Biofuels:
Agricultural commodity prices, food security, and resource use

A review of the scholarly literature and the public debate

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List of abbreviations

BMEL – Bundesministerium für Ernährung und Landwirtschaft
DDGS – Dried Distillers’ Grains with Solubles
ESIM – European Simulation Model
EU – European Union
FAO – Food and Agriculture Organization
FAPRI – Food and Agriculture Policy Research Institute
GHG – Greenhouse Gas(es)
GTAP – Global Trade Analysis Project (model)
IFAD – International Fund for Agricultural Development
IFPRI – International Food Policy Research Institute
IEEP – Institute for European Environmental Policy
IIASA – International Institute of Applied Systems Analysis
ILUC – Indirect Land Use Change(s)
JRC – Joint Research Centre
MIRAGE – Modelling International Relationships in Applied General Equilibrium
NGO – Non-Governmental Organisation(s)
OECD – Organization for Economic Cooperation and Development
RFA – Renewable Fuels Association
US – United States
USDA – United States Department of Agriculture
WFP – World Food Program
WFS – World Food System (model)
Executive summary

Current agricultural development faces many challenges. One of them is that the growth in global agricultural demand is outpacing supply growth. Price increases in international agricultural commodity markets are the result. This has raised concerns about both growing hunger and an expansion of the agricultural acreage around the globe. By some, the growth in biofuel production is blamed for a large portion of the price increases and the expansion of the agricultural acreage the world has seen since the turn of the millennium. The public debate about negative impacts of biofuels on the price of agricultural commodities and food as well as the use of natural resources is continuing.

The objective of this paper is to review the literature on various effects of global and EU biofuel production and to illustrate to what extent the public debate is driven by scholarly research. The analysis focuses on agricultural commodity market prices, global food security, and greenhouse gas emissions as well as the underlying land use conflicts. Particular emphasis is placed on related effects caused by bioethanol production in the EU.

The review of the literature shows a marked difference between the results of scholarly research on the one hand and NGO publications on the other hand. It turns out that the magnitude of the impact of biofuels on agricultural commodity prices is most probably much smaller than reported by various NGOs and in the media. The rather limited price increase caused by the growth in global biofuel production and consumption does not explain the rapid agricultural commodity prices increases seen since the turn of the millennium. This is even truer for EU bioethanol production and consumption. Unsurprisingly, many scientists are also more moderate than various NGOs in their assessments of the impacts of biofuel production on issues such as world food security and greenhouse gas emissions.

In sum, the emphasis on biofuel production and consumption in the public debate distracts from these root causes of rising international agricultural commodity prices and from other main drivers of hunger and increasing land use conflicts.

In fact, securing enough food has been a prime concern of humankind since its beginnings. This led two British economists, Malthus and Ricardo, to develop dismal projections about the future of humankind. However, the reality of world food and agriculture has been different. In the past century world agriculture had managed to produce ever more food for ever more people at ever declining prices. As a consequence, the percentage of the world population which was undernourished had declined.

The world food situation, however, has changed. The turn of the millennium has marked a mega trend reversal in international agricultural commodity markets. Since then, commodity prices in international agricultural markets have tended to rise. It has triggered a rather intense public debate about the causes of world hunger and policies to alleviate the situation.
It has been demonstrated in this paper, that an innovative and highly productive agriculture is a key to eradicate hunger around the globe. This is particularly true for 75 percent of the world’s poorest people living in rural areas and depending on agriculture and related activities for their livelihood. With such an agriculture the EU and the world at large can afford more of everything: More food, more feed, more biofuels, more natural habitats, more biodiversity, and along with it reduced greenhouse gas emissions resulting from an expansion of the agricultural acreage.

The conclusions of this paper are:

1. The methodological and empirical foundation of scholarly analyses of the impacts of biofuel production and consumption is just beginning to emerge. There are considerable variations in the quantitative results in the scholarly literature. As a consequence, there continues to be some degree of uncertainty about the actual quantitative impacts of biofuel production and consumption.

2. That scholarly research tends to yield much lower price increases and other related effects than those reported in various NGO publications is consistent with political economic theory. Scholarly analyses strive to generate as accurate results as possible. NGOs, however, usually emphasise only selective aspects and partial information of the issue at hand and offer spurious solutions which promise a lot of public attention and, thus, economic returns.

3. It is, therefore, advisable to keep both in mind when assessing the economic and environmental implications of biofuel production and consumption – the fairly early stages of scholarly economic analysis and the political economy of NGOs engaged in food and agriculture.

4. It is obvious that biofuels act to increase the demand for agricultural commodities and that they compete with food and feed for the scarce natural resources. There continues to be a range of estimates of the actual effects of biofuel production and consumption in the scholarly literature hinting at the need for further research. However, the results of scholarly research on this matter suggest that the impact of biofuels on prices and on resource competition is rather limited. This is supported by some simple and straightforward calculations in this paper. In fact, research consistently stipulates that variables other than biofuels such as population and consumption growth together with declining productivity growth, limited natural resources, rising energy prices, and some other variables are key drivers for the rapidly rising agricultural commodity prices and the continuing expansion of the global agricultural acreage.

5. Ultimately, the emphasis on biofuels in the public debate about world food security and related issues distracts from the root causes of persisting hunger and may lead to inadequate political responses which in the end may increase hunger rather than reduce it.
Zusammenfassung


Insgesamt entsteht der Eindruck, dass die Konzentration auf Biokraftstoffe in der öffentlichen Debatte von den wirklich maßgeblichen Bestimmungsfaktoren der Agrarpreisentwicklung und anderer Variablen der Agrarentwicklung ablenkt.

zung zu stellen. Infolge dessen ist der Anteil der Hungernden an der Weltbevölke-
runung gesunken.

Gleichwohl ist auch festzustellen, dass seit etwa der Jahrtausendwende die Agrar-
preise wieder steigen, und die öffentliche Debatte über die Gründe von Hunger und
Politiken zu dessen Bekämpfung wird intensiv geführt.

Eine innovative und hochproduktive Landwirtschaft ist ein Schlüssel, um den
Hunger in der Welt zu bekämpfen. Das gilt insbesondere für die 75 % der Ärmsten,
 die in ländlichen Gebieten in Abhängigkeit von der Landwirtschaft ihren Lebens-
unterhalt bestreiten. Mehr Nahrungs- und Futtermittel sowie Biokraftstoffe kön-
nen so erzeugt werden, und gleichzeitig können auf diese Weise mehr natürliche
Habitate und damit Biodiversität geschützt und der Ausstoß von Klimagasen redu-
ziert werden. Folgende Schlussfolgerungen werden gezogen:

1. Die wissenschaftliche Analyse der Auswirkungen einer Biokraftstofferzeugung
und deren Verbrauch steht erst am Anfang. Ausdruck dafür sind beachtliche
Variationen in den quantitativen Berechnungen in der wissenschaftlichen
Literatur. Folglich ist noch immer ein hohes Maß an Unsicherheit in der Be-
wertung von Auswirkungen der Biokraftstoffe zu konstatieren.

2. Dass die wissenschaftlichen Forschungsergebnisse deutlich geringere preis-
steigernde Effekte und damit in Zusammenhang stehende Auswirkungen auf-
zeigen als etwa Berichte verschiedener Nichtregierungsorganisation ist kon-
sistent mit der politikökonomischen Theorie. Wissenschaftliche Arbeiten zielen
darauf ab, sorgfältig ermittelte Resultate zu generieren. Verschiedene Nicht-
regierungsorganisationen heben jedoch oft selektive und partielle Informa-
tionen hervor und präsentieren auf dieser Basis gerne Scheinlösungen, die
Aufmerksamkeit und zusätzliche Mittelzuflüsse versprechen.

3. Beides – der noch junge Forschungsstand und die politische Ökonomie von
Nichtregierungsorganisationen, die sich in den Bereichen Landwirtschaft und
Ernährung engagieren, – sollte beachtet werden, wenn ökonomische und
Umweltwirkungen von Biokraftstoffen bewertet werden.

4. Es steht außer Frage, dass auch Biokraftstoffe die Nachfrage nach Agrarpro-
dukten erhöhen und mit Nahrungs- und Futtermitteln im Wettbewerb um
knappe natürliche Ressourcen stehen. Die tatsächlichen Auswirkungen der Bio-
kraftstofferzeugung und deren Verbrauch zu bestimmen, erfordert noch wei-
tere Forschungsanstrengungen. Dennoch ist offensichtlich, dass der Effekt
der Biokraftstoffe auf Preise und Ressourcenbeanspruchung vergleichsweise
gering ist, was durch einfache Kalkulationen bestätigt wird. In der Tat sind
das globale Bevölkerungs- und Einkommenswachstum, die geringen Pro-
duktivitätssteigerungen im Agrarsektor, knappe natürliche Ressourcen, stei-
gende Energiepreise und andere Variablen einige der Schlüsseldeterminanten
aktueller Entwicklungen.
5. Die Konzentration auf die Biokraftstoffherstellung in der öffentlichen Debatte um die globale Ernährungssituation und damit in Verbindung stehende Aspekte lenkt also von den wesentlichen Gründen anhaltenden Hungers in der Welt ab und kann zu nichtzweckmäßigen politischen Entscheidungen führen, die am Ende das Hungerproblem sogar verstärken können.
1 Introduction

Current agricultural development faces many challenges. One of them is that the growth in global agricultural demand is outpacing supply growth. The resulting price increases in international agricultural commodity markets (e.g., FAPRI, 2013; OECD and FAO, 2013) have raised concerns about both growing hunger and an expansion of the agricultural acreage around the globe—sometimes referred to as “indirect land use change” (ILUC). Such a land use change has become a cause for concern because it could result in increasing greenhouse gas (GHG) emissions and cause a loss of natural habitats and biodiversity in regions in which the agricultural acreage is expanded (Noleppa et al., 2013). Increasing world market prices and hunger are also raising fears of growing political instability and violence as well as increasing migration away from poor towards the rich and not so poor countries and the attendant cost (e.g., FAO et al., 2013).

By some, the growth in biofuel production is blamed for a large portion of the price increases and the expansion of the agricultural acreage the world has seen since the turn of the millennium. In the year 2008, around the time agricultural commodity prices peaked, the World Bank published a study in which more than 70 percent of the price increase at that time was attributed to the growth in global biofuel production (Mitchell, 2008). This study was harshly criticized (e.g., Urbanchuk, 2008). It was seen as grossly overestimating the impact of growing global biofuel production on agricultural commodity prices. As a consequence, a subsequent study by the World Bank published two years later stated that the earlier study was likely to have overestimated the impact of biofuel production on agricultural commodity prices (Baffes and Haniotis, 2010).

The public debate about negative impacts of biofuels on the price of agricultural commodities and food and the use of natural resources around the globe is continuing, however. The objective of this paper is to review the literature on various effects of biofuel production and to illustrate to what extent the public debate is driven by scholarly research. The paper will focus predominantly on agricultural commodity market prices, global food security, and GHG emissions as well as the underlying land use conflicts. Particular emphasis is placed on related effects caused by bioethanol production in the European Union (EU).

In the remainder of this paper we will, first, analyse the public and scientific debate in order to determine the magnitude of the impacts of biofuel production on agricultural commodity prices, the access to food, and GHG emissions (chapter 2). Second, we will assess the arguments used in the public debate from a broader development perspective (chapter 3); and, third, we will check plausibility and consistency of some arguments offered in the public debate (chapter 4). The paper ends with some conclusions (chapter 5).
2 Impacts of biofuels on world market prices, global hunger, and greenhouse gas emissions: A review

The following review of the scientific literature and the public debate is focussed on impacts of global biofuel production in general and of EU bioethanol production more specifically. Three aspects of the issue at hand will be addressed: agricultural commodity prices, food security, and GHG emissions. The discussion starts with literature findings on price effects.

Agricultural commodity price impacts

In a recent paper, Grethe et al. (2013) did a comprehensive economic analysis of the various effects of a discontinuation of biofuel subsidies in the EU. The study was commissioned by the Heinrich Böll Foundation and by Oxfam. The authors defined a scenario in which EU subsidies for biofuel production are phased out completely by the year 2020.

The analysis is based on the European Simulation Model (ESIM). This is a partial equilibrium simulation model which has often and successfully been applied in economic analysis (e.g., Banse et al., 2010). The results of the Grethe et al. (2013) study may be summarised as follows:

- The world market price of oilseeds would decline by 10 percent while the price of vegetable oils would go down by 16 percent.
- The world market prices of sugar, grains in aggregate and wheat in particular would decline by 3.4 percent, 2.1 percent, and 4.0 percent respectively.
- The global price index of cash crops (such as sugar, oilseeds, grains, potatoes) would fall by 2.6 percent. As will be demonstrated later, this is a reasonable order of magnitude of the actual price effect.

With respect to EU bioethanol production, the authors argue that the additional demand for sugars and grains for bioethanol production is comparably low in the EU. Therefore, the price reductions for sugar and grains are lower than for oilseeds.

Kretschmer et al. (2012) review the results of a number of earlier studies which were also based on market models and analyse the effects of biofuel production on international agricultural commodity markets. This work was commissioned by the Action-Aid organization.

The basic theoretical argument of the Kretschmer et al. (2012) meta-analysis is that the global production of biofuels acts to increase the demand for agricultural commodities. As a consequence, agricultural commodity prices tend to rise.
In order to analyse and determine the magnitude of the potential market price effects caused by biofuels, the authors, reviewed a total of twelve academic papers. Seven of these studies have a special emphasis on EU biofuel production. The other five studies focus on global biofuel production. Figure 1 summarises the commodity price effects reported in the Kretschmer et al. (2012) meta-analysis of global and EU biofuel production.

**Figure 1: Range of price effects reported in a meta-analysis of biofuel production in the EU and globally (in percent)**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>EU biofuel production</th>
<th>Global biofuel production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseeds</td>
<td>8 – 20</td>
<td>2 – 7</td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>1 – 36</td>
<td>35</td>
</tr>
<tr>
<td>Cereals / maize</td>
<td>1 – 22</td>
<td>1 – 35</td>
</tr>
<tr>
<td>Wheat</td>
<td>1 – 13</td>
<td>1 – 8</td>
</tr>
<tr>
<td>Sugar (cane / beet)</td>
<td>1 – 21</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: Own figure based on Kretschmer et al. (2012).

It is interesting to note that some of the price effects of EU biofuel production in figure 1 exceed those of global production. This would be an unreasonable result, as the EU biofuel production represents only a fairly limited portion of global production. For instance, the EU bioethanol production represents almost 6 percent of the global bioethanol production (RFA, 2014). By and large, this is due to the inherent uncertainty still embedded in modelling EU and/or global biofuel production effects (see also Noleppa and von Witzke, 2013).

The information provided by Kretschmer et al. (2012), together with the more recent calculations reported in Grethe et al. (2013), demonstrate at least three interesting other facts:

- A key result is that there are significant differences in the price effects of EU biofuel production between agricultural commodities. While the price effects for oilseeds and vegetable oils are fairly high, they are moderate for cereals such as maize and wheat as well as for sugars. In other words, price effects of bioethanol production are smaller than those caused by biodiesel production in the EU.

- The second remarkable result is that there is a considerable variation in the price effects by commodity or commodity group between the analyses included in the surveys. Obviously, there continues to be quite a bit of uncertainty about the magnitude of the price effect.
Finally, a conclusion by Kretschmer et al. (2012) warrants attention. Despite considerable uncertainty about the actual price effects of biofuel production, it is obvious that the overall price effects of both the EU and the global biofuel production are fairly small relative to the magnitude of recent price increase in international agricultural commodity markets as the FAO Food Price Index almost doubled in the past few years (see FAO, 2014a). This suggests that other variables may have a much larger impact on prices than the production of biofuels.

Yet another aspect of the Kretschmer et al. (2012) paper is the ambivalent effect of price increases on consumers and producers in developing countries. The authors argue that rising prices are detrimental for net food buyers (many of them residing in urban areas) while they may have positive impacts on net food sellers (typically residing in rural areas). The authors stress, however, that prices must stay high over extended periods of time if they are to lead to sustained benefits for producers, as price volatility in and of itself may be economically damaging.

In a study by Oxfam (2012) it is also argued that the price effect of EU biodiesel exceeds that of EU bioethanol production. This would be amplified by the fact that the EU is considered a major importer of biodiesel, as 42 percent of commodities used for the production of biodiesel are imported. For bioethanol, this number is reported by Oxfam (2012) to be only at 24 percent. In essence, the Oxfam (2012) paper argues that both biodiesel and bioethanol production are major driving forces of increasing food and oil product prices.

More specifically, the authors of the Oxfam (2012) paper refer to the Kretschmer et al. (2012) study and claim that a continuation of EU biofuel policies through the year 2020 would certainly act to increase the price of oilseeds by 20 percent, the price of vegetable oils by 36 percent, the price of corn by 22 percent, the price of sugar by 21 percent, and the price of wheat by 13 percent. In other words, the Oxfam (2012) study cites only numbers that are at the upper bound of the range of potential price increases reported in the Kretschmer et al. (2012) study (see figure 1 above).

Providing such selective information on biofuel impacts is a pattern that appears to be common in the public debate and statements of some non-governmental organisations (NGO). An Irish civil society organisation paper (Trocaire, 2013) also refers to Kretschmer et al. (2012). A key message in this publication is that the continuation of EU biofuel policies through the year 2020 would result in price increases which happen to be identical to those reported by Oxfam (2012); that is, Trocaire (2013) also cites only the upper bound of the range of potential price increases reported by Kretschmer et al. (2012). So does Action-Aid (2012).

In short, while the three papers surveyed here (Oxfam, 2012; Trocaire, 2013; Action-Aid, 2012) all refer to Kretschmer et al. (2012), none of them explicitly mentions that they only report the upper bound of the price ranges reported in the
scholarly literature and that real price effects of both EU and global biofuel production, most probably, are considerably lower.

A number of other NGO papers follow similar patterns in that they selectively report impacts which are at the upper end of the modelled effects of biofuel production on agricultural commodity prices:

- An earlier study by Action-Aid (2011) argues that EU biofuel production would account for at least 30 percent of the 2007/08 spike in agricultural commodity prices. However, no information is provided about how this number was generated.

- According to a paper by Grain (2013), both United States (US) corn and EU oilseed production for biofuel generation are seen as a key reason for low stocks and rising prices. This again is reported without information on how this conclusion was arrived at.

It becomes obvious that scholarly research, such as Grethe et al. (2013) and Kretschmer et al. (2012), tend to arrive at more differentiated conclusions on price impacts than the NGO papers reviewed here. Ecofys (2013) and also Hamelinck (2013) note that the results of studies on the price effects of biofuel production largely depend on the models applied and scenarios defined. That is, model results should always be interpreted with the appropriate care and accounted for the ways they were generated.

Hamelinck (2013) also makes use of a time-proven modelling tool, the World Food System (WFS) model developed by the International Institute of Applied Systems Analysis (IIASA) (see, e.g., IIASA, 2012). The author arrives at the conclusion that the impact of EU biofuel production on the prices of wheat and other grains is in the range of only 1 to 2 percent during the 2000 to 2010 time period while the price increasing effect on oilseeds and vegetable oils during the same period of time is around 4 percent (see also Ecofys, 2013). As will be demonstrated later in this paper, this is a reasonable order of magnitude of the actual price effect.

With unchanged EU biofuel policies the market prices of these commodities may be expected to increase by just another percent until 2020 (Hamelinck, 2013). Therefore, the authors draw the conclusion that the current and future expected price increases in these commodities must be the result of variables other than EU biofuel production.

Brockmeyer et al. (2013) also report that agricultural price increases caused by global biofuel production are fairly limited. The authors analyse the determinants of agricultural commodity prices until the year 2020 and base their analysis on one of the most frequently used and quoted general equilibrium models in agricultural economics known as the Global Trade Analysis Project (GTAP) model (e.g., Narayanan et al., 2012). Brockmeyer et al. (2013) base their commodity price pro-
jections on the change in global bioenergy production (not just biofuels!) expected by OECD and FAO (2012) in the year 2020. Their results suggest that with unchanged global bioenergy production world market prices for coarse grains would go up by 6 percent and the world market price of oilseeds by just 3 percent. According to the authors, the impacts of other variables on prices are much more important than those of the bioenergy sector.

The most recent comprehensive literature review of the effects of biofuel policies on the prices of agricultural commodities is done by Schmitz and Moleva (2013). The results of their survey again demonstrate that the empirical results vary over a wide range. In essence they argue:

• that the exact magnitude of the agricultural commodity price effects of biofuel production is still a matter of debate, and

• that variables other than biofuel production are the key drivers of rising commodity prices.

In view of Schmitz and Moleva (2013), there are several reasons which account for the wide range of model results reported in the literature. Three key reasons are as follows:

• The first is the length of the time period analysed. The shorter the time period envisaged the more inelastic is the reaction of market participants and the higher is the commodity price effect of biofuel production. In the long run, market participants are able to adapt (i.e. to react more elastically). Hence, the commodity price impact of an additional biofuel production declines with the length of the time period considered.

• The time period analysed matters as well. For instance, the relative importance of price determining variables during the price spike of 2007/08 differs from the drivers of the most recent price spike in 2010/11.

• The third and perhaps most important reason for the differences in the model results is the underlying modelling approach. The results depend to a large extent on the price determinants included in the analysis, the price and cross price elasticities used, and the model type (comparative static vs. dynamic; partial vs. general equilibrium; stochastic vs. deterministic).

It is also interesting to note that none of the results of the analyses reported in the Schmitz and Moleva (2013) and other scholarly papers have been validated by an ex-post projection. Thus it is not known, how well the model results track the real world during the time period analysed.

Schmitz and Moleva (2013) also develop an econometric model which consists of two parts. One is a multiple regression analysis. The key results of this analysis are that neither the price of corn is significantly affected by bioethanol production
nor is the soybean price significantly determined by the production of biodiesel. The authors also do a vector auto-regression analysis. Again the results show no statistically significant effect of bioethanol production on the market price of corn and of biodiesel production on the market price of soybeans.

In view of the publications surveyed above, three facts become apparent:

1. Both global and EU production as well as consumption of biofuels do impact on international agricultural commodity prices.

2. However, the magnitude of the impact is most probably much smaller than reported by NGOs and in the media. The rather limited price increase caused by the growth in global biofuel production and consumption obviously does not explain the rapid agricultural commodity prices increases seen since the turn of the millennium.

3. This is even truer for EU bioethanol production and consumption, as both represent only a rather small fraction of global biofuel sector.

**World food security impacts**

Although the scientific and public debate focuses on commodity price impacts of global and/or EU biofuel production and consumption, other issues are addressed as well in both scholarly papers and publications by NGOs. One of them deals with the effect of biofuel production on world food security. Some of the NGO trains of thought are listed below:

- Oxfam (2012) claims that hunger is increasing significantly as a consequence of biofuel production around the globe. The acreage used to produce biofuels from wheat and maize (i.e. essentially bioethanol) in the EU alone would have been sufficient to provide food for 127 million humans per annum.

- Action-Aid (2011) argues that the price spike of 2007/08 is largely caused by global biofuel production and that it had driven an additional 100 million humans into poverty while increasing the number of hungry humans by an additional 30 million. The authors also claim that biofuel production could increase foreign direct investment in agricultural land in developing countries which, in turn, would aggravate hunger and poverty in countries, where farmers have poorly defined or non-enforceable property rights in the land they use.

- In a more recent paper, Action-Aid (2013) emphasises that biofuel production of the G8 countries would act to reduce the food availability of up to 442 million humans.
A joint paper by a number of NGOs (Bird Life Europe et al., 2013) also deals with the hunger impact of biofuel production. In this paper, it is claimed that raising the cap for food-based biofuels from 5 to 7 percent in the EU would reduce food availability for almost 69 million humans.

These statements sound very alarming leading Searchinger (2013) to argue that the production of biofuels acts to reduce the availability of global food. However, they are either based on methods of analysis which are not being unveiled or they are based on overly simplistic assumptions:

- For instance, it is assumed that the entire acreage used for the production of biofuels reduces the acreage planted to food crops only.
- Moreover, they neglect that the production of biofuels does result in the production of by-products.

This not only ignores completely that for a considerable degree feedstuff is used to produce biofuels and that the production of by-products acts to reduce the overall price increasing effect of biofuels and the resulting availability of food and feed (see, e.g., Makkar, 2012).

Unsurprisingly, many scientists are more moderate than NGOs in their assessments of the impacts of biofuel production. They tend to be qualitative rather than quantitative in character:

- Gasparatos et al. (2013), e.g., stress that it may be useful to distinguish food availability effects for net-buyers from those of net-sellers in developing countries, as they are differently affected by increasing prices. Net-buyers obviously would lose, net-sellers would certainly gain.
- Swinnen et al. (2011) argue along similar lines. Consumers lose when prices go up while producers gain. Likewise food-importing countries lose while food exporting countries gain. Therefore it is important to distinguish between net-buyers and net-sellers.
- Hamelinck (2013) also emphasises this important aspect as do Schmitz and Moleva (2013).
- Grethe et al. (2013) arrive at the conclusion that a decline in the EU demand for biofuels and the resulting price reductions would have a positive effect on the nutritional status of food importing developing nations. However, they also argue that quantifying the magnitude of this particular effect is complex and not an easy task.

Again, it turns out that arguments on the food security impact of biofuels used by some NGOs which happen to fill the public debate differ quite a bit from the results of scholarly analyses.
GHG emission impacts

For an assessment of the findings in the pertinent literature on GHG emission impacts of global and/or EU biofuel production it is important to note that papers typically claim to analyse ILUC causing such emissions when, in fact, they analyse total land use changes. The vast majority of it is a simple change in crop-specific cultivation of agricultural acreage in use. For the purpose of this paper, the publication by Edwards et al. (2010) is a suitable point of departure. The authors claim to review the global ILUC of EU biofuel production. In essence, the paper, which has been commissioned by the EU Joint Research Centre (JRC), concludes that model calculations would result in significant ILUC effects of biofuel production. EU bioethanol production is reported to cause ILUC in the range of 0.2 to 0.7 million ha per 1.0 million ton of oil equivalent. The bulk of this expansion of the agricultural acreage is considered to occur outside of the EU. The numbers for EU biodiesel production are reported in the range between 0.2 and 1.9 million ha. Again, by far, the largest portion of it is seen to occur outside the EU.

As mentioned above, these numbers may not be very illustrative and they may be somewhat misleading as the models used cannot appropriately calculate ILUC. Rather they quantify only total land use changes and related carbon dioxide emissions. However, the results are consistent with other analyses facing the same restriction, i.e. the non-ability to distinguish ILUC from other land use changes:

- A paper by Bowyer and Kretschmer (2011) from the Institute for European Environmental Policy (IEEP) which was commissioned by two NGOs, namely Transport and Environment and Bird Life International, attempts to project the ILUC of EU biofuel demand in the year 2020 relative to the starting year 2008. The result of this analysis is that the ILUC would be in the range between 4.7 and 7.9 million ha. This would cause additional carbon dioxide emissions between 81 and 167 percent relative to the use of fossil fuel and it would be equivalent to the GHG emissions of an additional 14 to 29 million automobiles on EU roads.

- Bird Life International et al. (2010) report the ILUC of EU biofuel production to be at 6.9 million ha by 2020. The resulting carbon dioxide emissions would amount to up to 56 million tons. This would be equivalent to about 12 to 26 million additional cars on EU roads.

- Another paper by Gao et al. (2011) from the Center for International Forestry Research reports that global biodiesel production would lead to direct deforestation in Indonesia and Malaysia which would amount to 2.6 to 6.5 percent of total deforestation in these countries. This number for biodiesel production from soybean oil in Brazil would be up to 5.9 percent. The direct deforestation and, hence, the GHG emission effect of bioethanol production from sugar cane in Brazil and Columbia, however, are reported to be negligible.
• A study by Laborde (2011) from the International Food Policy Research Institute (IFPRI) has received much attention. It is based on IFPRI’s MIRAGE model and aims at quantifying the ILUC of EU biofuel production for the time period from 2008 to 2020. The analysis is based on the presumption that biofuel production in the EU would increase from 10.1 million tons in the year 2008 to between 17.8 and 20.9 million tons oil equivalent. The bulk of it would be accounted for by biodiesel production. The resulting land use change would be in the range of 1.7 to 1.8 million ha.

Only a minor part of it would be ILUC (see also Noleppa and von Witzke, 2013). The land use change would amount to additional carbon dioxide emissions which wipe out two thirds of the emissions saved by using biofuels. The GHG emissions from land use change caused by expansion of oilseed acreage for biodiesel would amount to 52 to 57 g carbon dioxide equivalent per MJ. This number for bioethanol is reported to be much lower and in the range of 4 to 17 g carbon dioxide equivalent per MJ.

The result of Laborde (2011) is consistent with findings by Grethe et al. (2013) and Searchinger (2013):

• Grethe et al. (2013) argue that bioethanol production in the EU would somewhat reduce the emissions of GHG, but that such a reduction in GHG emissions could be achieved at lower social cost by reducing energy consumption by other means.

• Searchinger (2013), in a paper commissioned by Friends of the Earth, reviews the results obtained in the Laborde (2011) paper. He claims that the additional carbon dioxide emissions caused by biodiesel would result in the fact that the total GHG emissions for biodiesel exceed those of fossil diesel. For bioethanol the result is different in that bioethanol results in GHG emissions, which are 25 to 45 percent lower than those of fossil fuels even when the emissions from land use changes are included.

The Laborde (2011) paper, although much criticised for a variety of reasons (see also Noleppa and von Witzke, 2013), is particularly interesting for the purpose of our paper because it is one of the very few studies which determine the effect of the biofuel sector relative to other market determinants. The results are that the increase of the biofuel sector in the EU until the year 2020 would account for only 1 percent of all global ILUC and, hence, GHG emissions calculated in the “business as usual”-scenario of the analysis. Therefore, market determinants other than biofuels contribute 99 percent to the loss in natural habitats and related carbon dioxide emissions.

Again the question arises, why the particular and obviously rather low effect of biofuel production and consumption dominates in the public debate.
Increasing land use conflicts

The nexus of increasing agricultural commodity prices, growing concerns about world food security, ILUC and related GHG emissions unveils that there is widespread agreement about the fact, that there is an increasing competition for the scarce natural resources in world agriculture. Food and feed crops compete with biofuel crops and other non-food crops and cause land use conflicts. However, the argument of such a resource competition applies equally to all crops which can be grown on land and which could potentially be used for the production of food crops and feedstuff as well as non-food crops such as cotton, rubber, or flowers and ornamental plants. Obviously, there is resource competition also between food crops such as between conventionally and organically produced foods or between staple foods and luxury food items.

Despite all this, biofuel production and consumption continues to be seen as a main driver of rising agricultural commodity prices, world hunger and global agricultural land use change by all too many NGOs. Scholarly analyses, however, tend to arrive at estimates which suggest a fairly limited impact of biofuel production on prices, food security, and global land expansion. In fact, they identify other variables as being the main drivers of the obvious changes world agriculture has to deal with today and in the decades to come:

- On the demand side these variables include population and consumption growth leading to changing eating habits and, thus, additional demand for food, in particular meat and other resource demanding food products, and non-food crops. In addition, there is an increasing demand for larger amounts of productive agricultural land to be managed under specific agri-environmental programmes in major industrialised countries and emerging economies.

- Key variables on the supply side include increasing scarcity of land and water, rising energy prices, global yield depressions due to climate change and the neglect of agricultural research with focus on productivity growth.

All these variables contribute to increasing land use conflicts. In addition, there are various sources of short term market determinants accentuating the resource competition. Variables such as weather risks, plant and animal pests and diseases or political interferences may lead to a higher degree of market uncertainty, i.e. price fluctuations, and tend to encourage farmers to invest in stability schemes. In this context it is interesting to note that biofuel production provides an element of stability to agricultural commodity prices.

In sum, the emphasis on biofuel production and consumption in the public debate distracts from these root causes of rising international agricultural commodity prices and additional market effects. In the end this acts to perpetuate hunger rather than eradicating or at least reducing it.
3 Access to food and increasing biofuel production: An agricultural development perspective

The return of Malthus and Ricardo?

Securing enough food has been a prime concern of humankind since its beginnings. Empirical evidence suggests that at least since the 13th century, the real price of food has shown an upward trend (Abel, 1978). During much of this time period, population growth was slow and per capita consumption was rising slowly as well. There was no agricultural science yet. As a consequence, the productivity of land was stagnant while the agricultural acreage in all too many countries of Europe could not be expanded any further, and in some it even declined over long periods of time.

In the late 18th century population growth and income growth began to accelerate in England and other European countries, while both the agricultural acreage and land productivity continued to remain constant or rise very slowly. As demand growth during that time vastly outpaced the growth in supply, agricultural commodity prices and the price of food rose rapidly. This led the two British economists, namely Thomas Robert Malthus and David Ricardo, to develop their dismal projections of the future of humankind (Malthus, 1798; Ricardo, 1817).

Given what they observed during their lifetimes on the markets for food and agricultural commodities in Britain, they concluded that the future of humankind should be marked by recurring food crises during which the population declines because people would starve to death or because they would start killing each other over the ever scarcer natural resource for food production, in particular agricultural land.

The dismal predictions of Malthus and Ricardo did not come true, however. The upward trend in the prices of food and agricultural commodities ended in the second half of the 19th century.

This mega-trend reversal in agricultural commodity prices was caused by the establishment of agricultural sciences by Albrecht Daniel Thaer, Justus von Liebig and some of their contemporaries in Europe. The knowledge they had generated permitted for the first time ever to sustainably farm the land over long periods of time by means of recycling plant nutrients in the form of animal manure, by adding legumes or a fallow to the crop rotation, or by investing in other science-based technologies such as higher yielding seed varieties.

As a consequence of this very first Green Revolution and the accelerating expansion of the agricultural acreage in the countries of the New World, agricultural supply began to grow faster than demand and commodity prices started to decline.
The second Green Revolution which was triggered by the work of plant scientist Norman Borlaug in the second half of the 20th century led to an even more accelerated global land productivity growth and to a continuation of the process of falling agricultural commodity prices (see figure 2).

**Figure 2: Index of real agricultural commodity prices, 1900-1990**

![Index of real agricultural commodity prices, 1900-1990](image)


This was the most remarkable phenomenon. In the year 1900, about 1.5 billion humans were living on this planet. By the year 2000 world population had quadrupled to 6.0 billion. At the same time, per capita food consumption in today’s rich countries rose at a rapid rate as well.

During that time world agriculture had managed to produce ever more food for ever more people at ever declining prices. As a consequence, the percentage of the world population which was undernourished had declined. However, despite the great successes of agricultural sciences, hunger has been persistent in a large part of the world. Estimates suggest that at present there are almost one billion people who suffer from malnutrition (FAO et al., 2012). Those are humans, mainly located in least developed countries, who have a purchasing power which is equivalent to USD 1.25 a day or less, and who have to spend 70 percent or even more of their meagre incomes on food.

The public debate on the causes of world hunger and suitable policies to alleviate it is rather intense. It is sometimes argued that, indeed, there is enough food for all humans around the globe. It is just a matter of distributing it fairly. But this argument is false. For extended periods of time the EU, the US, and other rich developed countries have pursued a policy of agricultural producer price support, which led to surpluses and which then were subsidised and dumped on the markets.
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of developing countries in direct competition to domestic production in these countries.

Obviously, this type of agricultural policy failed to yield success in the fight against global hunger. To the contrary, it accelerated the decline in agricultural commodity prices and delayed the development of agriculture and the overall rural sector in recipient countries because it acted to reduce the incentives for more production and investment there.

As noted above, the more than a century long trend of declining agricultural commodity prices has come to an end. The turn of the millennium has marked a mega trend reversal in international agricultural commodity markets. Since then, commodity prices in international agricultural markets have tended to rise – with significant fluctuations as in the past.

The reason for the upward trend in prices is simply that global demand growth is outpacing the growth in supply. This may be expected to continue and it has given rise to concerns about the future of world food security. It also has raised the fear that the dismal predictions of Malthus and Ricardo may eventually come true.

There are many variables driving this development. Some of them have been mentioned above. Scientists agree that global demand continues to grow at a rapid pace because of (e.g., Ray et al., 2013; Tilman et al., 2011):

- continued rapid population growth and
- considerable per capita consumption growth

both in developing and newly industrialising countries. Supply growth is not keeping pace with the growth in demand for a variety of reasons:

- Land and water for farming are becoming ever scarcer (e.g., Langeveld et al., 2013; Noleppa et al., 2013).
- The price of energy is rising (e.g., Kempfert and von Witzke, 2014).
- Global warming is also considered to have begun to negatively affect the growth in agricultural supply (e.g., Müller et al., 2009).

In addition, the yield growth in world agriculture has begun to decline. From the 1960s through the 1980s, global yield growth was around 4 percent annually. This number is now down to a little more than 1 percent per annum. In the EU and some other major producing regions, it is even below that (e.g., Kirschke et al., 2011; Piesse and Thistle, 2010; Spink et al., 2009). Projections of world food needs, however, suggest that the yield growth needed to meet the growing demand is at least at 2.4 percent per annum (Ray et al., 2013).
Finally, it should be repeated that there has been growing competition for the
scarce natural resources in world agriculture between food crop production, on the
one hand, and the production of non-food crops, on the other hand. It has been
demonstrated earlier in this paper that the impact of global biofuel production on
price increases in agricultural commodities and other market variables is rather
low and that the effects of EU bioethanol production are most probably marginal.

Apart from this, the argument of resource competition does not only apply to bio-
fuel crops. It also applies to the production of all other non-food crops which are
grown on agricultural acreage which could as well be used for growing food crops
and combating hunger.

Rising and falling prices both act to increase global hunger:
A paradox?

The literature on the impact of rising or falling agricultural commodity prices un-
veils what is a paradox at first glance, i.e. both, low or falling prices as well as high
or rising prices are bad for the poor and hungry of the world (e.g. Swinnen, 2011).

In the past it was argued that the agricultural and trade policies employed by the
EU and other rich industrialised countries acted to reduce world market prices
which, in turn, eroded the incentives for increased production and investment in
developing countries, thus, aggravating malnutrition and hunger in these countries.
At the same time, this policy made it easier for developing countries to pursue a
policy of low prices. However, after the prices of most agricultural commodities had
more than doubled since the turn of the millennium, the argument was turned
around. Now high prices are considered as acting to increase hunger.

This paradox can be resolved by distinguishing between short and longer term
effects:

• Obviously, rising prices act to increase hunger in the short run. The poor and
undernourished of the world spend a high proportion of their incomes on food.
The price of food, therefore, is the single most important determinant of real
incomes of the poor. Even moderate price increases have the potential to sig-
ificantly increase hunger around the globe.

• In the long run, however, high prices stimulate production and investment in
agriculture which act to increase profitability, wages and employment in this
industry.

That both, high and low prices may have negative effects on the poor, thus, is not a
paradox but a dilemma. Fortunately, this dilemma can be dissolved. The large ma-
jority of the undernourished and hungry humans of the world lives in the rural
areas of developing countries. In fact, 75 percent of the world’s poorest people, i.e.
approximately 1.4 billion humans live in rural areas and depend on agriculture and related activities for their livelihood; and 50 percent of hungry people are farming families (WFP and FAO, 2010; WFP, 2014b). They are often landless farm workers or smallholders – who do not produce enough food, live in poverty and are not able to feed their families – let alone to generate a surplus which could be sold in the market.

Empirical evidence shows that hunger tends to be most pronounced in those regions of the world in which farmers have the least access to productive technologies which have been employed successfully for a very long time in today’s rich countries such as mineral fertilizer, high yielding modern seed varieties or modern crop protection. Therefore, agricultural productivity growth in developing countries is a key in reducing hunger and malnutrition as it increases income and employment in the countryside; a precondition for this is, of course, good governance (e.g., WFP, 2014a).

The increasing availability of food then also improves the nutritional status of the urban poor, as declining prices act to increase their real incomes. In sum, agricultural productivity growth in poor countries together with good governance has the potential to raise incomes which, in turn, is a key variable in the fight against hunger for both rural and urban people in developing and least developed countries alike.

It has been demonstrated here, an innovative and highly productive agriculture is the key to eradicate hunger around the globe. With such an agriculture the EU and the world at large can afford more of everything (Noleppa et al., 2013):

- more food,
- more feed,
- more biofuels,
- more natural habitats,
- more biodiversity, and
- along with it reduced GHG emissions resulting from an expansion of the agricultural acreage.

Without productivity and resulting income growth in developing countries, very little will change: Hunger and malnutrition will persist, with or without biofuel production. What is needed is to increase agricultural productivity and to enable the poor and starving to participate in market activities.
4 A simple approach to check for plausibility and consistency

While there continues to be a fairly wide range of estimates in the literature of the quantitative impact of global and/or EU biofuel production on the prices of agricultural commodities, it is possible to obtain a rough estimate of the order of magnitude of the overall quantity and price effect based on a simple back-of-the-envelope calculation. The methodological framework for this calculation is provided in the annex.

Estimates of the global arable land used for the production of bioenergy crops have been reported to be in the range of 45 to 55 million hectares (BMEL, 2013; Jehring et al., 2012; Raschka und Carus, 2012; Zeddies et al., 2012). The global arable and permanent crops land is currently estimated to be about 1 550 million hectares (FAO, 2014). Therefore, the portion of global arable land planted to bioenergy crops should be in the range of approximately 2.9 to 3.5 percent.

Let the acreage planted to bioenergy crops be at 3.2 percent of total global arable and permanent crops land. In many models, the elasticity of global demand for agricultural commodities on aggregate is around –0.3. If the acreage used for bioenergy is as productive as the rest of the cropland around the globe, a share of bioenergy crops of 3.2 percent of the cropland would reduce global production of food and feed by 3.2 percent. According to equation (3) in the annex, the effect of global bioenergy production on overall agricultural commodity prices would be at 10.7 percent.

However, the assumptions made in the calculation are all fairly conservative in that they tend to overestimate the actual effect of global biofuel production on the prices of agricultural commodities. In fact, the result of this calculation represents an upper bound of the price effect caused by increasing biofuel production for the following reasons:

- One is that the 3.2 percent of the global acreage represents the entire bioenergy acreage and not just biofuel acreage. Unfortunately, no reliable information for just the biofuel acreage is available.

- The second effect results from the fact that in two of the three largest bioenergy producing countries, namely the US and the EU, the expansion of the biofuel crop production has come at the expense of set aside lands. This accounts for about 20 million hectares (USDA, 2004) or roughly 40 percent of the land used for the production of bioenergy in total. Accounting for this in equation (3) of the annex would cut the 10.7 percent price increase to approximately 6.5 percent.

- The third effect is the result of the fact that the production of biofuels also results in by-products which act to reduce the overall price increasing effects of biofuel crop production even further. Examples of such by-products include
soybean and rapeseed meal in the production of biodiesel, or beet pulp and dried distillers’ grains with solubles (DDGS) in the production of bioethanol from sugar beets and grains. According to Langeveld et al. (2013), approximately 40 percent of the biomass harvested from acreage devoted to biofuel crops around the globe is used as a by-product. Accounting for this would reduce the price effect even further to 3.9 percent.

According to latest available data from the European Commission, the JRC, and the USDA, published in ePURE (2013), EU bioethanol production accounts for approximately 1.4 million hectares or about 0.1 percent of current global arable land use; i.e. the contribution of EU bioethanol production to the more than 100 percent increase of international agricultural commodity prices since the turn of the millennium is significantly lower than 1 percent and, thus, in the range of white noise. This back-of-the-envelope calculation is in line with the findings of other scholars such as Grethe et al. (2013) and Hamelinck (2013). It demonstrates that the impact of global biofuel production on the agricultural commodity price increase is fairly limited and that of EU bioethanol is sub-marginal. The public debate about the price increasing effect of biofuel production and along with it about hunger and other related effects, therefore, is much ado about very little.

The public debate about biofuels distracts from the underlying root causes of increasing agricultural commodity prices and ultimately acts to perpetuate hunger around the globe rather than reduce it. It has been demonstrated in numerous studies that the most important driving forces of the upward trend in agricultural commodity prices are on the demand side the continuing rapid population and consumption growth in developing and newly industrialising countries. On the supply side, it has been the neglect of agricultural productivity growth and the oil price increase. The price of oil, e.g., has been a main driver of commodity prices since the turn of the millennium because agriculture is a fairly energy intensive industry, and the price of energy acts to increase the cost of production and, thus the commodity prices, because it significantly rises the cost of transportation (e.g., von Witzke and Noleppa, 2011).

5 Conclusions

In this paper we have reviewed the scholarly literature and NGO publications on the effects of biofuel production on agricultural commodity prices, global hunger and resource use, including related GHG emissions. The price and related effects of global as well as EU biofuel production vary over a considerable range. The scholarly analyses tend to arrive at the result that the impacts of biofuel production and consumption in the EU and globally are rather limited and that the variables other than biofuels are the root causes for the upward trend in international agricultural

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commodity prices. In contrast, various NGO publications tend to identify biofuels as the main culprit of rising agricultural commodity prices and along with it of increasing food insecurity and GHG emissions. The following conclusions from our literature review are in order:

1. The methodological and empirical foundation of scholarly analyses of the impacts of biofuel production and consumption is just beginning to emerge. Unsurprisingly, there are considerable variations in the quantitative results in the scholarly literature. As a consequence, there continues to be some degree of uncertainty about the actual quantitative impacts of biofuel production and consumption.

2. That scholarly research tends to yield much lower price increases and other related effects than those reported in various NGO publications is consistent with political economic theory. Scholarly analyses strive to generate as accurate results as possible. Various NGOs, however, emphasise only selective aspects and partial information of the issue at hand and offer spurious solutions which promise a lot of public attention and, thus, economic returns.

3. It is, therefore, advisable to keep both in mind when assessing the economic and environmental implications of biofuel production and consumption – the fairly early stages of scholarly economic analysis and the political economy of NGOs engaged in food and agriculture.

4. It is obvious that biofuels act to increase the demand for agricultural commodities and that they compete with food and feed for the scarce natural resources in the EU and in world agriculture. There continues to be a range of estimates of the actual effects of biofuel production and consumption in the scholarly literature hinting at the need for further research. However, the results of scholarly research on this matter suggest that the impact of biofuels on prices and on resource competition is rather limited. This is supported by some simple and straightforward own calculations in this paper. In fact, research consistently stipulates that variables other than biofuels such as population and consumption growth in both newly industrialised and developing countries together with declining productivity growth, limited land resources, rising energy prices, and some other variables are the key drivers for the rapidly rising agricultural commodity prices and the continuing expansion of the global agricultural acreage.

5. Ultimately, the emphasis on global and EU biofuels in the public debate about world food security and related issues distracts from the root causes of persisting hunger in all too many regions around the globe and, thus, may lead to inadequate political responses which in the end may increase hunger rather than reduce it.
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Annex: A back-of envelope calculation of the order of magnitude of price effects of biofuel production

Market equilibrium implies that the percentage change in supply equals that of demand. Equation (1) applies:

\[
\frac{dqs}{qs} = \frac{dqd}{qd}
\]

with:
- \( \frac{dqs}{qs} \) – percent change in the quantity supplied and
- \( \frac{dqd}{qd} \) – percent change in the quantity demanded.

The elasticity of demand for a good with regard to its own price is defined as depicted in equation (2):

\[
\varepsilon_d = \frac{\frac{dqd}{qd}}{\frac{dp}{p}}
\]

with:
- \( \varepsilon_d \) – own price elasticity of demand and
- \( \frac{dp}{p} \) – percent change in price.

Combining equations (1) and (2) and solving for the relative change in prices yields equation (3):

\[
\frac{dp}{p} = \frac{\frac{dqs}{qs}}{\varepsilon_d}
\]

which can be used to calculate a price effect of market quantity changes caused by market determinants such as global biofuel production or EU bioethanol production.
Biofuels: Agricultural commodity prices, food security, and resource use

A review of the scholarly literature and the public debate

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