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Abstract

This paper assesses the impact on the agricultural sector in the EU of implementing the National Renewable Energy Action Plans, set up by each of the EU member states, with respect to biofuels. The analysis is based on simulations conducted in the CAPRI model, which is a detailed partial equilibrium model of the European agricultural sector. The key contribution compared to previous studies is that the detailed official plans for the expansion of biofuel production is analysed rather than specific policy measures. In addition, the current CAPRI version allows analysis of changes in the total area used for agricultural purposes since land supply is endogenous to the model. The analysis shows that the impact of increasing the production from current (2010) levels to the production levels indicated in the National Plans would result in a limited increase in land used for agricultural purposes (+0.04 per cent) in the EU. However there are reallocations of the land use within the sector and a substantial increase in imports of primary agricultural products. This would imply that the policy will also affect land use outside the EU. The importance of the biofuel industry will grow significantly and the biofuel industry will become the most important outlet for some feedstocks (oilseeds), thus we should expect a closer link between agricultural markets and fuel prices. The expansion of biofuel production increases the prices of primary agricultural products, in particular for oil seeds, but even more so for vegetable oils which are used to produce biodiesel.

Keywords: EU, National Renewable Energy Action Plan, Land use, Biofuel, CAPRI

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1 Introduction

The last decade has seen a vast increase in the consumption and production of biofuels in the EU. This development has been stimulated by the EU and individual member states trying to increase the production of biofuels as a mean to promote growth in rural areas enhance energy security and reduce emissions of greenhouse gases from the transport sector. However, in recent years the support for biofuels has been questioned due to the possible impact of biofuels, produced from agricultural feedstock, on food prices and uncertainties about the emissions of greenhouse gases from biofuels.[1] In particular, the impact on land use has been receiving increasing attention since the impact of biofuel production from agricultural feedstocks on land use will be key to determine the potential of biofuels to reduce greenhouse gas emissions.[2]

The EU has set a target of 10 per cent renewable fuels by 2020 for each member state (EU 2009). The target is specified in terms of renewable fuels but in practice most of the renewable fuels is expected to be accounted for by the use of biofuels. In addition to the consumption target EU apply import tariffs to biofuels in order to shield domestic producers of biofuels from foreign competition; hence a larger share of the biofuels consumed is produced within the EU compared to a situation where biofuels could be traded without tariffs. To reduce the risk of higher greenhouse gas emissions as a result of increasing use of biofuels only biofuels providing a minimum reduction of emissions are counted towards the renewable fuel target. Besides trade policy, which is determined at the EU-level, policies to meet the renewable fuels target are implemented by individual member states. These policies vary significantly across member states and future policies designed to meet the target are unknown.[3] In addition, the development of prices of fossil fuels is uncertain, which makes it difficult to predict the level of intervention necessary to reach the volumes of renewable fuels required to meet the target.

In some previous studies of the EU biofuel policy various models are used to predict the demand for ethanol and biodiesel under specific assumptions about the biofuel policy, oil prices and other key variables.[4] In contrast to these papers this paper analyse the impact on agricultural markets in the EU of an increase in production of biofuel that meet the political plans rather than the impact of specific policies. Specifically, the paper studies the impact of meeting the renewable fuels target, without considering the actual policies used to stimulate demand for biofuel and the development of oil prices. Hence; the paper will address questions about what will be the impact of the planned production of biofuels on agricultural markets and land use in the EU compared to a baseline where production of biofuels in 2020 remains at the current (2010) production level of biofuels. It is likely that production of biofuel without any policies to promote biofuels would be significantly lower than the current levels since the production has benefited from trade policies, subsidies etc. However, the current production provides an objective starting point for comparison since the current level of

[1] For a discussion on food prices see (Dewbre et al. 2008) and (Ajanovic 2011)

[2] See for example (Searchinger et al. 2008) or (Timilsina and Shrestha 2011)

[3] For an detailed discussion of policies to support biofuels in the EU and the cost of the policies see (Jung et al. 2010)

[4] For example (Becker et al. 2010) and (Blanco Fonseca et al. 2010)

production is observable. It would be difficult to pinpoint the exact level of biofuel production without any policies to promote biofuels; hence to start with a predicted level of production without policies would introduce some degree of arbitrariness since the exact level of production without policies is unknown.

The target for production of biofuels e.g. ethanol and biodiesel is calculated based on the National Renewable Energy Action Plans (Europan Commission 2011). Even if these plans may be revised in the future they provide information on the current official plan for the composition of domestic production and imports of biofuels required to meet the renewable fuels target by 2020. It is, thus, likely that the action plans will be reflected by policies implemented to meet the target.

2 Biofuels

Biofuels production has increased rapidly the last decade stimulated by various policies particularly in the USA and the EU. Globally the production of Ethanol has increased from 17 to 86 billion litres and the production of biodiesel has increased from 0.8 to 19 billion litres between the years 2000 and 2010 (REN21 2011). The EU shares of global production is about 53 per cent and about 5 per cent for biodiesel and ethanol, respectively (REN21 2011). That is, the EU is the leading producer of biodiesel in the world but the production of ethanol is limited compared to the leading producers, USA and Brazil.

The EU targets for renewable fuels are consumption targets for each of the EU member states but targets for production of specific renewable fuels are not set; thus the targeted consumption could be reached by the use of any renewable energy source, including hydrogen, electricity, second generation biofuels and first generation biofuels (ethanol and biodiesel from agricultural feedstocks). However, given the short time period to 2020 and the current cost advantage of first generation biofuels over the other renewable energy sources it seems reasonable to assume that first generation biofuels will play an important role in meeting the target. The renewable fuels consumed could be produced either within the EU or imported since the target is set in terms of consumption rather than production. The National Renewable Energy Action Plans submitted to the EU by each member state describes the member state's plans for production and imports of renewable fuels in detail. Among other things the Action Plan provides information about the planned production volumes of ethanol and biodiesel as well as their import and production from feedstocks not competing with food production (wastes, non-food cellulosic materials etc.).[5] Since the focus of this study is the impact of increased demand for biofuels on the agricultural sector and land use within the EU the key information is the production volumes of first generation biofuels planned for in the EU since the first order impact on the agricultural sector will come from increased demand for agricultural feedstocks used in the production of ethanol and biodiesel. Moreover, the targets for renewable fuels consumption will by and large be meet by first generation biofuels according to the National Action Plans. Table 1 show that in order to meet the production planned for in the National Renewable Energy Action Plans the domestic production of ethanol and biodiesel approximately need to double compared to the current production. This

[5] Feedstocks specified in article 21(2) in (EU 2009)

represent a large increase compared to the current production levels, that themselves are achieved by various policies to support biofuel production in the EU. Jung et al. (2010) estimates that the total amount of support for biodiesel and ethanol production in the EU 2008 amounts to 3.01 billion Euro or 0.44 and 0.30 Euro per litre of fossil fuel equivalent for ethanol and biodiesel, respectively. To meet the consumption target of 10 per cent renewable fuels in the transport sector by 2020 the planned expansion of domestic production of first generation biofuels is not sufficient to meet the consumption target so the import is planned to increase significantly as well to account for 25.4 per cent of the biofuel consumption in energy terms (Europan Commission 2011). In addition to imports, other biofuels as defined by the EU (2009) in article 21(2) of the Renewable fuel directive, is expected to account for 8.6 per cent of the consumption of biofuels in energy terms (Europan Commission 2011).

Table 1. EU production and imports of biofuels (billion litres)

Biofuel	2010	2020
Fuel ethanol production	4.5	9.2
Biodiesel production	10	19.1
Fuel ethanol imports	1.2	3.5
Biodiesel imports	2.9	7.4

Notes: 2020 values predicted in the National Renewable Energy Action Plans. Energy units have been converted into litres assuming 1 ktoe = 1.321 million litres biodiesel or 1.978 million litres ethanol. Import of fuel ethanol is calculated as domestic consumption – domestic production since fuel ethanol is not reported in the trade statistics.

Sources: Own calculations based on data from REN21 (2011), EurObserv'ER (2011), and the European Commission (2011).

3 Method

To analyse the impact of the EU member states' plans to meet the consumption targets for renewable energy on agricultural prices and land use in the EU the planned production of first generation biofuels, as indicated in the National Renewable Energy Action Plans, is calculated (Europan Commission 2011). Thereafter the planned production volumes of first generation ethanol and biodiesel are implemented exogenously into the CAPRI model. The CAPRI model is computable partial equilibrium model that models agricultural production and markets in the EU and some neighbouring countries in great detail.[6] In addition trade flows between EU member states and other major countries and groups of countries is modelled.

3.1 Biofuels modelling

To predict the impact of increasing production of biofuels two types of economic models have been used in the literature; General Equilibrium Models (GE) and Partial Equilibrium Models (PE). The former models can be used to analyse the overall impact on the economy and allow

[6] For a description of the CAPRI model see Britz and Witzke (2008)

for interaction between sectors of the economy since they model the whole economy. The latter, on the other hand, only models part of the economy and thus can only provide an estimate of the first order impact on the sector or area described by the model. However PE models do usually provide more detailed information about the sector modelled. The possibilities to have both details provided by a PE models (CAPRI) and overall impact given by a GE model (GTAP) is explored in a recent paper by Britz and Hertel (2011) and provides ample opportunities for future development. However, for the purpose of the current paper a PE-model is a suitable option since the main focus of the paper is the impact on a particular sector and geographical area. The CAPRI model is chosen since it provides a detailed picture of the agricultural sector in the EU and model changes in the EU agricultural policies in much more detail than available GE models can do. Hence; CAPRI account for the interaction between agricultural policies and policies to promote biofuels and can provide a detailed view of the impact of increasing production of biofuels in the EU given the agricultural and trade policies of the EU. A drawback of the choice of a PE-model is that secondary effects on the agricultural sector from changes in other sectors due to increased use of biofuels are not captured in the model but these are most likely very limited since the biofuel and agricultural sectors are small compared to the whole economy in the EU. The geographical focus on the EU implies that changes in demand for biofuels in other countries, such as for example the USA, are not accounted for. This implies that the results presented will underestimate the global impact of biofuel use on the agricultural sector and land use since increased production in the rest of the world is not accounted for. On the other hand the biofuels policies in the USA and other countries outside the EU cannot be determined by the EU therefore it is interesting to focus on the impact of the plans of the EU by itself to determine the impact of decisions taken by the EU.

The current CAPRI-baseline provides predictions for agricultural markets 2020 and includes implemented and known changes to the EU agricultural and trade policies. However, trade in biofuels or, indeed, the market for biofuel is not modelled in the current version of CAPRI.[7] Hence, the demand for biofuels is set exogenously. However, as the focus of the current paper is the impact on the agricultural sector of reaching a pre-defined level of production rather than analysing the impact of individual biofuel policies modelling of the biofuel market is not necessary. Imports of biofuels is taken into account in the simulations by a reduction of the production necessary to meet the consumption target for renewable fuels set by the EU. The feedstocks used for the production of biofuels in the EU could either be produced in the EU or imported. The trade in feedstock is determined by CAPRI based on the relative cost of imported and domestic feedstocks; hence part of the feedstock used in the biofuel production will be imported with the exact quantities to be determined in the simulations. Second generation biofuels is not integrated in the model but the production levels of first generation biofuels can be reduced to take into account higher production of second generation biofuels. This way the impact of increased production of second generation biofuels on agricultural markets can be controlled for even though production of second generation biofuels is not integrated explicitly in the CAPRI-model. Based on the pre-

[7] An extension of CAPRI with a biofuel market has been used by Becker et al. (2010) however, this extension is not included in the current (May 2011) CAPRI version.

determined amount of ethanol and biodiesel to be produced, CAPRI determines the types of feedstock used and the geographic location of production. The use of feedstock is described by a nested CES function, where producers first choose their preferred feedstock and in a second step decides whether to buy domestic or imported feedstock. The producers' choice of feedstock is made to minimize production costs. In the biodiesel industry the production is divided into two steps; production of vegetable oil from primary agricultural products and conversion of the vegetable oil to biodiesel. The production of ethanol from sugar beet is also modelled in two steps; in the first step sugar beets are converted to sugar and then the sugar is used for ethanol production. Note that primary products, vegetable oil and sugar are traded, thus they can be produce either domestically or imported. Each feedstock used in the production of ethanol is converted to a fixed amount of ethanol and by-product. Ethanol can be produced from wheat, maize, barley, oats, sorghum, and the secondary products sugar and wine. The by-products from the conversion of ethanol from primary agricultural feedstocks are DDGS (wheat) or gluten feed (coarse grains) while the conversion of sugar beet to sugar result in the by-product molasses. Biodiesel is produced from the secondary products rapeseed oil, sunflower oil, soy oil and palm oil. The by-products oil meals and oil cakes is a result of the first stage processing from primary agricultural product into vegetable oils. The amount of the by-products is determined by the price relation between the by-products, vegetable oils and the feedstocks used in the vegetable oil production. The by-products are used as protein rich feed and therefore result in a reduction of demand for primary agricultural products used for feed and increases the supply of protein rich feeds. This contributes to reduce the additional demand for feedstocks created by the increased production of biofuels and may possibly reduce the costs of feeds for animal farmers. For a more detailed description of the integration of biofuels in the CAPRI model see Blanco Fonseca et al. (2010).

In this paper the current level of production of biofuels is compared to a situation with the production levels indicated in the National Renewable Energy Action Plans (Europan Commission 2011). The impact of EU-biofuel targets has been analysed previously applying various agricultural partial equilibrium models. Blanco Fonseca et al. (2010) compares several PE models including CAPRI and Becker et al. (2010) extends CAPRI to simulate various policy options for biofuels in the EU. The main difference between the application of CAPRI in Blanco Fonseca et al. (2010) and this paper is the implementation of the CAP health check reforms in the CAPRI baseline, endogenous land supply and a difference in methods to determine the baseline and the target level of biofuel production. Becker et al. (2010) includes biofuel endogenously as an extension to the CAPRI model and they are, thus able simulate the impact of policy alternatives on biofuel markets and biofuel trade flows. While Becker et al. (2010) have a more flexible approach to modelling biofuel policy and trade compared to this paper. The standard CAPRI model used for this paper fits the requirements to analyse the impact of the EU member states' plans for biofuels. In addition this paper allows greater flexibility in the use of land since land supply is modelled endogenously. This means that the total amount of agricultural land used in the EU is determined by the value of agricultural land relative the value of alternative uses of the land (Renwick et al. 2013). Higher feedstock prices that tend to make use of land for agricultural purposes more attractive should result in an increase in the total land area used in the agricultural sector. In previous studies the only change in land use came from a redistribution of land within the agricultural sector but with the addition of endogenous land supply the total amount of land used in the agricultural sector is determined within CAPRI, which is crucial to determine the extent of indirect land use changes, within the EU, resulting from an increased production of biofuels.

3.2 Scenario description

If policies are implemented to meet the 2020 target for biofuels in the EU this would induce changes in prices, production and land use compared to the current policy and the current level of biofuel production. The current production level is an illustrative point of comparison since it is observable as is current land use, prices and production. In addition, from a policy perspective it is relevant to know the difference between keeping existing policies and implementing new policy rather than comparing no policy to a new policy. Therefore this paper compare the impact of keeping current (2010) production levels of biofuels to producing biofuels volumes planned for in the National Renewable Energy Action Plans by 2020. The CAPRI model simulates agricultural and related markets in 2020 taking into account known changes to agricultural and trade policy, thus the results will indicate the differences between the two scenarios in 2020 keeping all other policies the same in both scenarios. It will not be relevant to compare the situation today with the situation 2020 since the differences between today, with current production of biofuels, and 2020, with targeted biofuels production, will not be a result of the changed production of biofuels only but a result of many different changes. To identify the impact of increased use of biofuel it is necessary to compare the outcome of the two policies at 2020. Table 2 illustrates the levels of biofuel production used in the simulations.

Table 2. First generation biofuel production in the EU 2020 by scenario (billion litres)

	Baseline	Policy scenario
Ethanol	4.5	9.2
Biodiesel	10	19.1

Note: 1 ktoe has been converted to 1.321 million litres biodiesel or 1.978 million litres ethanol.
Sources: REN21 (2011) and Europan Commission (2011).

The official plans for production of biofuels 2020 puts more emphasis on the production of biodiesel relative to ethanol compared to simulations of biofuel policies aimed at reaching the target of 10 per cent renewable fuels. For example, Blanco Fonseca et al. (2010), who bases their target level of biofuels on simulations using AGLINK-COSIMO or Becker et al. (2010) who use an extended version of CAPRI for their simulations. Their target levels of first generation biofuels are also significantly higher both for ethanol and biodiesel than in the official plans. Becker et al. (2010) who predicts the production of biofuels in the EU explicitly allowing for trade in biofuels and internal biofuel policies. The outcome of their simulations indicates that ethanol would be the main source of biofuels. In their scenario with no internal EU biofuel policy 4.3 billion litres of biodiesel and 7.6 billion litres of ethanol is produced. That is, compared to the actual production 2010 the production of biodiesel would decline but the production of ethanol would increase with no internal policies to support the biofuel production. In the policy scenario meeting the EU target for renewable fuels the production of ethanol is 19.5 billion litres and the production of biodiesel is 12.7 billion litres, thus the results from Becker et al. (2010) should result in a larger impact on ethanol feedstocks than in our study. The preference for biodiesel over ethanol in the National Renewable Energy Action Plans might partly be based on the fact that there is a large existing production capacity for biodiesel in the EU that is not fully utilized. The installed capacity for biodiesel 2010 was 25.1 billion litres according to European Biodiesel Board (2011) which should be compared to the production of biodiesel that was only 10 billion litres (see Table 1) in 2010, indicating low capacity utilization in the biodiesel industry.[8] This would also imply that the current production capacity in the EU is more than sufficient to produce the 19.1 billion litres indicated in the National Action Plans.

4 Results

The amounts of biodiesel and ethanol produced according to the model, presented in Table 3 deviates slightly from the levels of production specified in the scenario due to an aggregation bias in the CES production function but the results will not be altered by this.

Table 3. Simulated biofuel production in the EU (billion litres)

	Baseline	Policy scenario	Difference (%)
Ethanol	4.5	9.2	104 %
Biodiesel	9.9	18.8	90 %

Note 1 tonne has been converted to 1136 litres biodiesel and 1266 litres of ethanol.

As can be seen from Table 3 the policy scenario implies a large increase in the production of biofuels in the EU, 104 per cent and 90 per cent for ethanol and biodiesel, respectively. How large impact this will have on the agricultural markets depends on how easy production or imports of feedstocks used in the biofuel industry can be expanded and the demand share of the biofuel industry in the total market for various feedstocks. If the production or imports of feedstock could be expanded without significant costs we would expect a limited impact of the increased biofuel production even if the increase in itself is large. The same would be true if the share of the feedstock demand from the biofuel industry would be small in relation to the total demand for the feedstock. In addition, some of the demand from the fodder sector will be covered by the by-products from the biofuel production; hence some of the increased demand for feedstocks from the biofuel sector will be meet by reductions in the demand from the fodder sector.

The results presented in Table 4 show that the potential impact of an expansion of biofuel production can be significant since the demand for feedstocks from the biofuel industry makes up a quite large shares of the total demand for several feedstocks. The relatively larger weight of biodiesel in the production of biofuels is also reflected in a high share of demand from the biodiesel industry in all oils but particularly for rape seed oil where the share is close

[8] 1 tonne of biodiesel has been converted to 1136 litres of biodiesel.

to 60 per cent of total demand in the baseline. These shares will increase even more if policies are implemented to expand production of biodiesel, reaching a share above 78 per cent for rape seed oil and shares close to 50 per cent for the other oils. The ethanol industry is far less important looking at its share of total demand for various feedstocks. In the baseline scenario the shares is below 10 per cent for all feedstocks with the exception of rye. The importance of demand for ethanol production will increase though if the ethanol production expands according to the policy scenario, pushing their share in feedstock demand above 10 per cent for barley and sugar.[9] The higher shares of the biofuel sector in demand for agricultural feedstocks in the policy scenario would indicate a closer link between agricultural and energy markets as the share of demand for the feedstocks from the biofuel producers increases and the prices of biofuels interacts with prices for fossil fuel. The impact of expanded production of biofuels could be expected to be more pronounced for feedstocks used to produce biodiesel than the expansion of ethanol production but the actual impact will depend on the how easy production and trade flows can adjust to the increase demand. The magnitude of price changes will provide an important indication of how adjustable the markets are for the feedstocks as limited price changes will indicate either that there is not much adjustment or that the adjustment could be made without difficulties. The price effect on feedstocks will be important to analyse the impact on food prices but also to draw conclusions about the competitiveness of biofuels in the fuel market since a large share of the biofuel production costs are the cost of feedstock. Calculations based on data presented in OECD (2008) shows that the feedstock share of production cost for biofuels in the EU are above 90 per cent of the total production cost for both biodiesel from rape seed and ethanol from wheat. Changes in relative prices will also determine possible changes in the composition in the agricultural production.

Table 4. The Biofuel industry's share of demand for selected feedstocks in the EU 2020 in per cent

Feedstock	Baseline	Policy scenario
Soft wheat	2.37	5.17
Rye and meslin	14.63	24.86
Oats	1.60	3.32
Barley	7.93	14.74
Other cereals	2.54	5.57
Grain maize	1.31	2.95
Sugar	7.67	14.41
Soya oil	25.74	45.71
Sunflower seed oil	29.14	48.23
Palm oil	36.83	57.72
Rape seed oil	59.87	78.06

Source: CAPRI simulations, own calculations

Increasing the production of first generation biofuels from current levels (baseline) to the levels predicted in the National Renewable Energy Action plans (policy scenario) would have

[9] In the model sugar beets are converted to sugar than the sugar is used as feedstock in the ethanol production.

a quite modest impact on prices for ethanol feedstocks as shown in the first column of Table 5. The largest price changes can be observed for sugar and rye which could be expected since the ethanol producers have a relatively large share of the market for these feedstocks (see Table 4). The largest adjustment in production can also be noted for sugar and rye. The production increases 3.85 per cent and 4.33 per cent for rye and sugar, respectively. For the other feedstocks the adjustments are more limited, with the production of oats even declining slightly. This decline in the production of oats is a result of producers in the feed industry using less of it in their production and their reduction in demand for oats outweighs the increase in the demand for oats from the biofuel industry. Despite the rather modest changes in prices there are large adjustments to the trade balance of the EU-27 as a group. Net import of feedstocks increases by 19.55 and 22.10 per cent for grain maize and sugar, respectively and net export declines, in particular for rye.

Table 5. Change in prices, production and trade in the EU from baseline to policy scenario 2020 (per cent)

	Producer prices	Net production	Trade balance	Trade flow
Ethanol				
Wheat	1.21	0.96	-5.62	E/E
Rye and meslin	5.79	3.85	-25.06	E/E
Barley	2.27	2.83	-4.68	E/E
Oats	2.25	-1.12	-2.85	E/E
Grain maize	0.92	1.71	-19.55	M/M
Sugar	3.62	4.33	-22.10	M/M
Biodiesel				
Rape seed oil	42.14	11.27	-139.35	E/M
Palm oil	7.45	11.77	-50.37	M/M
Sunflower seed oil	19.09	8.61	-357.07	M/M
Soya oil	37.63	-6.17	-534.21	M/M
Rape seed	9.78	7.60	-36.37	M/M
Sunflower seed	7.85	3.09	-27.50	M/M
Soya seed	1.71	-8.20	5.10	M/M
By-products				
Rape seed cake	-6.87	11.25	1.89	M/M
Sunflower seed cake	-4.74	8.57	-2.08	M/M
Soya cake	-1.68	-6.16	4.71	M/M
Distillers dried grains	-15.12	104.17	76.39	M/M

Notes: A negative sign in the Trade balance column indicates a deterioration of the trade balance. The last column indicates whether the good is exported (E) or imported (M) in each of the scenarios (baseline/policy).

The higher production of biodiesel has a relatively larger impact on agricultural markets in terms of prices, production and trade compared to the higher production of ethanol. This should be expected since the biodiesel producers have rather high shares of total feedstock demands (Table 4). However it should be noted that the large increases in the price of secondary products e.g. rape seed oil, sunflower seed oil and soy oil is not fully reflected in price changes for the primary feedstock e.g. rape seed, sunflower seed and soy seed. While the price of rape seed oil increases 42.1 per cent the price increase for rape seed is only 9.8 per cent. The main reason for more limited impact on primary feedstock prices is that only part of the increasing demand for oils is satisfied by domestic production and that the primary feedstock markets are larger, thus can more easily adjust to an increase in demand from the biodiesel industry. The relative impact on trade is more pronounced and once again the largest impact is on trade with vegetable oils rather than on trade with the primary feedstock. However it is important to keep in mind that the production of primary feedstocks is much larger than the production oils in the case of rape seed and sunflower seed. In addition, trade is small compared to production for sunflower and rape seed products. The EU-27 goes from being an exporter of rape seed oil to be an importer and significantly increases its net imports of soya oil (+ 534 %) and sunflower seed oil (+ 357 %). Even though the relative impact on the primary feedstocks is less than on oils the import of rape seed and sunflower seed is 36.4 per cent and 27.5 per cent higher, respectively in the policy scenario. Palm oil production increases but the production in the EU-27 is very limited and almost all of the palm oil used is imported; hence an increase of net imports with 50 per cent will significantly affect countries outside the EU. Higher imports and lower exports of feedstocks is an important part of the adjustment to higher levels of production of biofuels in the EU even if trade with the biofuels themselves is limited.[10] This implies that to analyse the environmental impact of the EU biofuel policy the impact on the agricultural sector in countries outside the EU need to be accounted for even if biofuels are produced within the EU. The increased production of feedstocks within the EU can be achieved either through more intensive practices or increasing area used for feedstock production. The expansion of feedstock production should, however, at least partly be offset by a reduced need for fodder production since the production of oil cakes and DDGS increases as a result of higher production of biofuels. The lower prices of the by-products may also reduce the impact of higher feedstock prices for animal farmers. In addition, higher prices might reduce human consumption slightly even though the effect should be limited since the feedstocks are only a minor part of the price of the food products purchased by consumers.

Table 6 shows that arable land increases as a result of higher production volumes of feedstocks resulting from increased demand for biofuel. This is partially offset by a reduction in pasture land but the total area used in the agricultural sector also increases, thus the higher production volume of biofuels will result in more land in the EU being used for agricultural purposes than without the expansion of biofuels use. The total use of agricultural land in the EU increases by 0.04 per cent or equivalently 72 390 ha. However, the result presented underestimates the impact on land use on a global scale for two reasons. Firstly, an important effect of the increasing biofuel demand was a worsening the trade balance of the EU for feedstocks used by the biofuel industry. This indicates that production of biofuel feedstocks will increase outside the EU as a response to the increasing demand for biofuels in the EU. Secondly, import of ethanol and biodiesel is required to increase with 192 per cent and 155

[10] In the simulations trade in biofuels is not modeled but the exogenous production volumes simulated are adjusted for imports.

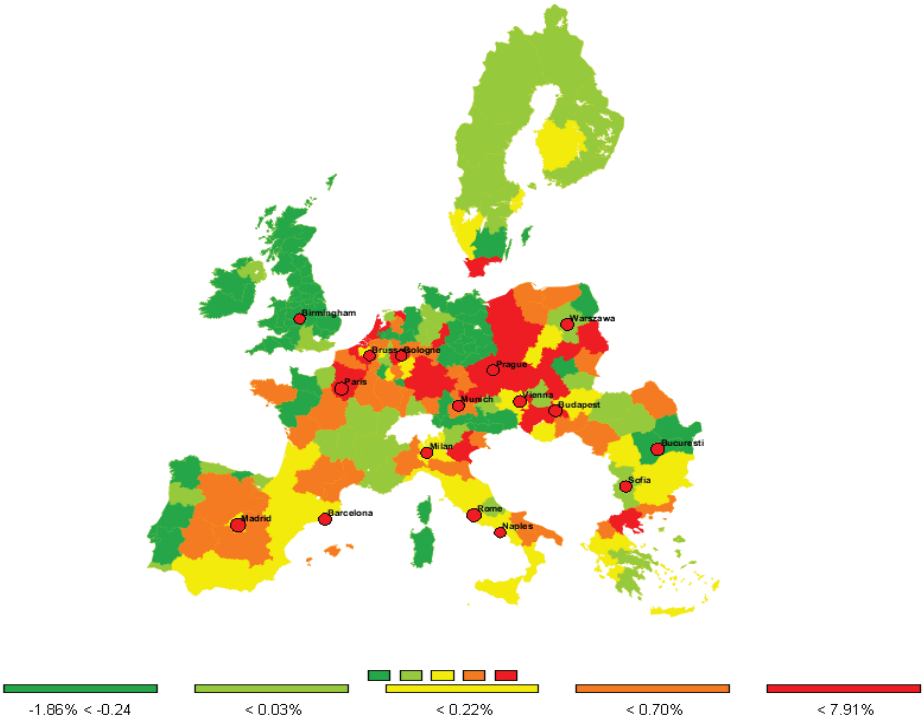
per cent, respectively to meet the renewable energy target for the transport sector according to the National Action Plans. This implies that the EU biofuel demand will result in land use changes outside the EU that are not reflected in this paper.

Table 6. Land use in the EU

Land type	Change in area (%)
Pasture	-0.67
Arable land	0.39
Utilized agricultural area	0.04

The analysis of aggregated changes in land use at the EU level might hide important changes in the regional level since regions where agricultural land use increases might be averaged out by regions reducing its agricultural land use. Therefor the analysis is disaggregated to the NUTS-2 level in figure 1.

Figure 1. Change in agricultural land area 2020 (baseline/policy scenario in per cent)



In Sweden for example the agricultural area is reduced in Smaland, where the main agricultural production is based on animals and fodder crops. In contrast in the South of Sweden where cereals, oil seeds and sugar beets are the primary activities the land use for agricultural increases.

It can be seen in figure 1 that, indeed, there are regional differences in the impact of increased biofuel production on agricultural land use. Most notably, in the western parts of the EU (Ireland, UK and Portugal) and in some other regions the land used for agricultural purposes declines slightly. In central parts of EU on the other hand the agricultural area increases with the largest relative impact in regions of the Czech Republic. This confirms that the regional impact on land use is much more diverse than indicated by the changes on the EU-level. For the purpose of analysing the environmental impact of biofuels hence; it is important to consider the regional impact of biofuel policies. A detailed analysis of the environmental impact of the biofuel policy is beyond the scope of this paper though.

5 Conclusions

Increasing production of biofuel in-line with the National Renewable Energy Action Plans will have a significant impact on agricultural market, particularly on the feedstocks used for production of biodiesel. In 2020 the biofuel industry will use a substantial share of the total production of vegetable oils. Increasing demand from the biofuel industry results in higher prices for feedstocks used by the biofuel industry, which will increase the production of these feedstocks. According to the Action Plans, imports of biofuels will cover part of the consumption of biofuels. In addition, there will be increasing indirect import of biofuels as the imports of feedstocks for biofuel production increases significantly. Hence; this will have an impact on land use outside the EU. Since the biofuel production will cause changes in the land use of the entire agricultural sector both within and outside the EU sustainability criteria only covering the production of biofuels will not be sufficient to guard against adverse effects on the amount of greenhouse gases emitted. The aggregated area used for agricultural within the EU will not be affected much (+ 0.04 per cent), indicating that additional emissions from land use change within the EU is not a concern. However, a regional analysis reveals significant differences across regions of the EU. In some areas, most notably the Czech Republic the total agricultural area increases and in other regions, for example in the UK, it decreases. In addition, the conversion of pasture land to arable land might imply additional emissions of greenhouse gases. This shows that eve n if the overall impact on total agricultural land use within the EU is limited, the actual environmental impact from changes on the regional level will be more significant and need to be considered in environmental analysis of the biofuel policy.

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