020 would require 26% of the world's crops today.
- If 100% of all the world's harvested biomass were devoted to bioenergy, that would yield probably on the order of 30% of the world's energy supply today, and probably less than 20% of the world's energy supply by 2050.¹⁹ That includes not merely all the world's crops, but all the world's harvested forage, timber, and crop residues.

To produce these outputs, people manipulate on the order of 75% of the world's vegetated lands (Haberl 2012) and devote 85% of the water they withdraw from rivers and aquifers (Foley 2011)

The underlying limitation lies with photosynthesis. Although plants with abundant water and good growing conditions can at times convert 3% of the solar energy that hits their leaves, over the course of the year even the most efficient plants tend to convert less than 0.5% of solar energy into biomass (Mackay 2008). For many crops used for biofuels, and even many timber plantations, the conversion rates are even lower. Converting this biomass energy into electricity in turn reduces that efficiency down to 0.1 to 0.2%. By contrast, standard solar cells now convert 10% of solar energy.

Many estimates of large bioenergy potential do not come to grips with these challenges. They sometimes count excess forest growth beyond that needed for timber, but such forest growth is contributing to a large forest carbon sink that plays a critical role in holding down climate change. Many estimates implicitly assume that the world's savannas are carbon-free lands (Hoodgwyck 2005; Cai 2011), but the one published study that actually attempt to calculate the carbon losses from converting those lands, conclude that few would provide greenhouse gas benefits over a couple of decades (Beringer 2011).

In short, any serious effort to produce substantial quantities of biofuels would require a vast increase in the total production of crops or other biomass. Such increases would come on

¹⁸ These figures are based on author's calculations from world crop production in 2011 as reported in FAOSTAT and higher heating value energy contents for different crops as reported in Wirsenius ____.

¹⁹ Haberl 2012 calculates that 100% of world biomass harvests contain roughly 230 exajoules of energy. As of 2011, world primary energy consumption was roughly 530 exajoules (EIA 2012). However, biomass cannot be used as efficiently as fossil fuels when used for transportation fuel (JRC ____), or when used for electricity (Searchinger 2011b). Assuming at least a 25% loss in efficiency, brings the effective energy supply down to roughly 30% as of 2011. The OECD projects an energy demand of 900 exajoules in 2050 (Marchal 2011). That implies that 100% of today's biomass consumption would supply around 20% (19%) of total energy in 2050.

top of the large increases already needed for food, feed or timber products. Any effort, therefore, to produce meaningful quantities of bioenergy would result in large-scale competition with the use of land for other human needs or carbon storage.

4.1.3. Potential uses and policies for bioenergy that avoid or minimize land use competition

One of the limitations of existing biofuel policies is that they make no effort to avoid land use or food competition. In various ways, they encourage bioenergy producers to obtain their feedstocks from common stores. As a result, their immediate consequence is to remove crops that would otherwise go to food production. To the extent they stimulate additional production, they do so by increasing prices. The same price increase that might help to stimulate efforts to boost yields on existing agricultural land simultaneously raises prices for the world's poor and reduces their consumption and also sends a market signal for farmers to expand cropland in ways that release carbon. Any viable biofuel policies that would avoid this land use competition must specify that biofuels use feedstocks that are non-competitive.

The best alternatives involve focusing on biomass from waste products. The potential, although limited, is probably meaningful (Haberl 2012b).

Another possibility is to focus on bioenergy to supply energy poor countries, particularly where modern bioenergy can replace traditional, inefficient forms of bioenergy, such as charcoal. In much of Africa, for example, energy use is extremely low. The potential exists, therefore, to supply meaningful quantities of bioenergy for local consumption without greatly taxing the world's land use. We explore both the tensions provoked by land competition and the potential for bioenergy strategies for local development in the next section.

4.2. Land investments and displacements

Debates over the impact of biofuels in the food price hikes of 2008-9 is paralleled by discussions over the importance of biofuels in the surge of global land investments, the phenomenon baptized as land grabbing, which is increasingly being recognized as a simultaneous land and water grabbing. In Brazil, new style international investments in biofuels predate the price hikes although only by a few years. Earlier large-scale foreign investments were stimulated by the incentives for environmental protection. Large-scale land investments have also accompanied the global restructuring of value chains as in the case of forestry, paper and pulp.

4.2.1. Land Grabbing and Monitoring Role of NGOs

In its 2011 report, the International Land Coalition (ILC), which monitors land investments worldwide, suggested that between one third and two thirds of all land investments were biofuels related. The land grab phenomenon has been continuously monitored also by the NGO Grain and by CIFOR with their interactive maps, and has been the subject of international conferences organized by the Land Deals Politics Initiative (LDPI) which have produced numerous studies of land grabbing on all continents. Friends of the Earth have also produced a detailed report on land deals in Africa (2010).

It should be recognized that for the provision of data and analysis in relation to recent global land investments NGOs have assumed a leadership role and even the World Bank has shown itself to be largely dependent on their sources. The FAO has also conducted a major study of foreign land investment in 17 Latin American countries, focusing in particular on the role of capital rich resource poor States preoccupied with food/energy security.

4.2.2. Scale of Investments and Participation of Biofuels

A range of specific motives has been adduced, but the underlying common denominator is that land/water is now perceived to be a globally scarce resource, reflected in the price pressures on food crops, and all continents have been targets. The ILC brings together, CDE, GIGA.GIZ and CIRAD and in 2012 launched its Land Matrix with data on large land investments. Since 2000, 1,217 transactions have been registered involving over 83 million hectares, 1.7% of total agricultural land (www.landportal.info/landmatrix). Some 625 deals involving 43.7 million hectares are from sources considered reliable. Africa is the principal target with 754 transactions accounting for 56.2 million hectares, which equals 4.8% of the continent's total agricultural land, an area equivalent to Kenya. Asia comes next with deals amounting to 17.7 million hectares followed by Latin America with 7 million. GRAIN has similarly launched new data in 2012 using more restrictive criteria: deals dating from 2006 which have not been cancelled involving large-scale foreign investments for food crops. They register 416 deals covering 35 million hectares and argue that 10 million hectares are now the subject of such investments each year (www.grain.org). The GRAIN data excludes non-food crops such as jatropha which has motivated land deals of hundreds of thousands of hectares. Nevertheless, in GRAIN's identification of the motivations for investments, biofuels come a close second to food, although, as we have seen, it is difficult to make a clear distinction between the two in the case of first generation biofuels.

4.2.3. “Available” or “marginal” Land” and the Rights and Practices of Traditional Communities

The justification for such investments lies in the notion of “available” land which is equated with unused and un-owned land. NGO and peasant organization mobilization have exposed this myth and it is now accepted that land which is the object of investment is normally land which is occupied by traditional communities under different forms of communal rights or as State land.

CIFOR has carried out case studies in Sub-Saharan Africa, in Ghana, Mozambique, Tanzania and Zambia highlighting the complexities of defending local communities land rights (German, 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. Local chiefs may be cheated or co-opted, or the local community as a whole may be won over to the promised of development. 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, focuses on the strengthening of 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 et al, 2011, Biofuelswatch, 2012). A particularly systematic account is that provided by Cotula et al (2008) in a study conducted for FAO/IIED entitled *Fuelling Exclusion*. This study recognizes that biofuels 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 as pasture land, 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 biofuels land deals.

Jatropha investments in SSA have most clearly tested the concept of marginal lands. Identified as a non-food crop capable of growing on marginal lands it has been widely adopted

as the ideal solution to the food-fuel dilemma. The GEXSI (2008) study calculated that 97 jatropha projects were underway in 2008 and that by 2015 some 2 million hectares would be dedicated to this crop in SSA. We have seen in an earlier chapter that jatropha has also been adopted as the key alternative to food-crop fuels in China and India. Nyari (2012), the vice-chairman of RAINS, active in Ghana, has provided a detailed account of the investments of the Norwegian company, Biofuel Africa which exemplifies all the issues mentioned in the previous paragraphs. The marginal land in this case was forest land which provided decisive food and non-food services for the local community. Biofuel Africa had bulldozed more than 2.600 hectares, including shea trees decisive for their food security, before the local communities were able to put a stop to the project.

Table 3.

Land Deals in Africa – CIFOR Source: <http://www.cifor.org/bioenergy/maps>

Country	Type of Investment	Number of investments	Land (ha)	Feedstock type	Annual production targets (litres/ha)	State of investment				Total (ha)
						operational	Project stage	Held up	Abandoned	
Congo DR	Foreign	2	154,000	Jatropha, Palm oil	No data					154,000
	Domestic	0								
Zimbabwe	foreign	1	14,000	sugarcane	44,000	1				164,000
	Domestic	5	150,000	Sugarcane,Jatropha	58,400	4			1	
	Forein/domestic				No data					
Mozambique	Foreign	27	624,162	Jatropha, sugarcane, sweet sorghum, Palm oil	No data	24	1		2	645,162
	Domestic	1	21,000		No data					
Malawi	Foreign	2	>7000	Jatropha	No data					>7000
	Domestic	2	No data	sugarcane	42,000	4				
Zambia	Foreign	12	827,483	Sugarcane, jatropha, Palm oil	No data	9	3		1	827,483
	Domestic	1		Jatropha	No data	1				
Angola	Foreign	6	92,600	Sugarcane, Jatropha, oil palm	No data	5	1			206,600
	Domestic	3	114,000	Sugarcane, sorghum	No data	1	2			
Namibia	Foreign	3	460,000	Jatropha, sugarcane	No data	2			1	460,000
	Domestic	0			No data					
Tanzania	Foreign	17	407,622	Palm oil, Jatropha, sugarcane, 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, sugarcane, woody biomass	No data	14	1		2	1,249,600
	Domestic	0			No data					
Kenya	Foreign	3	161,000	Jatropha, sugarcane	No data	3				211,000
	Domestic	1	40,000	sugarcane	No data	1				
Uganda	Foreign	1	10,000	Palm oil	No data	1				10,000
	domestic	0			No data					
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, Sugarcane	No data		1		1	610,490
	Domestic	4	113,990	Castor, Jatropha, oil palm, Sugarcane, Pongamia, various vegetable oils	No data		1			
Sudan	Foreign	1	600,000	Jatropha	No data	1				660,000
	Domestic	2	60,000	Jatropha, Sugarcane	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	Sugarcane, 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, sugarcane, Rapeseed, Oil palm	No data	18	1			1,202,200
	domestic	5	151,250	Jatropha, sugarcane	No data	5				
Mali	Foreign	6	142,432	Sugarcane, 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	Sugarcane, 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	Sugarcane, Jatropha	No data	2				

Recent research has shown that many of the jatropha projects have now been abandoned or have been replaced by food crops as it is becoming clear that jatropha needs both water and modern inputs if it is to achieve acceptable productivity levels (Friends of the Earth, 2010, African Biodiversity Network, 2010). Tim Williams (2012), from the International Water Management Institute, has insisted that while water is in fact the key resource, land deals are negotiated without explicitly taking into account the water implications of large-scale projects because land and water are subject to different regulatory systems and different governmental responsibilities. Large-scale projects can lead to water being overdrawn, to the diversion and the drying up of water sources. Women as water providers can be particularly prejudiced as they often have to travel greater distances to find water sources. In addition, large-scale monoculture may modify rainfall patterns.

The myth of unused, available land has been recognized by The International Finance Corporation (IFC) the investment branch of the World Bank, whose Performance Standards, to be adopted by investors financed by the IFC, include Standard 5 on "Land Acquisition and Involuntary Resettlement". 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 later 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" (Ward et al, 2012, p 37). A similar conclusion was reached by a recent World Bank publication (Deininger & Byerlee, 2011).

4.2.4. The Importance of Production Typologies for Identification of Policy Options

An evaluation of biofuels land investments should at the same time take into account the different types of possible production systems, since these can have different consequences for income, employment, and rural development. A recent UNU-IAS study on Biofuels in Africa by Gasparatos et al (2010) develops a useful typology of biofuels at the level of individual production systems, demonstrating the importance of going beyond aggregate considerations. Using a 2x2 matrix they distinguish on the one hand between the scale of production (small holders and/or out-growers x large scale farms) and the motives of production (national blending mandates/exports x local fuel production). Four types of production system are identified: 1) small-scale biofuel projects for electrification; 2) commercial firms or mines producing biofuels for own use; 3) out-growers or small holders linked to commercial farms or biofuels processing plants; and 4) large-scale commercial plantations. On this basis the study identifies different types of investments and investors in the African case, with type 4 predominating in the case of private investors and type 1 in the case of NGOs and Foundations geared more to rural/local development. Maltitz (2012) has elaborated a similar typology to explore the different ways in which bioenergy can be integrated into development strategies.

Developing countries need investment in agriculture, but foreign investments for the promotion of biofuels have to date shown themselves to be prejudicial to local communities without providing broader benefits to the host country. Such investments, however, should align themselves with the emerging alternative roadmap for biofuels promotion which gives priority to rural development goals, to the objectives of energy security and is premised on strategies for sustainable land use.

5. SOCIAL IMPLICATIONS OF BIOFUELS

Fundamental shifts between man and nature and between men and women within the organization of family and community life are often not captured directly in economic data and monetary indicators but they may have lasting effects on the food security perspective of millions in developing countries. This chapter reviews the way biofuels investments are affecting two such shifts – in land rights and gender rights – and discusses a key mechanism, certification schemes, currently being explored to ensure compliance to international norms and regulations to evaluate the degree to which they include the necessary social criteria. The chapter concludes with a discussion of approaches which integrate biofuels within the broader category of bioenergy as a decisive component in sustainable development strategies which give equal weight to social, economic and environmental factors.

5.1. Communal Lands and Food Security

While it is recognized that most cultivable land in the North is currently being used, this same understanding is not extended to the South, where the overwhelming proportion of identified “available” land is said to be located. Lands left under fallow, pastoral lands, and communal grazing or forest lands, and water sources belie apparent availability. The environmental and biodiversity concerns of the Rio-Summit brought traditional communities and their land rights to the attention of global governance bodies, which elaborated the first policy prescriptions of which the most important was the need for the “free, prior and informed consent” of the community concerned before any intervention was contemplated (Tamang, 2005, Actionaid, 2010).

In the case of biofuels investments we are primarily dealing with lands subject to customary rights of access and tenure, but which may also be State lands. In some countries, land tenure is conditional on its productive use with which communal land may be said not to apply. In the course of successful negotiation customary rights are generally exchanged for leases, which may be as long as 99 years or as short as 15 and even include a clause permitting revision after 2 years (Cotula et al, 2010). While these leases should in principle be susceptible to reversion to the communal rights of the community involved (although it is difficult to imagine that large-scale plantations will preserve the resources typical of communal lands), in practice the option then is for them to become State lands.

Where profound asymmetries of power and economic resources exist, rights can be routinely trampled on. In addition, opportunism and corruption, which are endemic to modern governments and not the preserve of failed States, can cheat communities out of their rights while formally following the rules of the game. On the other hand, within traditional communities, co-option and opportunism are favored by patriarchal systems of authority. Empowerment, therefore and the promotion of a vigorous civil society are the pre-conditions for the ability to defend and negotiate rights.

In many cases, the host State and the local communities see opportunities in the proposed investments. This was the case in the north of Ghana where low prices for traditional crops and long periods of rural unemployment led to a welcoming of proposed investments for jatropha plantations (Nyari, 2012). There is no reason to expect more or less of biofuels than other cash crop plantations, but it is clear that if “good practices” prevail, such investments may be positive both for the local community and the country as a whole in the form of export earnings.

To the extent that investments rely on international bodies and development banks or other forms of public funding, principles such as “prior, informed consent” could become a conditioning commitment. It has been suggested in the previous chapter that current IFC, Performance Standards on Land Acquisitions are too lenient, and should be revised. The speed and size of investments for highly uncertain projects, those dealing with jatropha in particular, suggest that much of the capital is speculative or that the conditions for investment are unusually favorable. The predominance of investors new to land and agriculture investments indicate that these investments have not been subject to traditional calculations on returns (GRAIN, 2012). A notable feature of these investments is the land size, often quite disproportionate to any conceivable productive project (see Table on African

investments). Policies which can ensure that large-scale investments adopt socially responsible practices will allow them to be integrated as components in national and regional biofuels/bioenergy strategies (Harrison et al, 2010, Maltitz & Stafford, 2012).

If the social structure of rural communities on which food security depends is to be preserved proposals for land investments must be subject to the internationally recognized principles of “free, prior and informed consent” and the scale of such investments should be consonant with the proposals for production. In many countries, as we have seen, such a procedure is coherent with existing requirements that land tenure be conditional on its productive use.

5.2. The Gender Dimension of Biofuel Expansion

The gender dimension has been one of the least explored aspects of biofuels development. Recently, however, a growing number of studies has tried to bring to the attention of policy makers the importance of taking gender into account in biofuels development (Arndt et al., 2010; Cotula et al., 2008; Karlsson, 2008; Nelson et al., 2011a, 2011b; Rossi & 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 et al., 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 feed-stocks could potentially benefit the rural poor, women in particular. To the extent that biofuels 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, patriarchy system often excludes them from the village decision making process. In addition, government programs generally place men as the decisions makers on behalf the household.

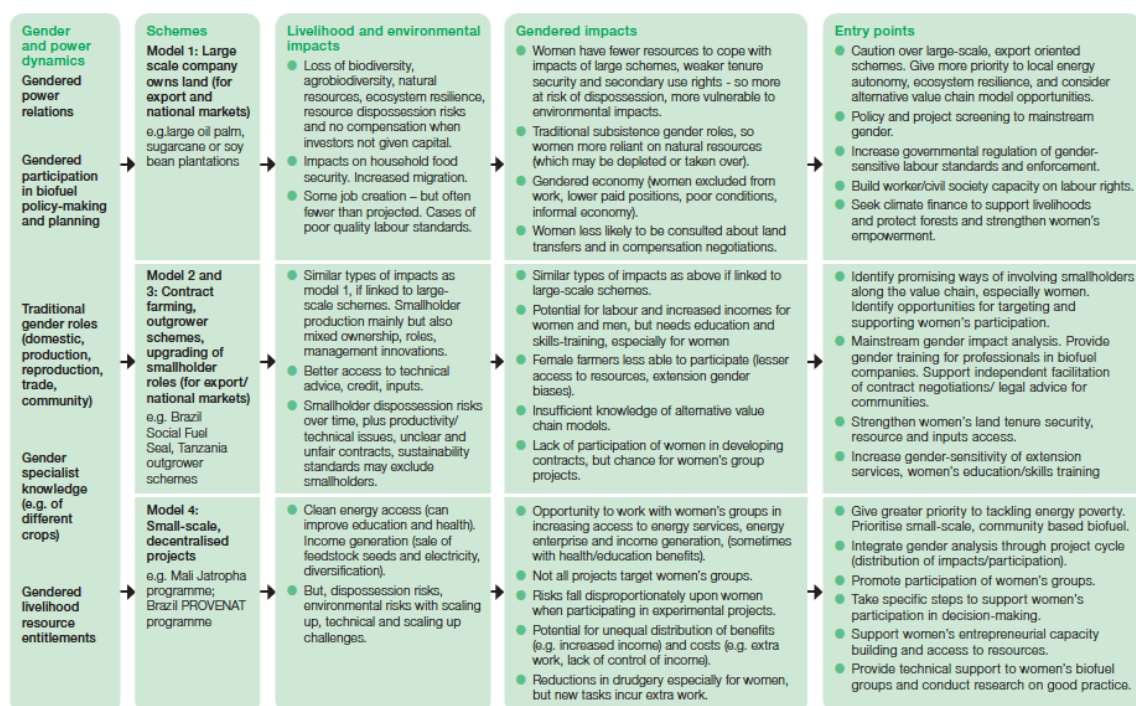
When biofuel expansion increases the price of feedstock crops, it promotes land use change from previously forest lands or food crop agriculture to cash crops. The effect of such land use change on women can be observed in the case of oil palm expansion in West Kalimantan, Indonesia (Julia and White, 2012). According to Julia 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 Julia and White, women’s land rights were eroded even further when government programs designated only the husband (or another male descendent) 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 Julia 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 subsistent plot. The gender balance of labor which 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. 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 to 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 & Lambrou, 2011a). Further study is required to explore the differential impact of these schemes on gender relations. The figure below proposed by Nelson & Lambrou (2011a, 2011b) in a report designed to guide policy makers when dealing with biofuels provides a first map of these gendered impacts.

Figure 13.



5.3. Certifications Schemes and Social Compliance

In the case of biofuels and other policy constructed markets there is no clear separation between public and private forms of institutionalizing these markets. Agricultural zoning which has become a key element in the validation of these markets is eminently a public attribution. Biofuels becomes a commodity as the result of policy which requires agreements on the technical (often contested and political influenced) criteria which constitute standards. Many of these market's justification, however, go beyond the characteristics of the products and extend to their conditions of production. These may vary from market to market and are less susceptible to regulatory control.

Certification schemes have emerged to deal with the identification of these qualities and the confirmation of their presence along the different activities of specific but global value chains. The varied international agreements and conventions which provide a proto-legal framework for new quality standards constitute the elements from which these certifications schemes are constructed.

The European Union 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 certifications schemes are virtually obligatory since only certified products count for the mandatory renewable fuels targets. One limitation is that the European Union

does not explicitly demand the inclusion of social criteria and of the seven schemes already recognized (with dozens more in the pipeline) the majority have no, or only very weak, social clauses.

Internationally the GBEP has been active in the promotion of sustainability criteria and indicators for biofuels. Within this framework the FAO has led the negotiations on social criteria, and provisionally agreed indicators cover:

- Net job creation
- Wages
- Changes in unpaid time spent by women and children collecting biomass
- Biomass used to expand access to modern energy services
- Change in mortality and burden of disease attributable to indoor smoke from solid fuel use
- Incidence of occupational injury, illness and fatalities

Willingness to reach agreement was also reached with relation to the following points although further discussion is still required:

- Food security
- Labor conditions
- Access to land, water and other natural resources
- Household income (Morese, 2010)

The multi-stakeholder Roundtable Sustainable Commodities initiatives – which include soy, palm-oil and biofuels – also explicitly include social criteria. The Principles and Criteria for Biofuels incorporate the following social concerns:

- Human and labor rights
- Rural and Social Development
- Local Food security
- Land Rights (RSB, 2010)

Important progress is, therefore being made to ensure that social criteria are included in certification schemes which qualify for access at least to European market. 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 inter-governmental groups – from all continents.

Certifications 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. On the other hand, there are many certification schemes not all of which are multi-stakeholder or include social criteria. This makes it possible for UNICA, the representative of the Brazilian ethanol producers to be a member of the RSB but to certify its products through another certification scheme Bonsucro.

A further limitation of certification schemes is the difficulty (costs, logistics) of ensuring enforcement. In many instance, therefore, the social criteria reduce themselves to the national legislation of the exporter country. Certification schemes, in addition, are applied at the level of the individual farm or firm and therefore are unable to take into account the broader context in which the production activities in question are being developed (Harrison et al, 2010).

5.4. Biofuels or Bioenergy for Development

Developing countries have long experiences of large-scale cash commodity crop exports. While the large plantation model is often favored by technical factors, a variety of business models prevail depending on the local conditions and the labor, land and regulatory frameworks. Recently good agricultural practices in the form of Globalgap have integrated base-line social conditions into these production systems. From the perspective of local development, out-grower contract schemes

would seem to offer better prospects although various studies have concluded that this arrangement is often a camouflaged form of wage labor.

Large-scale biofuels, therefore offer few surprises, although they may involve important spill-overs in terms of infrastructure, agricultural services and some levels of competence creation. For governments they offer the added attraction of export earnings. The negative factors have also been widely documented – displacement of rural population, threats to biodiversity, appropriation of water sources and pollution threats from agricultural inputs.

Alongside these large-scale investments, NGOs, private foundations and cooperation programs have been promoting a wider conception of biomass use within the framework of sustainable development, local, rural and urban. Initiatives such as COMPETE, Probec, Re-impact 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 & Stafford, 2010).

Many of these projects are specifically geared to the needs of rural communities “off the grid”, which may be quite small now in some regions, such as Latin America, but are often a majority phenomenon in Africa and Asia. The key here, therefore, is for the development of technologies which can be rapidly replicated and whose use and maintenance can be readily assimilated (Bogdanski et al, 2010)

Of particular significance are adaptable technologies for cooking, heating and water management. 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 & Thuber, 2009, Rai & McDonald, 2009; WHO, 2006; www.worldbank.org/hnp).

More strategically these forms of appropriation of biomass also partially address the central problem which we have identified in discussions of large-scale land investments – 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 relieves both time and space which would allow rural communities more flexible conditions for negotiations of new land uses, including more commercially organized biofuels to attend to the country’s wider energy needs (K. Benedict, 2011). Such a combination converges with the four principles around which a common SSA biofuels policy is currently being forged:

- Be designed for the promotion of rural development;
- Be geared to the objectives of energy security;
- Develop the ability to attract appropriate investments; and
- Be based on sustainable land use.

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APPENDICES

Appendix I. Biofuels Policies by Country, Type, Mandates and Subsidies/Incentives

Country	Mandate		Biofuels mandatory target		Main Feedstock	Estimates of Government Subsidies, Including Mandates, for Biofuels	
	B% (biodiesel)	E% (ethanol)	Tools	Biodiesel		Ethanol	Biodiesel
<i>Countries with the major blending mandates that will drive global demand:</i>							
United States	- Advanced biofuels (1.21%) - Cellulosic biofuels (0.002 – 0.010%) - Total renewable fuels (9.21%)	Advanced Energy Research Project Grants, Improved Energy Technology Loans, Advanced Biofuel Production Grants and Loan Guarantees, Advanced Biofuel Production Payments, Biodiesel Education Grants, Biomass Research and Development Initiative, Value-Added Producer Grants (VAPG), Biobased Transportation Research Funding, Advanced Biofuel Feedstock Incentives, Cellulosic Biofuel Producer Tax Credit, Laws and Regulations.	- Advanced biofuels: 2.0 billion gallons; - Cellulosic biofuels: 3.45 – 12.9 million gallons; - Total renewable fuels: 15.2 billion gallons. Overall, the US is moving towards a 36 billion gallon biofuels target by 2022. Biomass-based diesel: 1.3 billion gallons (2013)		Corn for ethanol. Soybean for biodiesel.	US\$0.4 billion (a)	US\$7.7 billion (a)
European Union	5.75% . Under review: 5% (2020).	Tax incentives. Utility quota obligation. Tradable renewable energy certificate. R&D spending	13,825 million liters	5,853 million liters	Estimated: 10.1 MMT of cereals, about 10.3 MMT of sugar beets, and about 9.7 MMT of vegetable oils and	US\$5.8 billion (a)	US\$2.1 billion (a) EUR 3.2 billion (2007), EUR 3.0 billion (2008) (b)

animal fats

Brazil	B5. Under discussion: B7 (2013), B10 (2014), B20 (2020).	E18-E20.	Differentiated tax exemptions. Social Biofuel Certification. Industrial products excluded from the tax.	20.6 million m ³ (2011)	2.7 million m ³ (2011)	Sugarcane for ethanol. Soy (> 70%) for biodiesel.	US\$0.1 billion (a)	US\$2.6 billion (a)	
China	Mandatory in six provinces and 27 cities in Hubei, Hebei, Shandong and Jiangsu 15% (2020)	E10 (in 9 provinces)	Several government agencies and state companies planted jatropha seeds for biodiesel production. In 2011: national regulations against the illegal use of recycled waste cooking oil for human consumption. Exemption of five percent consumption tax on biodiesel production as using waste cooking oil for biodiesel production (lobbying from the industry to make this a permanent policy).	2012: 568 million liters 2020: 2 million tons	2012: 2,433 million liters 2020: 10 million tons	Corn (>76%); wheat (>16%); cassava (7%) for ethanol. Used/waste kitchen oil or residue from vegetable oil crushers for biodiesel	US\$0.1 billion (a)	US\$0.4 billion (a) US\$0.9 billion (2006) (b)	
<i>Latin America and Caribbean Countries:</i>									
Argentina	B7	E5	Accelerated amortization. Anticipated recovery value-added tax. Exemption of the water infrastructure tax. Doesn't apply to exports.	0.75 million tons (2011)	260 million liters	Soy for biodiesel. Sugarcane for ethanol.	N/A	N/A	
Bolivia	B2.5, B20 (2015).	E10	Exemption of Specific Tax. 50% reduction in the tax burden.	N/A	N/A	Soy for biodiesel. Sugarcane for ethanol.	N/A	N/A	
Chile	B5 (not compulsory)	E5 (not obligatory)	Fuel specific tax exemption. Funding for R&D consortiums.	N/A	N/A	Corn for ethanol. Used/waste kitchen oil or residual oil or animal fat for	N/A	N/A	

							biodiesel		
Colombia	B10, B20 (2020).	E10.	Tax exemption for production and final end use. Creation of tax-free zones for feedstocks production. Soft loans for investments. Subsidies of FFV.	800 thousand liters per day. 2020: 3.8 million liters.	N/A		Palm oil for biodiesel. Sugarcane for ethanol.	N/A	N/A
Costa Rica	B10	E7	N/A	N/A	N/A		Palm oil for biodiesel. Sugarcane for ethanol.	N/A	N/A
Dominican Republic	B2 (2015)	E5 , E15 (2015).	Incentives for renewable energy sources R&D projects. 100% of tax exemption.	N/A	N/A		N/A	N/A	N/A
Ecuador	B10	E5	Pilot studies. FEISEH fund to promote investments projects in hydrocarbons.	N/A	N/A		Palm oil for biodiesel. Sugarcane for ethanol.	N/A	N/A
El Salvador	-	E10	Tax exemptions.	N/A	N/A		Sugarcane for ethanol.	N/A	N/A
Guatemala	-	E5	Tax exemptions.	N/A	N/A		Palm oil for biodiesel. Sugarcane for ethanol.	N/A	N/A
Honduras	-	-	Development of norms and processes of production and consumption.	N/A	N/A		Palm oil for biodiesel. Sugarcane for ethanol.	N/A	N/A
Mexico	-	E2 in Guadalajara.	Promotes feedstocks production (agricultural and livestock, forest, algae, biotechnological and enzymatic processes). Value-added tax exemption.	N/A	N/A		N/A	N/A	N/A
Nicaragua	-	-	Biofuels production programme.	N/A	N/A		Sugarcane for ethanol.	N/A	N/A
Panamá	B10 (suggested).	E2 (2013), E5 (2014), E7 (2015), E10	N/A	N/A	N/A		Sugarcane for ethanol.	N/A	N/A

		(2016).							
Paraguay	B5	E24	Tax benefits for biofuels production. BIOCAP.	N/A	N/A	N/A	N/A	N/A	N/A
Peru	B5	E7.8	Promoting investments for production and commercialization.	N/A	N/A	Palm oil for biodiesel.	N/A	N/A	N/A
Uruguay	B5	E5 (2015).	Total or partial tax exemption for fossil fuels. Requires the use of domestic biodiesel	N/A	N/A	N/A	N/A	N/A	N/A
<i>Asian countries:</i>									
India	B20 (2017).	E5, E20 (2017)	N/A	N/A	N/A	Sugarcane for ethanol. Jatropha for biodiesel.	N/A	N/A	N/A
Indonesia	B2.5, B5 (2015) B20 (2017).	E3, E5 (2015), E15 (2017).	N/A	N/A	N/A	Sugarcane for ethanol. Palm oil for biodiesel.	US\$197 million (January 2006– June 2008) (b)		
Malaysia	B5	-	Biodiesel will be price controlled while the government has recently removed the subsidy on fossil diesel.	N/A	N/A	Palm oil for biodiesel.	US\$ 19 million (2006) (b)		
Philippines	B5	E10		N/A	N/A	Sugarcane for ethanol. Coconut for biodiesel.	N/A	N/A	N/A
South Korea	B3	-	N/A	N/A	N/A	Soy (70-80%) and waste (20-30%) for biodiesel.	N/A	N/A	N/A
Thailand	B5	E10	N/A	2020: 1.643 million liters	2022: 3.285 million liters	Sugarcane and cassava for ethanol. Palm oil for biodiesel.	N/A	N/A	N/A
Vietnam	B5 (in some big	E5 (in some big	N/A	2020: 50 million liters	2020: 500 million liters	“Basa” fish oil, used cooking oil and	N/A	N/A	N/A

	cities by 2015)	cities by 2015)					rubber seed oil for biodiesel. Jatropha is encouraged. Cassava for ethanol.		
<i>African countries:</i>									
Angola	-	E10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ethiopia	-	E5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kenya	-	E10 (in 1 city)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Malawi	-	E20	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mozambique	-	E10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nigeria	-	E10 (no mandatory)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
South Africa	-	E10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sudan	-	E5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zimbabwe	10% (2015)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
<i>Other countries:</i>									
Canada	B2 (national).	E5 (national) and up to E8.5 in 4 provinces.	N/A	N/A	N/A	N/A	N/A	CAD\$198-210 million (2006); CAD\$287- 344 million (2007); CAD\$378-466 million (2008) (b)	
Jamaica	-	E10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Australia	B5 (in New South Wales)	E6 (in New South Wales)	N/A	N/A	N/A	N/A	N/A	AUD13 million (2004–2005), AUD34 million (2005–2006), AUD 95 million (2006–2007) (b)	

(a) IEA 2009 estimates based on inventories of tax advantages and price-gap approach (IEA, 2011).

(b) Global Subsidy Initiative estimates based on country studies (for certain periods) (Gerasimchuk *et al.*, 2012).

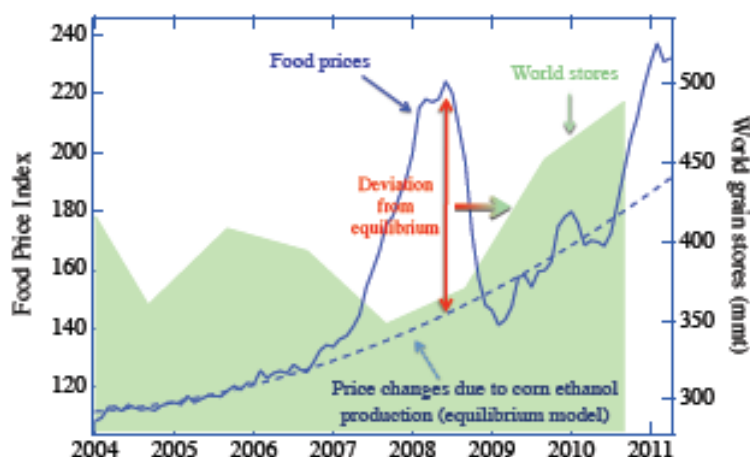
FFV – Flexible Fuel Vehicles; FEISEH – Ecuadorean Investments Fund in the energy and hydrocarbon sector (Fondo *Ecuatoriano de Inversión en los Sectores Energético e Hidrocarburífero*); BIOCAP – Paraguayan Biodiesel Chamber (*Cámara Paraguaya del Biodiesel*).

Source: Dufey (2011), USDA (2012), ANP (2012), SAC (2012), US Department of Energy site, Universidad de Chile, MME-Brasil (2012), NextFuel (2012), Eleve (2012), Man (2008), Salvatore & Damen (2010), Fengxia (2007), Dermawan *et al.*, 2012, ADB, 2012, IEA (2011), (Gerasimchuk *et al.*, 2012).

Appendix II. Speculation and Changes in Stocks

For the most part, papers finding a large role for speculation in driving up agricultural crop prices do not discuss stocks. One exception is a paper that points to the rise in stocks after the end of harvest year 2008 and into 2009. (Lagi, 2011). According to this paper, this rise in stocks reflects the speculative activity that drove up crop prices in 2007 and through the spring of 2008.²⁰ Yet, if that is true, then the collapse in price after the spring of 2008 should have resulted in a decline in stocks by stock year 2009. In fact, stocks increased at the end of 2009.

Chart 1



Source: Figure 3 of Lagi 2011

The more fundamental problem is that stock changes from year to year reflect not only changes in demand but also in supply. The simple explanation for the rise in stocks at the end of 2008 is that 2008 was a bumper crop year, with both yields and total production well above trends (see discussion in text). Excluding China, production in 2008 was 97 MMT more than in 2007, and 213 MMT more than in 2006, and that resulted in a growth in grain stocks outside of China of 62 MMT from 2007 to 2008, and a total of 80 MMT from end of crop season 2006 to end of crop 2008.²¹ In short, both the sharp drop in prices by the end of 2008, and the rise in stocks in 2008 are well explained by the bumper crop of 2008.

The growth in the use of grain for ethanol was 40 MMT from 2006 through 2008, which should be treated as roughly a 28 MMT increase when accounting for the feed value of by-products. The increase in stocks of 80 MMT at the end of 2008, even when adding in this increase in ethanol consumption, is far less than the increase in production of 213 MMT in 2006. That implies that during 2008, there was a large increase in consumption for grain for reasons beyond the rise in ethanol. That contradicts the view that speculators were driving up prices by withholding crops from the market.

²⁰ The graph reproduced from that paper lags the stock changes by one year in the belief that changes in purchasing behavior only show up on a year time lag in stocks. To us, that actually makes the fit between the speculative theory even worse. As shown by this graph, stocks would have increased only in late 2009 despite the fact that crop prices collapsed in 2008. That would make it impossible to explain increases in stocks as a function of price increases due to speculation.

²¹ Production and stocks outside of China are more relevant to the speculation argument as China's stocks are dictated primarily by government policy and China was neither a significant importer nor exporter of grains in these years (Abbott, 2011, p. 11, Fig. 12). However, the change in production including China was even larger: harvest in 2008 was 118 MMT higher than in 2007, and 238 MMT higher than in 2006.

The harvest in 2009 outside of China was also strong from the standpoint of both yield and total production, particularly for wheat which had a large increase in area harvested. It too does a good job of explaining the modest continued rise in grain stocks of 27 MMT outside of China, 82% of which came through wheat. In short, grain stocks outside of China reflect changes in production, and do not correspond over the whole period of 2007-2009 to "speculation."

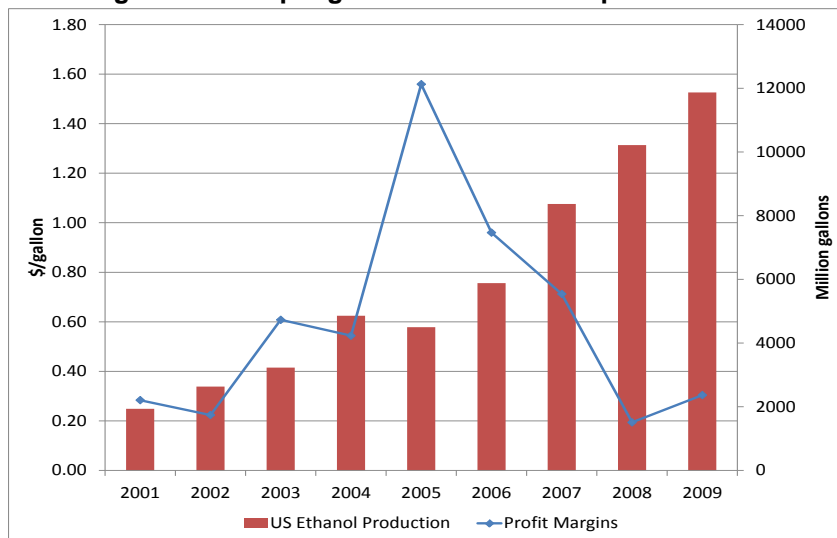
Appendix III. Drivers of Increased U.S. Biofuel Production

Biofuels have had a relatively long history of public support in the forms of subsidies, but that support did not lead to the capacity to produce them in large scale until recently. As an example, the blender's tax credit, a strong support measure to encourage ethanol demand in the US has been in place since the Energy Bill of 1978. However, a large growth in ethanol production did not occur until the mid-2000s.²²

Several factors contribute to the recent increase, such as a ramp up of policy support in the form of both direct production and consumption subsidies and consumption mandates. However, current levels of biofuel production are not driven solely by public support (Babcock, 2011). A key factor on the increase of biofuel production and consumption and in particular of ethanol has been the rapidly escalating prices for energy which made ethanol a viable and attractive substitute for gasoline based on its economics. As a matter of fact, biofuels are currently the only liquid transportation fuel available in large scale to substitute fuels as their price escalates (Babcock, 2011). Another factor that contributed to the rapid expansion of demand and ensuing production in the U.S. was the de-facto ban of methyl tert-butyl ether (MTBE), a gasoline oxygenate, in the mid-2000s. Ethanol was the only alternative oxygenate available to substitute MTBE and its demand soared. With an ethanol supply limited by the production capacity, the price of the biofuels increased rapidly (see charts 12 and 13).

The high demand and prices for ethanol in the mid-2000s occurred at a time in which the price of corn was relatively low, providing high returns to biofuel production. The production margins shown in chart 12 acted as strong incentives to invest in the expansion of the ethanol refinery capacity. Tax credits and the ensuing introduction of mandates under the renewable fuel standards (RFS) provided a secure market and reduced investment risks. The result was an industry in which production capacity increased at a rapid rate in the second half of the 2000s. However, research has found (e.g. Babcock, 2011) that a large expansion of the ethanol industry would have occurred due to the requirement for oxygenated fuels even in the absence of tax credits or mandates.

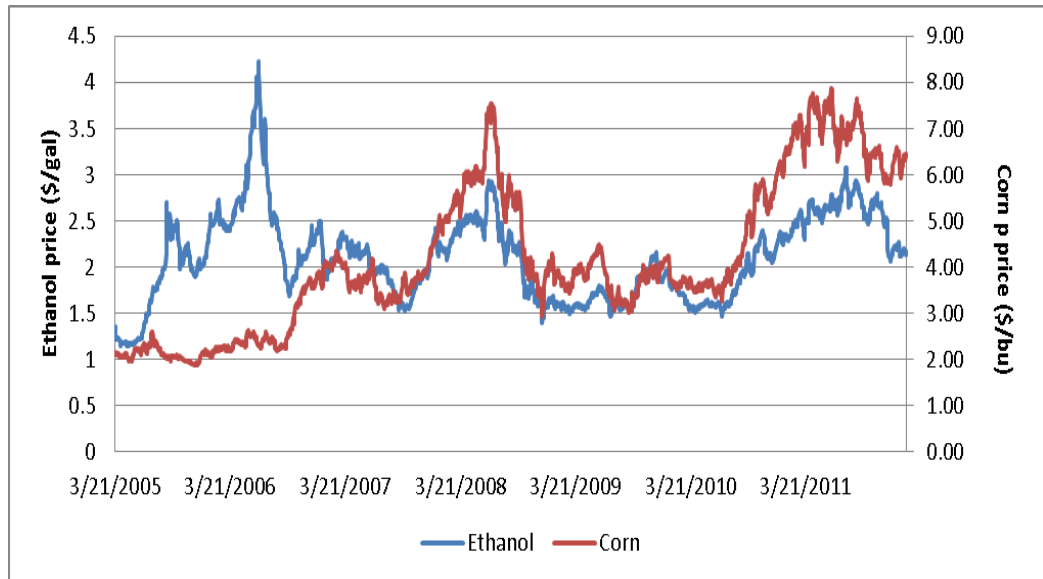
Chart 2. High profit margins led to rapid growth in US ethanol production.



Source: Babcock 2012a.

²² It should be noted that this subsidy was let expire at the end of 2011.

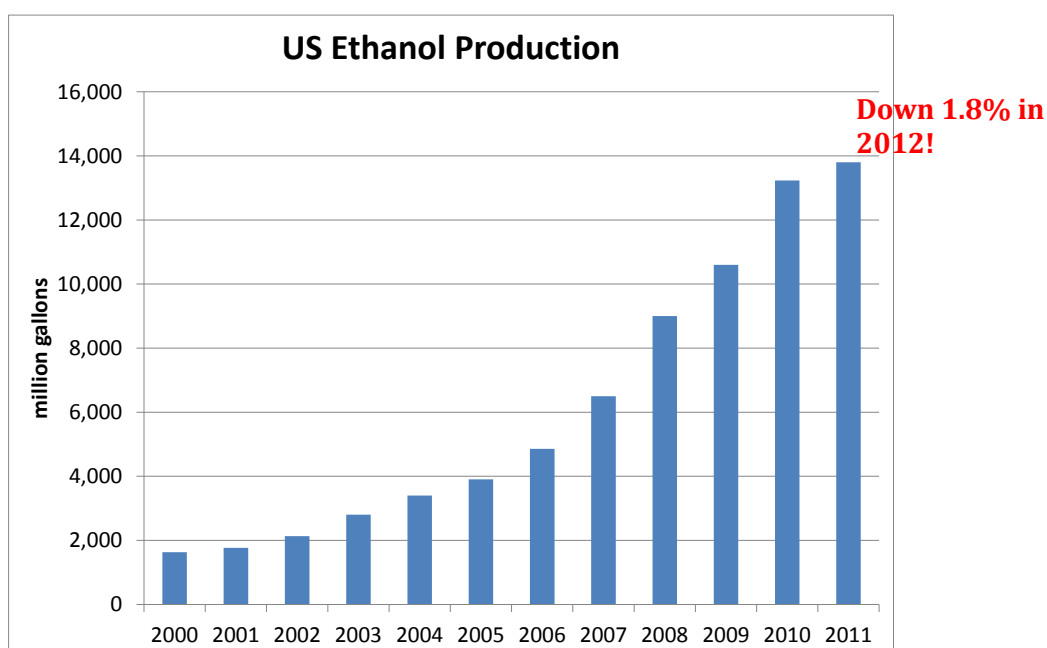
Chart 3. Daily evolution of Chicago Board of Trade futures prices for ethanol and corn between early 2005 and 2012.



The price gap that opened in 2005 and 2006 spurred the capacity investment and production of the following years. Capacity to transform corn into ethanol kept the two prices moving together, and in particular it is thought to have prevented the price of corn from falling below its energy valuation (factoring in the blenders tax credit between 2007 and 2010).

During several months in 2008, the combination of high oil prices and the 51 cent per gallon U.S. tax credit for ethanol meant it was economical to produce ethanol up to \$7.00 per bushel, eventually the price of corn rose to levels that eliminated the returns. More recently, however, the price of corn is starting to be above its value as ethanol, creating hardship for some ethanol plants that have either lowered production levels or went bankrupt. This can be seen in chart 14, which shows production growth slowing down considerably in 2011, and the expectation is to see a decline in 2012.

Chart 4. US Ethanol production growth slows down in 2011. Production is expected to decline in 2012



Source: Babcock 2012b

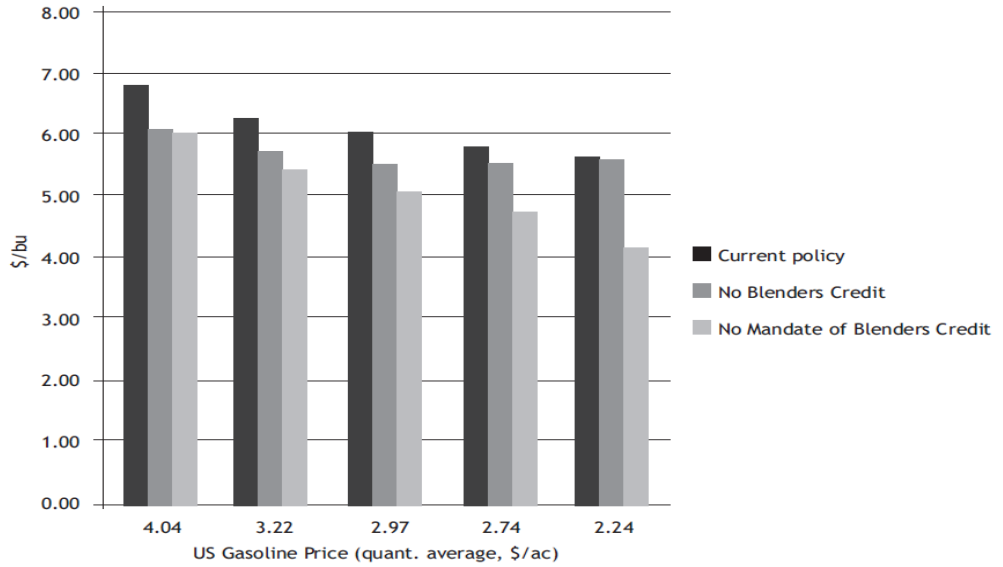
The expansion of the corn-ethanol production expansion has come to a halt. Notice that the costs of production as represented by the price of corn in chart 13 has increased more than that of ethanol eroding producer returns (see also chart 12). The U.S. market is close to the level it can consume with the existing fleet and distribution infrastructure (blend wall). Also the current capacity is close to the 15 billion gallons mandated under RFS2. The resulting ethanol prices and high corn prices reflecting their energy valuation largely removed the incentives to invest in new capacity. It is widely believed the U.S. corn ethanol industry will not expand significantly beyond current levels. However, with sustained high energy prices and relatively low production costs, other countries such as Argentina and Brazil are investing in corn-ethanol refineries.

Technology improvements over time and tremendous investments in industrial processing capacity effectively led to the current situation in which large amounts of feedstocks can be converted into energy. This capacity provides the opportunity for market participants to arbitrage between the two markets if their prices are misaligned. The intuition is simple. If the price of corn is low relative to its value as a source of energy in the form of ethanol, there is a profit opportunity for ethanol producers that will increase production. Clearly the extent and speed in which they can react depends on the amount of idled capacity and the rate at which new capacity can be brought online. The additional derived demand for corn will act increasing its price and closing or reducing the opportunity to arbitrage. Conversely, if the energy price is low, ethanol plants will react by lowering production, reducing the quantities of corn demanded and its price. It should be noted though that if energy prices become sufficiently low, other sources of demand such as the feed demand will act as the residual user and determine prices. This was the situation until the mid-2000s.

One of the first studies providing this insight and analyzing the implications of the link created by ethanol between energy and agricultural markets was Elobeid et al. (2006). The authors argued there that in a high energy price environment, corn was underpriced relative to its energy content. Based on an arbitrage argument they predicted a doubling of the price of corn from the early 2000's if the price of crude remained at around \$60/barrel. Clearly the price of crude oil surpassed their assumption, and led to higher equilibrium level price of corn. Similar insights are provided by Tyner and Taheripour (2007). Note that in this logic, the high price of corn is not the result of the additional quantity demanded but of the new value that is transmitted to the crop as a substitute for gasoline.

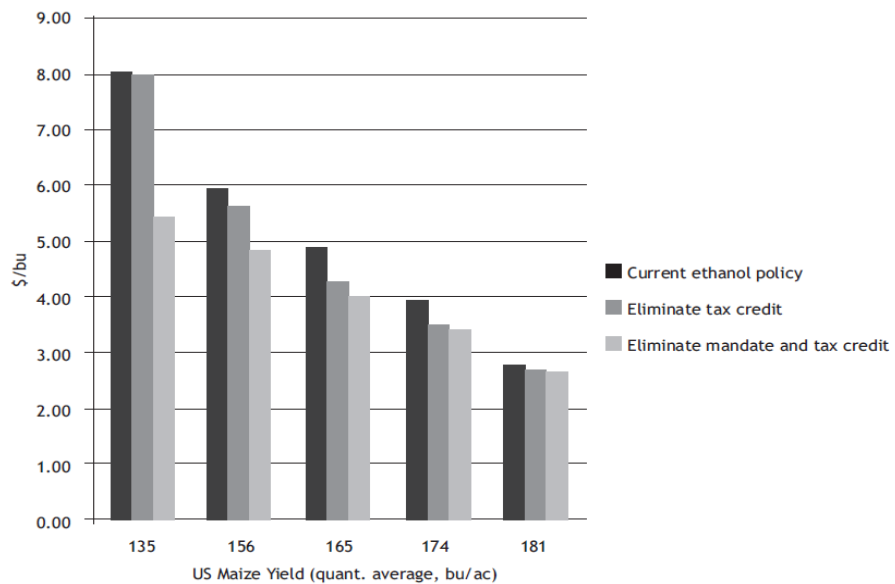
The existence and impacts of this link has been empirically analyzed by many authors in both the agricultural economics and energy literatures. Evidence available confirms it, pointing to spillovers not only on levels but on volatility between these markets. Some authors find that some of price relationships between ethanol and corn are due to arbitrage conditions that arise in the future, but impact current pricing relationships as a result of the storability of both ethanol and corn (Mallory, Hayes, and Irwin, 2010).

Chart 5. Impacts of US tax credits and consumption mandates under different gasoline prices



Source: Babcock 2011

Chart 6. Impacts of US tax credits and consumption mandates under different corn yields



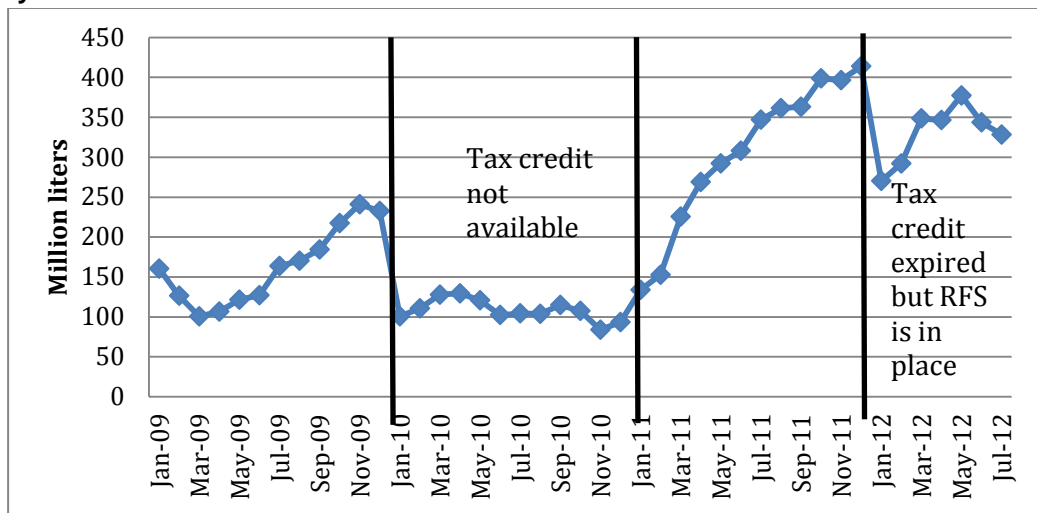
Source: Babcock 2011

A disturbing implication of the link established between the energy and agricultural commodity markets is that the advocated elimination or reduction on the size of the support to biofuel production by development and civil society organizations may not have as large an impact in reducing commodity prices as they might hope. Babcock (2011) illustrates that the impact of the elimination of tax credits or mandates is highly context dependent. Charts 15 and 16 show that two commonly used policies (tax credits and mandates) may have little or no effect on the price of corn when energy prices are high.

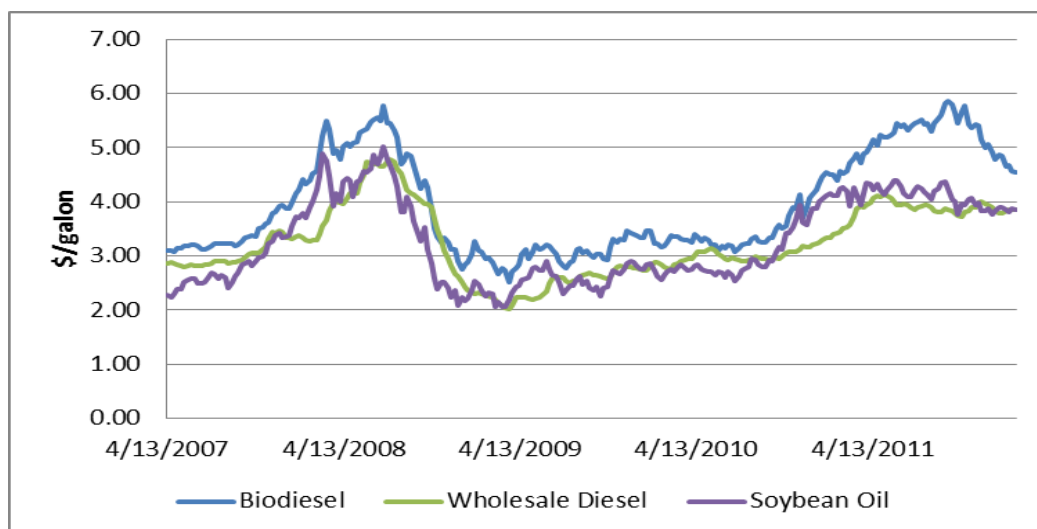
The story is different for biodiesel, which is clearly much more dependent on government support than ethanol in order to be economically viable. There is no question, as the recent lapse in support in the US demonstrated, the size of the biodiesel industry would be much smaller in the absence of public support (see chart 17). The reason for the policy-dependence of the biodiesel markets is that the feedstock to produce it, namely vegetable oil is expensive relative to diesel (see chart 18). The higher historical price of biodiesel, relative to diesel and therefore the viability of its production can be attributed mostly to public support in the forms of tax credits or consumption requirements. In the US, when the tax credit lapsed in 2010 production declined sharply. The current implementation of the Renewable Fuels Standards, mandating biodiesel consumption prevented a similar production decline after the credit expired at the end of 2011.

Another interesting feature can be observed in chart 18. The price of biodiesel increased significantly relative to that of diesel and soybean oil indicating that a price and production margins increase was needed to entice producers to supply the quantities that were needed under the RFS. Mandates and tax incentives interact in the market for biodiesel and the derived demand for soybean oil in an analogous way as was presented for the ethanol and corn markets. The main difference is that the price of vegetable oils usually surpasses their value as a diesel substitute. In this case, the mandates are more likely to bind, and the biofuel producers are more dependent on policy supports for economic viability. Therefore, policy modifications such as mandate reductions, or the implementation of flexible mandates can be more effective at modifying feedstock prices than in the case of ethanol.

Chart 7. Monthly US Biodiesel Production



Source: Elaborated base on EIA data.

Chart 8. The price of biodiesel has been higher than that of diesel

Source: Elaborated based on USDA and EIA data.

A wide variety of policies, including tax reduction or total exemptions, greenhouse gas emission policies, blending requirements, renewable portfolio standards for transportation energy and other types of energy all contribute in shaping the historical evolution of biofuels (Rajagopal and Zilberman, 2007). The existence of a myriad of support policies complicates the analysis of biofuel markets and its mediating interaction with energy and commodity markets. Mandates muddle the picture. Binding mandates break the link between energy and commodity prices. Given the complexity, to disentangle the effects of biofuel production levels and support policies on agricultural prices and land use changes, researchers are relying on increasingly sophisticated models. While clearly not perfect, the models provide the best tools available to isolate and quantify the impacts of biofuels on commodity prices.