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LAND UNDER PRESSURE

GLOBAL IMPACTS OF THE EU BIOECONOMY

FULL REPORT | November 2016

Friends of the Earth Europe

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GLOBAL IMPACTS OF THE EU BIOECONOMY

Friends of the Earth Europe is the largest grassroots environmental network in Europe, uniting more than 30 national organisations with thousands of local groups. We are the European arm of Friends of the Earth International which unites 74 national member organisations, some 5,000 local activist groups, and over two million supporters around the world. We campaign on today's most urgent environmental and social issues, challenging the current model of economic and corporate globalization, and promoting solutions that will help to create environmentally sustainable and socially just societies. We seek to increase public participation and democratic decision-making. We work towards environmental, social, economic and political justice and equal access to resources and opportunities on the local, national, regional and international levels

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November 2016. Design: www.onehemisphere.se **Images:** (front cover) Mass soybean harvesting at a farm in Campo Verde, Mato Grosso, Brazil: © Alf Ribeiro. (inside) © component

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EXECUTIVE SUMMARY

BIOECONOMY: A DYNAMIC POLICY AREA IN THE EU

Over the past 15 years, the European Commission has increasingly dealt with the bioeconomy in its environmental and economic policy strategies and initiatives, primarily driven by the wish to foster economic growth whilst reducing fossil fuel use and greenhouse gas emissions. The creation of a specific EU Bioeconomy Strategy in 2012, to be updated in 2017, in particular shows that it is an area the EU sees as strategically important. Other EU policies currently impacting specific areas of the bioeconomy include the Renewable Energy Directive affecting developments in bioenergy and biofuels, and, in future, the EU Strategy on Plastics and potentially the EU Packaging and Packaging Waste Directive will have an impact on bioplastics development.

ASSESSMENT OF EUROPE'S GLOBAL CROPLAND DEMAND FOR NON-FOOD PRODUCTS

This report assesses the global cropland demand for non-food products produced by the global and European bioeconomies and thus complements the large number of already available studies related to land demand of food consumption and dietary patterns. The report analyses the historical development of Europe's global land demand over the past 20 years and evaluates potential social and environmental impacts related to the non-food bioeconomy. Furthermore, a brief assessment is carried out of future developments for two products of key importance: biofuels, as the commodity with the highest current land demand of all non-food products, and bioplastics, a market with comparatively small land appropriation, but with very high growth rates. Due to limited data availability, wood and wood products are not analysed.

EUROPE'S CONSUMPTION OF NON-FOOD PRODUCTS IS HIGHLY DEPENDENT ON FOREIGN LAND AREAS

A rapidly growing share of global agricultural areas is devoted to the production of biomass for non-food purposes. These products include, for example, oil crops for the production of biofuels, fibre crops for textile production and cereals for biofuels and bioplastics. In 2010, 12% of the globally available cropland was used for non-food purposes, an increase of over a third since 1995.

Despite being only the fifth-largest producer region, the EU is the number one consumer region of non-food cropland, illustrating the significant dependency on imported products and embodied foreign land areas. 65% of the land areas satisfying EU consumption are located in other world regions, most notably in Asia, including China, Indonesia and Thailand. Vegetable oils - including soybean, palm, rapeseed and sunflower oil - form the largest group of non-food products, accounting for almost 29% of total imports of non-food bioproducts in 2010. They are the basis for producing biodiesel as well as a large range of consumer products, including soaps, detergents, paint and plastic.

LAND DEMAND RELATED TO CONSUMPTION OF BIOFUELS AND BIOPLASTICS WILL SIGNIFICANTLY INCREASE IN THE FUTURE

Based on various biofuel policy scenarios, including a maximum share of 7% first generation biofuels by 2020 for EU transport sectors, an increasing trend of production and use of biodiesel and bioethanol can be observed. Estimates of land requirements for future global biofuel use reach an area of up to 180 million hectares globally by 2020, three times the size of France. Estimates of Europe's global land footprint for biofuels are scarce; a previous study for Friends of the Earth Europe indicated an area demand of more than 11 million hectares in 2020. Another recent report indicated that land conversions, i.e. expansion of cropland at the expense of forests, other natural lands and abandoned land related to the expansion of EU's biofuel consumption following the limit of 7% biofuels could reach 6.7 million hectares globally in 2020. Only a quarter of this land conversion is estimated to take place within Europe, with significant areas being converted also in Southeast Asia and Latin America.

Global production volumes of bioplastics are rapidly increasing with growth expected to more than triple between now and 2019. The current land requirement for bioplastics covers 1.1 Mha globally and is expected to reach 1.4 Mha by 2019. Further environmental concerns relate to the design and end-of-life management of bioplastics, including issues with waste prevention, recyclability, biodegradability and composting.

THE POTENTIAL BENEFITS OF THE BIOECONOMY CAN BE OFFSET BY OTHER ENVIRONMENTAL AND SOCIAL IMPACTS

One key objective of a further expansion of the EU bioeconomy is to reduce the carbon footprint of the European economy and the dependencies related to imports of fossil fuels. However, when further expansion requires growing land areas, especially in tropical regions, environmental and social impacts may be severe – including land grabs and deforestation.

A literature review of bioeconomy activities in the key supplying countries of the EU bioeconomy indicates that the most frequently reported negative impacts related to the EU bioeconomy occur in the social sphere. The rapid emergence of large farm operations and refineries in developing countries are an important underlying driver of increasing incidences of land tenure problems, harsh working conditions and more volatile food commodity markets. The most frequently reported negative environmental impact in the case studies is the degradation of water quality as a result of nutrient pollution, followed by water scarcities and climate change.

Sun Biofuels jatropha plantation in Mozambique.
© Nilza Matavel

THERE ARE OPTIONS TO REDUCE THE NEGATIVE ENVIRONMENTAL AND SOCIAL IMPACTS

Based on the reported negative social and environmental impacts, the EU should develop and implement strategies to minimise them. The first and most important option is to reduce Europe's demand for bio-based products as part of a wider strategy to decrease absolute levels of material and energy consumption. Given that land across the EU is characterised by growing areas of marginal croplands, the authors believe that a second option could be to support a shift towards domestic feedstock for EU's bioeconomy, which could reduce social and environmental impacts in tropical and subtropical regions. Development on marginal lands must be approached with caution however, ensuring it is carried out within sustainable limits and respecting local ecosystems and communities. Furthermore, as negative impacts are largely related to agricultural land use, land-saving initiatives such as recycling and re-using should be supported to reduce potential negative impacts.

SIGNIFICANT KNOWLEDGE GAPS EXIST AND SHOULD BE FILLED THROUGH INVESTMENT INTO RESEARCH

Given the far-reaching global implications of an expanding European bioeconomy, robust methods and indicators need to be developed and applied, in order to properly assess Europe's resource use from a consumption (or footprint) perspective as well as the related environmental and social impacts. However, significant database and knowledge gaps still exist. While first results related to Europe's global land demand for non-food products are presented in this report, methodologies to estimate and relate environmental and social impacts to activities in the EU bioeconomy are almost entirely missing. **Significant investment into research is therefore required to develop appropriate methods and indicators for analysing the potential environmental and social impacts of current policy and industry strategies related to the expansion of Europe's bioeconomy, and, ultimately, to be able to relate the assessment to a concept of global environmental justice.**

CONTENTS

*ANNEXES ARE AVAILABLE ONLINE AT
http://www.foeeurope.org/sites/default/files/resource_use/2016/annexes-land-under-pressure-report.pdf

1. INTRODUCTION

1.1 BACKGROUND

Natural resources form the basis for all human activities. In order to provide goods and services, our economies and lifestyles, regardless of consumption levels, are dependent on a constant input of natural resources. These resources comprise raw materials, energy and water – and land.

Land is vital to our economy and livelihoods: all raw materials and energy carriers, such as our food and fuel, are extracted from land (or water) areas, and it provides areas for buildings as well as transport infrastructure. In addition, land has a high recreational and aesthetical value for humans and is essential for regulating ecosystems and for maintaining plant and animal biodiversity. However, there is only a limited amount of bioproductive land available on this planet and human pressures on it are steadily increasing. There are three main reasons for this.

1. The **land footprint per capita** in industrialised countries **continues to be very high**. With more than 3,000 m² per capita in 2010, EU Member States had cropland footprint that was more than 40% above the global average. Only industrialised countries with large land areas and low population densities, such as the USA, Canada and Australia, have higher per capita cropland footprints. High consumption levels of meat and dairy products in particular determine this high level of land demand. Almost 50% of the overall cropland footprint of the EU is related to the production of animal products (Fischer et al., 2016).

2. **Middle classes are growing rapidly** in several world regions, most notably in emerging economies such as China. Increasing incomes **change consumption behaviour, lifestyles and diets**, with a general increase in the consumption of animal-based products. For example, in East Asia, changes in diets have by far surpassed population growth as the main driver for increasing food-related land demand in the past 30 years (Kastner et al., 2012).

3. The third reason, and the one on which this report will focus on, is the rise in pressures on global land resources due to **increasing demand by industrialised countries for non-food biomass products related to the bioeconomy** – i.e. biomass that is used as an energy carrier (for example, biofuels) or as raw materials (for example, bioplastics or textiles). These non-food uses of cropland are the most rapidly growing category within the overall EU cropland footprint, largely due to the necessity of reducing reliance on fossil resources. In 2010, around 28.2 million hectares were appropriated around the world for the production of non-food products consumed across the EU and contributed to 18% of the overall cropland footprint, up from 14% in 1995 (Fischer et al., 2016).

With regard to international trade, Europe is the only world region that is a net importer of the four major natural resource categories: materials, water, carbon and land (Tukker et al., 2016). This **import dependency** is visible with regard to many non-renewable raw materials such as metal ores and fossil fuels, but also concerns biomass-based raw materials and products, such as fodder, energy crops and timber. Attached to these direct imports of raw materials and products are large amounts of embodied resources, such as water or land that was required in the producing countries in order to produce the goods and services exported to the EU. A recently published report on the EU's land footprint illustrates the urgency of addressing the topic of global land demand related to EU consumption, not just to ensure we remain within planetary boundaries in the quantity of resources used, but also to decrease related environmental and social impacts across the globe which are linked with production processes, such as biodiversity loss and land grabbing (FoEE, 2016).

1.2 OBJECTIVES AND FOCUS AREAS OF THIS REPORT

Against the background of the EU's rising cropland footprint related to the expanding EU bioeconomy, Friends of the Earth Europe want to **further assess the global land demand due to current policy and market trajectories for non-food products of the bioeconomy**, and to evaluate potential social and environmental impacts resulting from these developments. A focus will be on past trends, as accompanied by a brief look into future developments of biofuels and bioplastics. The report will provide recommendations to limit the negative impacts of the EU's global land footprint for its non-food bioeconomy.

There is no commonly-agreed global or EU-wide definition of the bioeconomy, but most existing policy strategies (see Box 1) are based on a broad scope, including the food and non-food as well as the forestry sectors. **This report puts the focus on the non-food component of the bioeconomy and its related land demand and thus aims to complement the large number of already available studies related to land demand of food consumption and dietary patterns** (for example, Bruckner et al., 2015; Fischer et al., 2016; FoEE, 2016; Giljum et al., 2013; Kastner et al., 2011; Kastner et al., 2012; Weinzettel et al., 2013; Yu et al., 2013). Non-food products of the bioeconomy include bioplastics, natural oils, fibres, rubber, animal products (such as skins), and feedstock for energy production (such as biofuels).

The report is **concentrated on the cropland footprint** and thus excludes land areas related to the production of wood and wood products. Although timber is a key resource in the bioeconomy context, the calculation of land demand related to timber consumption is currently difficult due to limited data availability regarding actually harvested forest areas – in contrast to overall forest areas (Bruckner et al., 2015; Fischer et al., 2016).

BOX 1. DEFINITIONS OF THE BIOECONOMY

A bioeconomy can be generally defined as 'an economy where the basic building blocks for materials, chemicals and energy are derived from biomass-based resources, such as plant and animal sources' (McCormick and Kautto, 2013). However, the definition of the scope of the bioeconomy varies across regions and sources. In 2012, the EU published its Bioeconomy Strategy (European Commission, 2012b), presenting it as a key element to achieve 'smart and green growth' in Europe. In this document, the Commission applies a broad definition of the bioeconomy that encompasses agriculture, food, forestry, bio-materials such as paper and wood, bio-chemicals and bio-energy.

The *German National Policy Strategy Bioeconomy* (BMEL, 2013), as the most advanced strategy on the Member State level, defines that in addition to agriculture and forestry, the manufacturing industries in the food, wood and paper, construction, textiles, chemical and energy sectors are also part of the bioeconomy. What current descriptions of the bioeconomy do have in common is to present biotechnology, i.e. technologies that use biological matter as the basis for producing goods and services, and biorefinery concepts, i.e. technologies to replace petroleum-based refineries, as core elements of a bioeconomy, producing a wide range of bio-based products and fuels (McCormick and Kautto, 2013).

The report is structured as follows: Chapter 2 provides a summary of the assessment of historical trends of the cropland footprint related to the EU bioeconomy between 1995 and 2010. Chapter 3 presents the findings from a brief analysis regarding possible future developments of the cropland footprint of biofuels and bioplastics at the global (and partly EU) level. Chapter 4 gives an overview of the environmental and social impacts of an expanding EU bioeconomy, highlighting the threats, but also the opportunities for biomass-producing countries and regions. Chapter 5 provides a conclusion to the report, summing up the key points and findings and providing research recommendations.

Annexes to the report (in three sections) are available online at http://www.foeeurope.org/sites/default/files/resource_use/2016/annexes-land-under-pressure-report.pdf

Mass soybean harvesting on a farm in Campo Verde, Mato Grosso, Brazil.
© Alf Ribeiro

2. THE CROPLAND FOOTPRINT OF NON-FOOD PRODUCTS: A HISTORICAL VIEW

KEY MESSAGES IN CHAPTER 2

- Global cropland devoted to the cultivation of non-food products increased by 37% between 1995 and 2010, making it the fastest growing component of the overall global cropland footprint.
- The EU's cropland footprint of non-food products is highly dependent on land areas in other countries – 65% of the land required to satisfy EU consumption is located in other world regions, primarily in Asia.
- Cropland for vegetable oil production accounted for 39% of the non-food global cropland footprint, making it of significant importance. These products, which include soybean, palm, rapeseed and sunflower oils, form the raw material basis for producing biofuels and a wide range of consumer products.
- Asia is the leading producer region, growing almost 50% of global crops (in terms of land use) used for non-food products in 2010, while the EU contributed just 8%.
- Through the analysis of global patterns of raw material producers, processers and consumers, it is shown that despite being only the fifth largest producer region, the EU is the number one consumer region of non-food cropland.

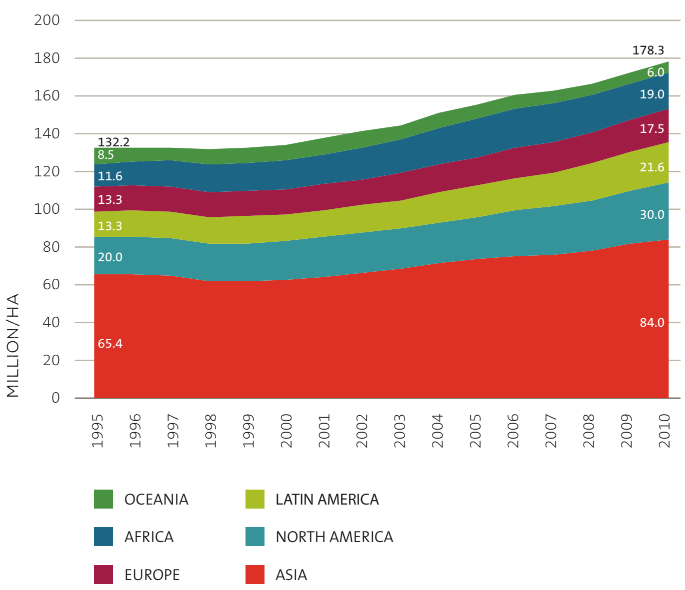
This chapter presents the main results obtained from model calculations of global biomass flows and related land requirements. It covers all cropland areas related with the production of non-food commodities derived from crop and animal products. Results were obtained by applying a globally consistent top-down approach avoiding any form of double-counting (see Annex 1 for technical details of the applied physical-economic model). The first section presents the global cropland requirements for the production of non-food products. The second section illustrates how these non-food products are traded on international markets, from agricultural production to processing industries and then to final consumers. The third section focuses on the role of the EU as a final consumer, investigating the geographical and product structure of the cropland footprint for its consumption of non-food products. Note that calculations are currently only possible up until 2010 due to limitations in data modelling.

2.1 CROPLAND REQUIREMENTS FOR NON-FOOD PRODUCTS: THE GLOBAL PRODUCTION PERSPECTIVE

With increasing material and energetic demand for non-food bio-based products, the land area to produce these has expanded significantly over the past 20 years. Figure 2.1 illustrates the cropland requirements for non-food products, disaggregated by continents, for the period of 1995 to 2010.

FIGURE 2.1 CROPLAND REQUIREMENTS FOR GLOBAL PRODUCTION OF NON-FOOD PRODUCTS, 1995-2010

NUMBERS REFER TO ABSOLUTE LAND AREAS IN MILLION HECTARES



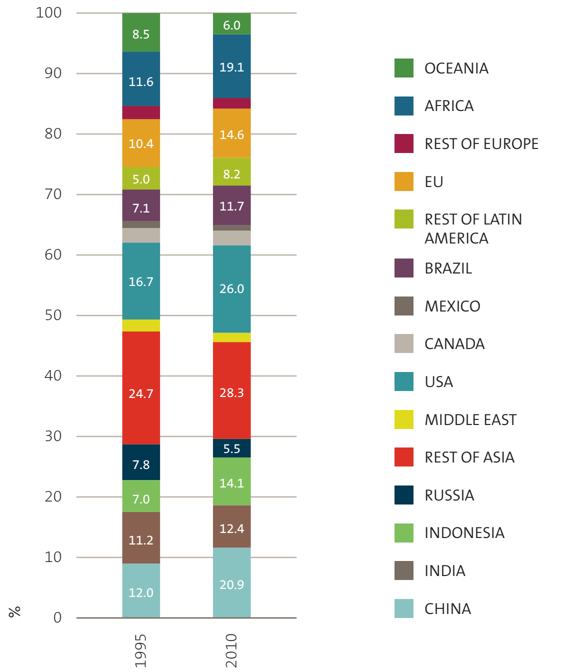
SOURCE: OWN CALCULATIONS.

In 1995, more than 132 million hectares (Mha) were required for producing biomass. This area increased to more than 178 Mha in 2010, a growth of 37% in only 15 years, faster than population growth in this period which was 20%. In 2010, non-food agricultural areas thus accounted for approximately 12% of overall global cropland (global cropland area is approximately 1.5 billion hectares). This compares to 49% for the production of food products and 39% for the cultivation of fodder crops for livestock (Fischer et al., 2016).

Figure 2.2 provides a more detailed country-by-country breakdown of the cropland requirements for the non-food products, illustrating the major producing countries within each continent. With a share of 47% in 2010, Asia (including Russia and the Middle East) was by far the largest producing region (more than 84 Mha devoted to the production of non-food items). Figure 2.3 shows the product composition within each country and world region in 2010. Note that Figure 2.3 takes a production perspective, indicating the share of land in each country and region used for the production of certain crops. The product shares relating to European consumption can differ slightly, as Chapter 4 explains in more detail.

FIGURE 2.2 CROPLAND REQUIREMENTS FOR THE GLOBAL PRODUCTION OF NON-FOOD PRODUCTS, 1995 AND 2010

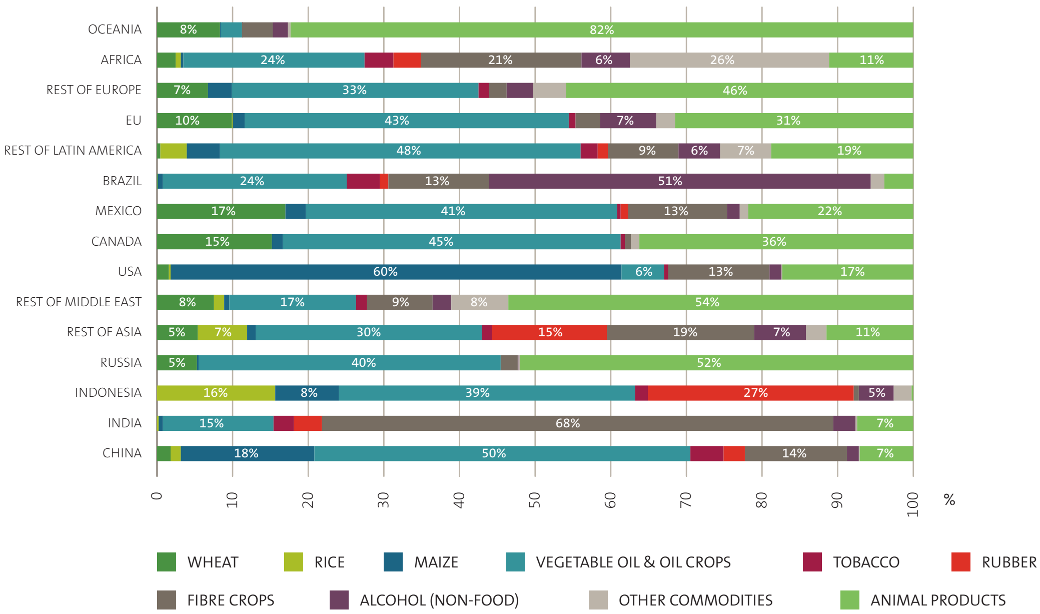
NUMBERS REFER TO ABSOLUTE LAND AREAS IN MILLION HECTARES



SOURCE: OWN CALCULATIONS.

New land clearing, digging of drainage canal in peatland in Ladang Sawit Mas Plantation concession, Ketapang district, West Kalimantan, Indonesia.
© Jason Taylor

FIGURE **2.3** | PRODUCT COMPOSITION OF CROPLAND REQUIREMENTS FOR NON-FOOD PRODUCTS, 2010 NUMBERS REFER TO SHARES IN TOTAL PRODUCTION OF NON-FOOD PRODUCTS



SOURCE: OWN CALCULATIONS.

Key facts and figures related to Figures 2.2 and 2.3 on global non-food crop production:

- China, India and Indonesia were major producers of non-food products, contributing 20.9 Mha (25%), 12.4 Mha (15%) and 14.1 Mha (17%), respectively, to the Asian total in 2010. Strong increases in land requirements were observed in China and in Indonesia.
- Growth in China was mainly related to vegetable oils and oil crops, with soybean oil being the major product. To a lesser extent maize for ethanol production also expanded (compare the shares in Figure 2.3).
- The expansion in Indonesia mostly focused on vegetable oils; Indonesia is the world's largest producer of palm oil and second for coconut oil, which together accounted for 39% of its non-food cropland areas in 2010 (Figure 2.3). Indonesia is also a major producer of natural rubber (27% of the non-food area in 2010), a raw material used, for example, in the cement industry, the chemical industry and the clothing industry.
- Production in the USA expanded by around 10 Mha between 1995 and 2010, mostly driven by increased maize production for ethanol. Maize held a share of 60% of all non-food agricultural areas in the year 2010, making the USA the number one ethanol producer world-wide.
- Within the EU, land areas for non-food production increased by around 4 Mha, reaching 14.6 Mha (8% of the total non-food agricultural area) in 2010. The product composition in the EU was dominated by vegetable oils and oil crops (43%), with rapeseed and sunflower being the dominant products. Animal products, such as hides and skins, also play a notable role in the EU (31% of total non-food agricultural area in 2010).
- Land areas devoted to the cultivation of non-food products also grew in Africa, to more than 19 million hectares in 2010, whereas land areas were decreasing in Oceania.

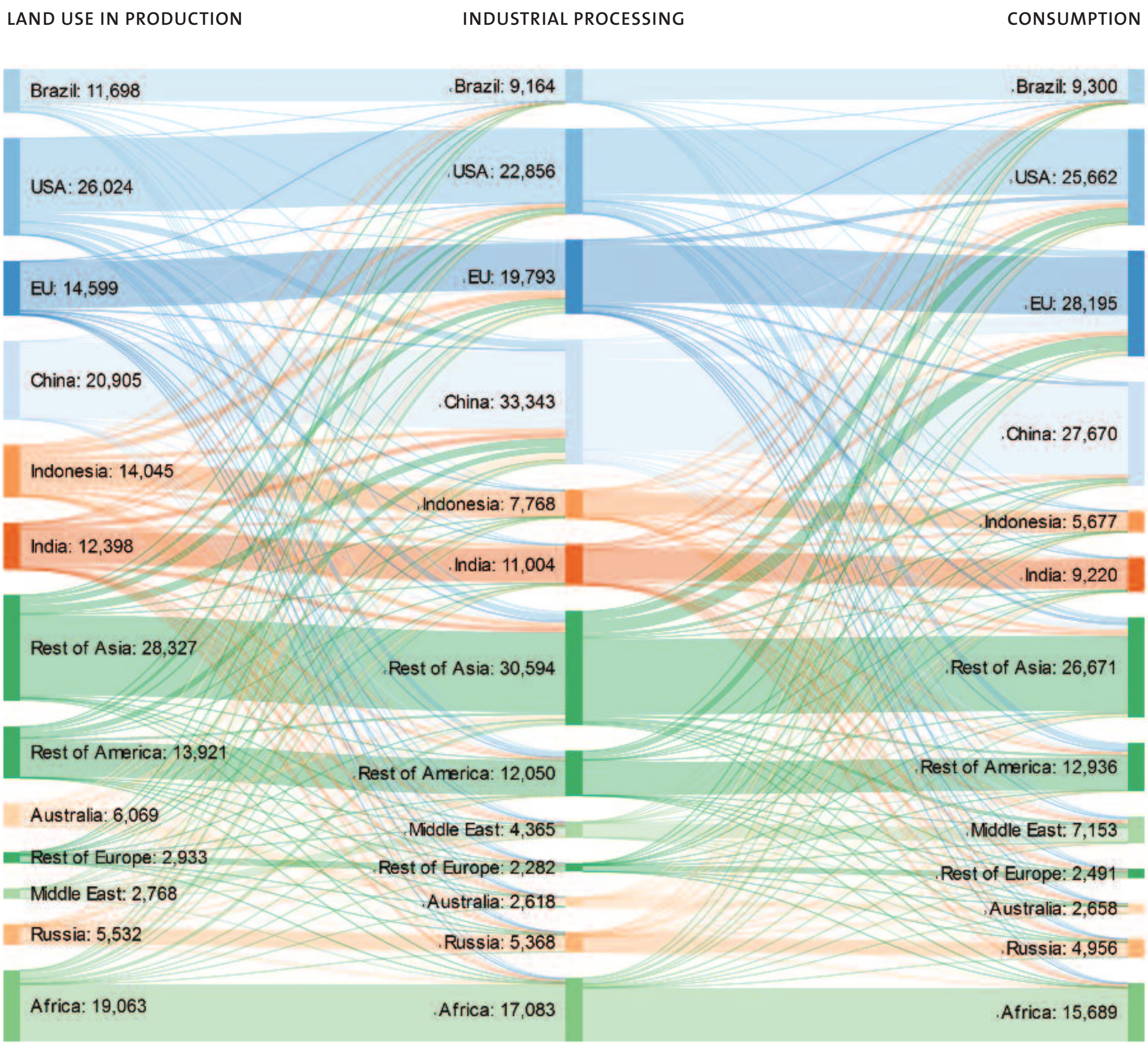
2.2 FROM THE PRODUCTION TO THE CONSUMPTION PERSPECTIVE

The previous section provided an overview of the production perspective, i.e. quantifying those land areas in producing countries and regions where biomass for non-food purposes was cultivated. The harvested biomass is then further processed by industries, such as producers of biofuels or bioplastics, or the rubber or textile industries. These industries may be located in the same country, or may import feedstock from other countries. After processing, bioeconomy end-products are consumed by individuals, governments, businesses, or are put on stock for use in the following years. Consumption and changes in stock constitute the so-called final demand of an economy. Again, consumers may be located in the country of production or processing, or the final products may be exported to be consumed in other world regions.

A Sankey diagram is well suited to illustrate the international flows of land associated with non-food biomass products. Using the same groupings of countries and regions as the previous section, Figure 2.4 shows on the left side where the non-food products are produced, in the middle part where the industries are located that process the respective biomass products, and on the right side where the final products are consumed. Note that the aggregated totals of embodied land are identical in all three parts of the flow diagram.

FIGURE 2.4 GLOBAL FLOWS OF EMBODIED LAND ASSOCIATED WITH NON-FOOD PRODUCTS, 2010

NUMBERS IN THOUSAND HECTARES



SOURCE: OWN CALCULATIONS.

On the left side, the producing countries and regions are illustrated, as they have been analysed in the previous section. It can be seen that **most countries and world regions are net-exporters of biomass and related land areas between production and processing**, implying that a large part of the involved manufacturing processes (and related value added) do not take place in the producer country of the raw material. For example, in 2010, Brazil produced crops destined for non-food uses on around 11.7 Mha. However, Brazilian industries only processed crops equivalent to around 9.2 Mha. This means that products equivalent to an area of around 2.5 Mha were exported to processing industries in other countries and regions. This pattern is even more pronounced in Indonesia, where the domestic processing industry processed only around half of the primary products produced within Indonesia (7.8 Mha compared to 14 Mha). Indonesia is a major exporter of unprocessed palm oil and other non-food products, most notably to the EU and the 'Rest of Asia' region.

The column in the middle of Figure 2.4 illustrates the geographical location of the industries that further process the biotic raw materials into products. It can be seen that large processing industries are located in China, where biomass products produced on more than 33 Mha were processed in 2010. Only around 21 Mha have been cultivated for non-food purposes in China itself. From a processing perspective, China is thus a net-importer of embodied land from other world regions. With 19.8 Mha, **the EU also had a significant processing industry with around a quarter of the required raw materials being imported from other world regions**.

Moving to the right side of Figure 2.4, the flows of embodied cropland from the processing industries to the countries and regions of final consumption are illustrated. The EU was the largest consuming region with more than 28 Mha, followed by China, 'Rest of Asia' and the USA. **The dependence of EU consumption on foreign land areas is striking**. In 2010, less than half of the land required to produce these non-food products (around 12.5 Mha) was located in the EU itself. Large amounts of embodied land (7.3 Mha) were imported to serve the further processing of these non-food products in the EU, most notably vegetable oils for biofuel production from Indonesia and other Asian countries. Most of the processing output (equalling 19.8 Mha of embodied land) served consumption within the EU itself. In addition, processed products were imported from all other world regions, including China (4.4 Mha; primarily vegetable oils), 'Rest of Asia' (3 Mha; vegetable oils and rubber) and the USA (1.6 Mha; primarily maize).

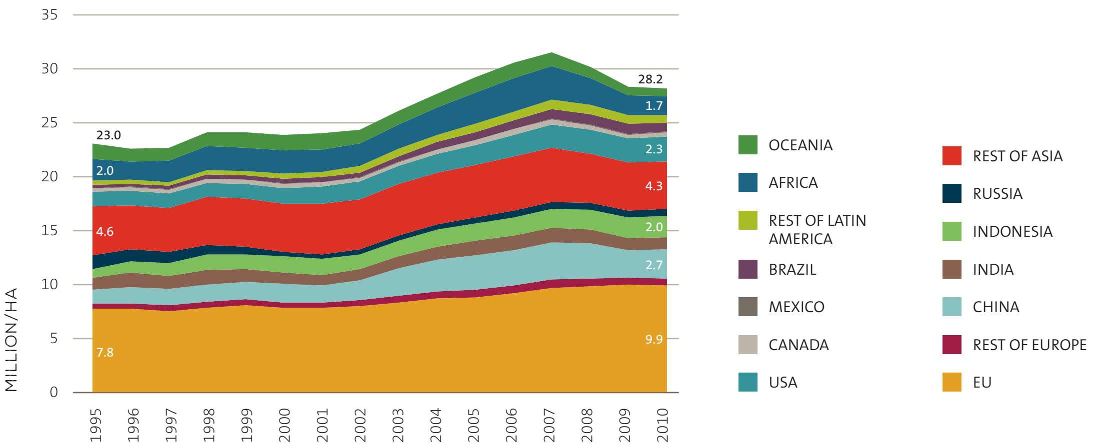
2.3 THE EU CROPLAND FOOTPRINT OF NON-FOOD PRODUCTS: THE CONSUMPTION PERSPECTIVE

The previous section illustrated that the EU is a massive consumer of non-food products, with a significant share of required biomass – and related embodied land – being imported from other world regions. We now take a closer look at the development of the EU cropland footprint for non-food products over time as well as its geographical and product composition.

Figure 2.5 is an illustration of the producing countries and regions serving the consumption of non-food products in the EU from 1995 to 2010.

FIGURE **2.5** CROPLAND FOOTPRINT OF EU'S CONSUMPTION OF NON-FOOD PRODUCTS, BY PRODUCING COUNTRY AND REGION, 1995-2010

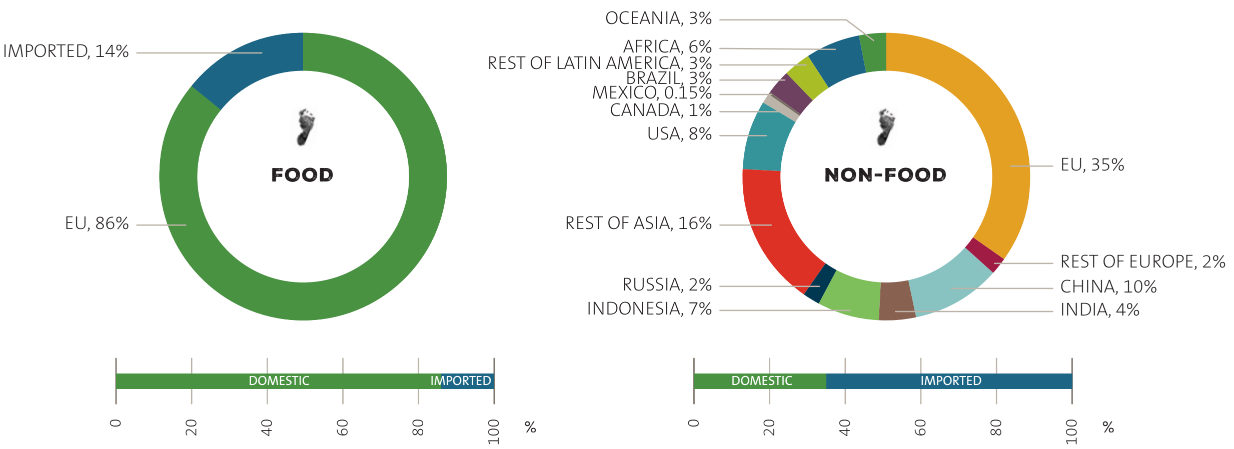
NUMBERS REFER TO ABSOLUTE LAND AREAS IN MILLION HECTARES



SOURCE: OWN CALCULATIONS.

The overall cropland footprint of the EU's consumption of non-food products increased by 23% from around 23 Mha in 1995 to 28.2 Mha in 2010, after reaching a peak in the year 2007 (with 31.5 Mha). While the vast majority of cropland embodied in the EU's food consumption in 2010 stemmed from the EU itself (more than 86.5%, see Fischer et al., 2016), for non-food products only 35% (9.9 Mha) were based on domestic land resources (Figure 2.6). The remaining **65% of the cropland (18.3 Mha) was imported from outside the EU**. With 2.7 Mha of embodied land, China was a major supplying country, accounting for almost 10% of the EU's non-food cropland footprint, mainly in the form of vegetable oils, maize, and fibre crops (or derived products). Indonesia, with 2 Mha, also provided large areas, largely related to palm oil. The 'Rest of Asia' group, including Malaysia, Bangladesh, the Philippines and Thailand, amongst others, supplied Europe particularly with vegetable oils, rubber, plant fibres and non-food alcohol. North America also played an important role as an exporter of maize for industrial uses (e.g. in the form of starch and ethanol).

FIGURE 2.6 A COMPARISON BETWEEN THE SHARES OF DOMESTIC AND IMPORTED CROPLAND IN THE EU'S TOTAL CROPLAND FOOTPRINT FOR THE FOOD AND NON-FOOD SECTORS, 2010

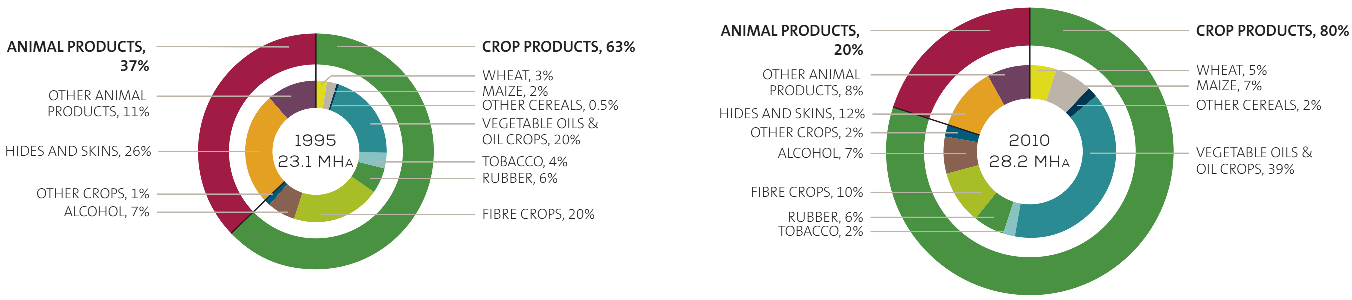


SOURCE: OWN CALCULATIONS.

Looking at the product composition of the EU's cropland footprint for non-food products in 2010 (28.2 Mha), more than one third was related to vegetable oils and oil crops, mainly for use as biofuels (Figure 2.7). This is more than double the embodied land of this category in 1995. Increasing consumption of vegetable oils were therefore a main determinant for the overall growth of the EU non-food bioeconomy cropland footprint.

Another noticeble aspect is the change in composition of the EU non-food cropland footprint between 1995 and 2010. While in 1995, crop products contributed only 63% to the overall land footprint of the EU bioeconomy, this share increased to 80% in 2010. This includes an increasing use of cereal products like maize and wheat, used to produce for example ethanol or bioplastics, and non-food alcohol, used for biofuel production. In contrast, the embodied land related to the consumption of animal products, such as hides and skins, showed a declining trend.

FIGURE 2.7 PRODUCT COMPOSITION OF THE CROPLAND FOOTPRINT OF EU'S CONSUMPTION OF NON-FOOD PRODUCTS, 1995 AND 2010



SOURCE: OWN CALCULATIONS.

Forests cleared and burnt for production of biofuels in Salta, Argentina.
© Hernan Giardini / Greenpeace Argentina

3. FUTURE TRENDS OF CROPLAND FOOTPRINTS OF NON-FOOD PRODUCTS

KEY MESSAGES IN CHAPTER 3

- Over the past 15 years, the EU has put increasing focus on the bioeconomy in the drive to reduce fossil fuel use. One of the policy initiatives creating significant impact has been the targets and caps on biofuels, most recently (at the time of writing this report) the 2015 policy to limit the share of first generation biofuels in total transport fuels by 2020.
- Based on increasing demand for biofuels in the EU and other world regions, production is expected to expand rapidly in the coming years: global biodiesel production could increase by 27% between 2014 and 2024, reaching almost 40 billion litres; bioethanol production could grow by 15%, to almost 135 billion litres in 2024.
- The implementation of biofuel policies, in comparison to the absence of policies, has significant impacts on production and consumption levels in the EU – the presence of specific policies would result in an increase in EU biodiesel consumption of more than 550% and of bioethanol consumption of almost 210% by 2020.
- Studies investigating the land requirement of increased consumption of biofuels from a land footprint perspective are scarce. Depending on different assumptions regarding biofuel shares, estimates of global land requirements range between 120 and 180 million hectares by the year 2020. According to a Friends of the Earth Europe report, the EU's land footprint related to biofuel consumption is estimated at around 11 million hectares in 2020. Another recent study estimated the land conversions, i.e. the creation of additional cropland related to an expansion of biofuel production under the 7% EU share of biofuels at 6.7 million hectares globally in 2020.
- In the next three years, global production of bioplastics is expected to more than triple, with rigid packaging (which includes single-use plastics) dominating this growth, and Asia increasingly taking on the largest share of production (80% by 2019, compared with just 5% share of production in Europe).
- Very few studies exist which examine the land requirement of bioplastics. One recent study estimates current land requirement for bioplastics to be 1.1 Mha globally and expected to reach 1.4 Mha by 2019. However, given the fast growth predicted for bioplastics, further research of their future land requirement and related environmental and social impacts is crucial.
- Other pressing concerns with bioplastics relate to their design and end-of-life management, with little clear or satisfactory standards defining their recyclability, biodegradability or compostability, leading to difficulties in waste management and consumer confusion. There is also concern from civil society groups that the pressing need to reduce overall material consumption is being overlooked by the focus on replacing fossil-based plastics for bio-based.

While the last chapter focused on the historical developments in the cropland footprint of non-food products of the bioeconomy in the past two decades, this chapter takes a brief look into future trends in two categories – biofuels and bioplastics – using currently available research and data. Biofuels were chosen as they are the most important category in terms of land requirements (see above), and bioplastics as they are one of the fastest growing areas of the bioeconomy, yet one on which little research on impacts of their growth has been done so far.

The analysis in this chapter will be based on relevant EU policies and targets, predicted production capacities from business reports and outlooks, as well as on results from scientific studies investigating scenario-based land requirements of biofuels and bioplastics. Note that this chapter considers studies that have been carried out latest by 2015 and thus do not take into account current EU policy discussions on biofuels, which will have a significant impact on biofuel consumption levels in the future.

3.1 POLICY FRAMEWORK

Over the past 10-15 years, the European Commission has increasingly dealt with the bioeconomy in their environmental and economic policy strategies and initiatives. The following table provides an overview of the main policy developments since 2003.

These developments illustrate approaches towards an intensified use of biomass-based resources, primarily driven by the need to reduce fossil fuel use and to limit greenhouse gas emissions. The creation of a specific EU Bioeconomy Strategy in 2012 in particular shows that it is an area the EU sees as strategically important. Targets and caps are set for biofuels, with a maximum of 7% of transport fuel to be based on first generation biofuels by 2020. For bioplastics, no specific EU policies, targets or caps have been developed so far, yet in recent years it has been an area receiving widespread attention and facing increasing demand by industries and consumers. On the whole, the move away from fossil fuels is, and will, inevitably lead to an increasing demand for alternative feedstocks and will expand the need for agricultural land.

Furthermore, by the time of this report publication, an updated Renewable Energy Directive (RED), including a sustainability policy for bioenergy, will have been published (due 30th November 2016) which will impact the development of the area of EU bioenergy consumption within the bioeconomy. On top of that, other EU initiatives related to the non-food bioeconomy in the near future include the updating of the EU Bioeconomy Strategy (2017/2018), which will likely have an indirect effect on markets for bio-based products, particularly in terms of driving innovations of renewable resources, infrastructures for bio-based products and processes, knowledge acquisition, and methodological standards for bio-based products (see also OECD, 2013); a Strategy on Plastics, including examining the use of biomass as a feedstock (2017); and the potential inclusion of measures to promote bio-based packaging within the EU Packaging and Packaging Waste Directive (2017).

TABLE 1 | OVERVIEW OF POLICY DEVELOPMENTS RELATED TO THE BIOECONOMY SINCE 2003

YEAR	POLICY DEVELOPMENT
2003	The Biofuels Directive sets a target to complement 5.75% of all petrol and diesel used in transport by biofuels for 2010.
2005	The Directorate-General Research of the European Commission develops the Knowledge-Based Bio-Economy (KBBE) concept.
2007	Within the EU Energy and Climate Change Package (CCP), EU leaders set the target, among others, of renewable energy having a share of 20% of the EU total energy mix.
2009	The overall policy for production and promotion of energy, called ‘Renewable Energy Directive (RED)’, sets targets on 20% of energy consumption and 10% of transport fuel based on renewable resources by 2020. Additionally, individual targets of Member States report their plan on how to meet these targets on National Renewable Energy Action Plans (NREAP).
2009	The ‘Fuel Quality Directive (FQD)’ is adopted concerning technical standards for transport fuels and requiring the reduction of GHG emissions of the transport fuels by a minimum of 6%, between 2010 and 2020.
2010	The ‘Europe 2020: Jobs and Growth Strategy’ acquires the target of increasing the share of renewable energy up to 20% by 2020.
2012	The EU Bioeconomy Strategy innovated the strategy plan ‘Sustainable Growth: a Bio-Economy for Europe’ as a part of the Europe 2020 Flagship Initiative for a Resource Efficient Europe.
2014	The European Union´s 2030 Framework for Climate and Energy Policy builds on the CCP and sets the target of increasing the share of renewable energy up to 27% by 2030.
2015	The EU reforms its RED targets to cap crop-based biofuels (conventional biofuels) to 7% for its transport sectors by 2020.

3.2 BIOFUELS

This section provides a brief overview of future trends in global and European biofuels production and consumption and examines related land requirements. The policy target within the Renewable Energy Directive of a maximum of 7% first generation biofuels for the transport sector by 2020 is currently the main driver impacting biofuel demand in Europe.

BOX 2. WHAT ARE BIOFUELS?

Biofuels are a bio-based alternative for liquid or gaseous transport fuel and are used in the form of bioethanol or biodiesel. Bioethanol is based on sugar and cereal crops and is used to replace petrol, and biodiesel is based on vegetable oils and is used to replace diesel (European Commission, 2012a). Over the past 10 to 15 years, biofuels have become a significant alternative energy carrier for road transport. In Europe, the use of biofuels increased over 20 fold between 2000 and 2011 (IEEP, 2014).

Biofuels can be split into two different categories, based on how they use land: conventional (first generation) biofuels and advanced (second- and third-generation) biofuels. Conventional, or first-generation, biofuels use feedstock-requiring virgin land, such as sugar, starch and vegetable oils. In contrast, advanced, or second- and third-generation biofuels are produced from feedstocks without direct land demand, such as wastes and agricultural residues, non-food crops, or algae (European Commission, 2012a). Thus, in terms of land requirement, first-generation biofuels, such as bioethanol and biodiesel, are of particular interest and are therefore the focus of this section. Future reports need to investigate the land demand of advanced biofuels, for which little evidence exists so far.

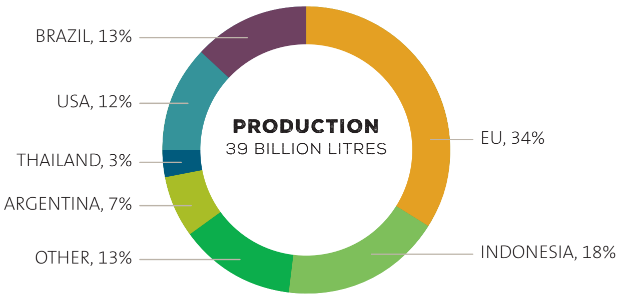
Market Trends

The 2015-2024 Agricultural Outlook report by the Organisation for Economic Co-operation and Development (OECD) and UN Food and Agriculture Organisation (FAO) includes projections on biofuels use globally and regionally. The projections for the EU are based on the 7% share of first generation biofuels by 2020. Their research shows that the EU is expected to reach this limit in 2019 and will continue to be a main importer of biofuels.

The report's projections should be interpreted with care, as uncertainties exist regarding the support for biofuel blending in transportation fuel, which will be shaped by a number of factors including macroeconomic developments in key countries, relative prices of feedstocks and fossil fuels, prevailing views on environmental benefits of biofuels and the global food security situation (OECD and FAO, 2015).

Regarding biodiesel, an increase in production of 27% between 2014 and 2024 is expected on a global level, reaching 39 billion litres, and the EU will continue to be a main producing region with a share of 34% of global production by 2024 (Figure 3.1). Biodiesel consumption will increase by 8.3 billion litres globally and again, the EU represents the main consumer with a 35% share by 2024. However it is projected that consumption will increase to its highest level in 2019 when the 7% limit is assumed to be met.

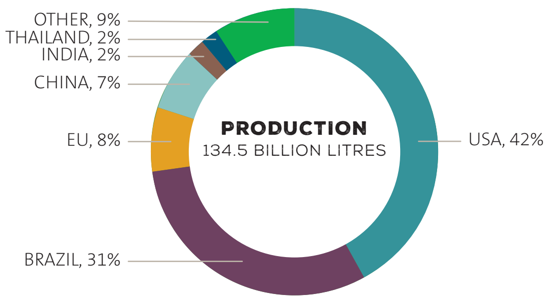
FIGURE 3.1 | REGIONAL DISTRIBUTION OF WORLD BIODIESEL PRODUCTION & CONSUMPTION IN 2024



SOURCE: OECD-FAO, 2015.

Regarding bioethanol, on the global level an increase in production of almost 15% between 2014 and 2024 is expected, reaching almost 134.5 billion litres, with the EU holding a 7% share in production by 2024 (Figure 3.2). EU production is expected to peak in 2019 at 10 billion litres and to decrease thereafter due to an assumed decrease of gasoline use. Bioethanol consumption will increase by 21 billion litres globally, with an 8% share of the EU by 2024. Both production and consumption of bioethanol will primarily take place in the United States and Brazil.

FIGURE 3.2 | REGIONAL DISTRIBUTION OF WORLD ETHANOL PRODUCTION & CONSUMPTION IN 2024



SOURCE: OECD-FAO, 2015.

The main feedstocks for producing biofuels will continue to be coarse grains and sugarcane for bioethanol production, and vegetable oils for biodiesel production (assuming the a share of 7% of first generation biofuels by 2020 and a mix of price trends and policy support driving trends in other countries/regions).

A look into the impact of policy targets

To research the potential impacts of policy targets for biofuels production and consumption, a study investigated biofuel balances for two scenarios: first, a scenario without any biofuel targets, and second, a scenario with an EU biofuel target of 8.5% by 2020 (consisting of 7% first generation and 1.5% second generation biofuels) (Blanco Fonseca et al., 2010).

The calculations show that the implementation of biofuel policies, in comparison to the absence of policies, would result in an increase in EU biodiesel production of more than 585% and consumption of more than 550%. High impacts also occur regarding bioethanol, with EU production increasing by almost 180% and consumption by almost 210% (see Table 2).

TABLE 2 | EU BIOFUEL BALANCES WITH AND WITHOUT BIOFUEL POLICY MEASURES IN 2020, IN MILLION LITRES

	PRODUCTION			CONSUMPTION		
BIOPLASTIC	WITHOUT POLICIES	WITH POLICIES (8.5% TARGET)	INCREASE DUE TO POLICY (IN %)	WITHOUT POLICIES	WITH POLICIES (8.5% TARGET)	INCREASE DUE TO POLICY (IN %)
Biodiesel	3,536	24,243	586	4,316	28,196	553
Bioethanol	6,385	17,790	179	6,868	21,239	209

SOURCE: BASED ON (BLANCO FONSECA ET AL., 2010)

Land requirements

A large number of studies exist that assess the various environmental impacts of an increased production and consumption of biofuels. However, only a limited number of these studies quantify the actual land demand of biofuels and take a land footprint perspective. Annex 2 summarises the available studies, which deliver a wide range of results based on different scenario specifications and assumptions that refer particularly to the share of biofuels. As EU biofuel policies affect land requirement worldwide, referred studies focus both on the global as well as on the EU level.

A comprehensive discussion on the land-related implications of biofuel feedstock production and consumption needs to take into account also indirect land use changes (ILUC), as these can offset the potential carbon savings from biofuels (Lapola et al., 2010) and contribute to biodiversity losses and deforestation. First studies on ILUC related to EU biofuels consumption have recently been published (Ecofys et al., 2015) and main results related to land conversions due to expansion of biofuel production will be summarised below.

Land requirement of worldwide biofuel use

The key results of the existing studies can be summarised as follows:

- Based on the assumption of a 10% share of first generation biofuels in EU transport fuel, Detzel and colleagues (2013) project the global land requirement of biofuels to reach between 120 and 180 million hectares by 2020.
- Various scenarios based on different biofuel targets were also conducted by Hélaine et al (2013). They investigated the impact on land requirements of changing from a “base scenario” with a 10% biofuel target, to an 8% target, as well as a scenario without any target. Decreasing the target by 2 percentage points would result in a reduction of the harvested area of 1.8 million hectares by 2020. The assumption of no biofuel target would decline the harvested area by 5.9 million hectares.
- Another estimation was published by UNEP (2009) under the assumption that 10% of the global transport fuel demand would be met with first generation biofuels by the year 2030. According to this study, between 118 and 508 million hectares would be required to produce the required feedstocks. The range of these land requirement estimates is very high due to assumptions made on the number of countries implementing biofuel policies, on the type of feedstock, the geographical location of production and the expected yield increases (UNEP, 2009).

Land requirement of EU biofuel consumption

The land requirement related to EU biofuel consumption from a land footprint perspective was examined in a Friends of the Earth Europe report in 2014 (Schutter and Giljum, 2014). Based on the 10% of transport fuel based on renewable resources by 2020in place at that time, the total global land use embodied in biofuels consumed in the EU was estimated to increase by 130% between 2010 and 2020. Accordingly, EU biofuel consumption would require 11.3 million hectares by 2020, the size of Poland and Sweden combined.

In a recent study for the European Commission (Ecofys et al., 2015), various scenarios related to increased consumption of biofuels in the EU were evaluated regarding their effects on the expansion of cropland and the greenhouse gas emissions resulting from land conversions. One of the scenarios assumed a maximum level of 7% of first generation biofuels by the year 2020. The model results indicate an additional land expansion in the magnitude of 6.7 million hectares globally, the majority (5.2 million hectares, or 78%) being used for additional cropland and the rest for short rotation timber plantations. Only around a quarter (1.8 million hectares) of the land conversion is expected to take place within the EU, half at the expense of previously abandoned land and the other half of natural vegetation. Almost the same amount of land conversion (1.6 million hectares) is estimated to take place in Southeast Asia.

3.3 BIOPLASTICS

In this section, the market trends of bioplastics (see Box 5 for definitions) are discussed, followed by a summary of studies investigating the projected land requirement of bioplastics and other issues concerning this material, including its design and end-of-life management. For the purpose of this report focusing on land requirements, bioplastics refers to biomass-based plastics only, both biodegradable and non-biodegradable.

BOX 3. WHAT ARE BIOPLASTICS?

Bioplastics are products that stem fully or partly from biomass. Feedstocks can include corn or sugarcane. Depending on the chemical process, bioplastics can be biodegradable or non-biodegradable. As biodegradation does not depend on the material basis, fully bio-based plastics can be non-biodegradable, while fossil-based plastics (used in combination with other bioplastics) can be biodegradable.

In the literature (Elnashar, 2011; European Bioplastics Association, 2015), bioplastics are differentiated into three categories:

- Biodegradable plastics derived from fossil carbon,
- Biodegradable plastics derived from polymers converted from biomass, and
- Non-biodegradable plastics derived from polymers converted from biomass.

Market Trends

The future development of bioplastic markets is significantly affected by strategies of leading companies in that sector, which is in contrast to biofuels consumption, which is to a larger extent driven by policies (see above). Companies such as Samsung Electronics and Toyota plan to intensify their use of bioplastics, while Coca-Cola plans to produce 100% Bio-PET bottles that are primarily made from sugarcane ethanol. Given that around 5.7 tonnes of sugarcane are required to produce one tonne of Bio-PET bottles with a bio-based content of 30%, illustrating the importance of discussing the impact of a rapidly increasing use of bioplastics on land requirements (Morrison and Golden, 2015).

The global production capacity for bioplastics was around 1.5 million tonnes in 2012 and is forecasted to reach almost 8 million tonnes in 2019 (Table 3). Almost 84% of bioplastics in 2019 will be non-biodegradable, meaning that they are not compostable and may need to go through a complex recycling process. Overall, within the next three years, the global production capacity of bioplastics is expected to more than triple, affecting the amount of feedstocks and required land.

370% GROWTH IN GLOBAL BIOPLASTICS PRODUCTION BETWEEN 2014 AND 2019

TABLE 3 | GLOBAL PRODUCTION CAPACITY FORECAST OF BIOPLASTICS BETWEEN 2012 AND 2019, IN MILLION TONNES

BIOPLASTIC	2012	2013	2014	2015	2016	2017	2018	2019
Biodegradable bioplastics	0.57	0.61	0.64	0.76	0.86	1.06	1.13	1.29
Non-biodegradable bioplastics	0.92	1.01	1.03	1.18	1.18	2.55	5.61	6.56
Total Bioplastics	**1.49**	**1.62**	**1.67**	**1.93**	**2.04**	**3.61**	**6.73**	**7.85**

SOURCE: (IFBB, N.D.; NOVA-INSTITUTE, 2015)

In order to understand the trends in the use of bioplastics, the global production capacity of bioplastics by market segment in 2014 and 2019 is illustrated in Table 4. In 2019, almost 6 million tonnes of bioplastics are expected to be used for rigid packaging, by far the fasted-growing and most dominating product group. Rigid packaging includes many single-use, short-lived plastics items such as drinks bottles, cosmetics packaging and some food packaging.

...INCLUDING **644%** GROWTH IN USE FOR RIGID PACKAGING...

Additionally, the capacity of bioplastics production (referring to the processing phase) varies significantly between world regions and is characterised by a shift towards Asia (see Chapter 2 for more information on shifting trends in non-food biomass production and processing). Between 2014 and 2019, Asia´s role as a region for bioplastics production is expected to increase from a share of almost 60% to more than 80%. Consequently, the share of all other regions will likely decrease, such as Europe´s share of production capacity from more than 15% in 2014 to around 5% in 2019 and North America´s from 14% to around 4%. The absolute production levels will increase in all world regions, with the exception of Australia/Oceania (see Table 5).

TABLE 4 | GLOBAL PRODUCTION CAPACITY OF BIOPLASTICS BY PRODUCTS IN 2014 AND 2019, IN MILLION TONNES

YEAR	RIGID PACKAGING	FLEXIBLE PACKAGING	TEXTILES	OTHER CONSUMER GOODS	AGRICULTURE, HORTICULTURE	AUTOMOTIVE, TRANSPORTS	BUILDING, CONSTRUCTION	ELECTRICAL, ELECTRONIC	OTHERS
2014	0.79	0.36	0.19	0.13	0.11	0.09	0.02	0.01	0.01
2019	5.88	0.59	0.56	0.21	0.18	0.38	0.02	0.02	0.01

SOURCE: INSTITUTE FOR BIOPLASTICS AND BIOCOMPOSITES (IFBB), N.D.

TABLE 5 | PRODUCTION CAPACITY OF BIOPLASTICS BY REGIONS IN 2014 AND 2019, IN MILLION TONNES AND PERCENTAGE OF GLOBAL CAPACITY (IN BRACKETS)

YEAR	ASIA	SOUTH AMERICA	EUROPE	NORTH AMERICA	AUSTRALIA/OCEANIA
2014	0.988 (58.1)	0.204 (12.0)	0.261 (15.4)	0.238 (14.0)	0.085 (0.5)
2019	6.327 (80.6)	0.808 (10.3)	0.385 (4.9)	0.322 (4.1)	0.078 (0.1)

SOURCE: INSTITUTE FOR BIOPLASTICS AND BIOCOMPOSITES (IFBB), N.D.

...AND **81%** SHARE OF PRODUCTION CAPACITY IN ASIA IN 2019

Land requirements

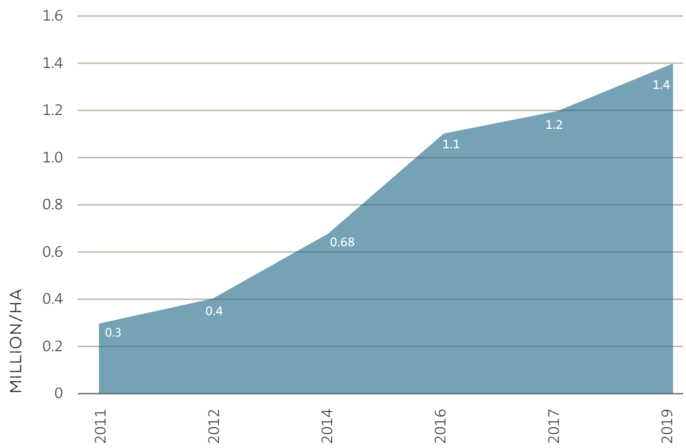
In terms of the land requirement of bioplastics, very few reports have been published so far which investigate future trends (see Table 6), and the furthest into the future any of the three studies look is to 2019. No study takes a consumption-based, or land footprint perspective. A study by the European Bioplastics Association (2016) estimated that the land required for bioplastic use worldwide is about 1.1 million hectares today and is expected to increase to 1.4 million hectares by 2019, which would be equal to 0.02% of available global arable land.

However, facing the currently predicted more than tripling of bioplastics production by 2019, as well as the area of bio-based materials gaining more attention on a political level, further research of its future land requirement and related impacts and impacts is crucial. Analysing potential environmental and social impacts is especially important considering that bioplastics consumed worldwide will mainly be produced in Asia, where related production impacts including land degradation and a loss of natural habitats, reduced water quality, increased levels of pollution and land conflicts can be observed (see Chapter 4 for more details).

The continued increase of land use for bioplastic production is shown in Figure 3.3.

FIGURE 3.3 PROJECTION ON LAND REQUIREMENT FOR WORLDWIDE BIOPLASTIC PRODUCTION BETWEEN 2011 AND 2019

IN MILLION HECTARES



SOURCE: EUROPEAN BIOPLASTICS ASSOCIATION, 2016; INSTITUTE FOR BIOPLASTICS AND BIOCOMPOSITES (IFBB), N.D.; BIOPLASTICS FEEDSTOCK ALLIANCE, 2015.

TABLE 6 OVERVIEW OF AVAILABLE STUDIES ON LAND REQUIREMENTS OF BIOPLASTICS

SOURCE	INVESTIGATED PERIOD	GEOGRAPHICAL FOCUS	SCENARIO-BASED LAND REQUIREMENT
European Bioplastics Association, 2015 and 2016	2011-2016	World	2011: 0.30 Mha 2014: 0.68 Mha 2016: 1.10 Mha 2019: 1.40 Mha
Institute for Bioplastics and Biocomposites (IfBB), n.d.	2012-2016	World	2012: 0.35 Mha 2016: 1.10 Mha
Bioplastics Feedstock Alliance, 2015	2017	World	2012: 0.40 Mha 2017: 1.20 Mha

SOURCE: OWN COMPILATION.

Bioplastics and the Circular Economy

Beyond concerns on the land requirements and production impacts of bioplastics, another crucial aspect is that of their design and end-of-life management. Bioplastics could potentially have a positive role to play in the transition to a true circular economy, which prioritises consuming within the limits of the planet, ethical and local sourcing, resource efficiency, waste prevention, reuse and recycling. However, there are concerns by some stakeholders and civil society that a shift to bioplastics is merely a shift in the business model of the plastic industry – there is no evidence that bioplastics solve the problems currently caused by plastic pollution and our "throwaway" society.

A part of the problem relates to how bioplastics are designed – they can potentially be recyclable, biodegradable, compostable, or none of the above. This is an issue when it comes to consumer awareness and end-of-life management. Many bioplastics are not recyclable or are complex to recycle due to their material properties, but often still enter the current plastic recycling process, causing distortion of collection and recycling processes – concern about this has been expressed by many plastic converters.[1] Furthermore, there are issues with bioplastics which are biodegradable or compostable – current EU and international standards mean these bioplastics are only possible to biodegrade or be composed under very specific conditions (high temperature and humidity) in industrial composting installations (ISO 14852:2004; EN 13432:2000). Finally, current low recycling (only 26% for plastics (PlasticsEurope et al., 2013)) and compost rates in Europe increase the likelihood of bioplastics' deposition in landfills resulting in the release of methane (when degraded without oxygen).

Without implementing more ambitious measures to change the way we produce and consume (in particular a reduction in single-use plastics), and ambitious policy targets on prevention, reuse and recycling and strict standards for the design of bioplastics, the current practices of waste management of bioplastics will likely persist.

FOOTNOTE:

1 'EuPC calls on legislator to support separate collection of degradable plastic materials and ban oxo fragmentable plastics', EuPC, September 2013

4. ENVIRONMENTAL AND SOCIAL IMPACTS OF THE EU NON-FOOD BIOECONOMY

KEY MESSAGES IN CHAPTER 4

- Research shows that potential positive impacts of the bioeconomy, for example reduced fossil fuel dependency, need to be assessed in relation to the potential increase in negative social and environmental impacts accompanying the use of land and biomass in the global land system.
- Although the empirical base in this report is small, the underlying analysis shows that, without a robust assessment tool and participative processes, responsibility for, and agreement on, such trade-off effects with respect to vulnerable actors and ecosystems in the countries of origin currently cannot be sufficiently taken and safeguarded by the actors in the EU bioeconomy
- In terms of most severe impacts, it can be concluded that the EU's biodiesel land footprint has detrimental impacts on the global environment. This report shows evidence of the large scale of embodied land areas for EU consumption of biodiesel, as well as the concentration of production of feedstock for biodiesel in tropical and subtropical regions, mainly in Southeast Asia.
- The most frequently reported negative social impact related to the EU bioeconomy is the impact on vulnerable socio-demographic groups in developing countries, i.e. mainly subsistence farmers and women in countries with unclear land access rights.
- The most frequently reported negative environmental impact in the case studies is the degradation of water quality as a result of nutrient pollution, followed by water scarcities and climate change.
- Bioplastics are a small but emerging activity in the bioeconomy, not only in the EU but also in supplying countries (Thailand, China, and the USA). Social and environmental impacts mainly relate to the strong tendency towards a monoculture of sugar cane and starch crops, which are generally associated with relatively high application levels of fertiliser and pesticides, as well as with erosion-prone land management.

4.1 NEED FOR A HOLISTIC IMPACT ASSESSMENT OF THE EXPANDING BIOECONOMY

There are diverging visions on the potential development of the bioeconomy. The most optimistic vision is a green, knowledge-based industry revolution driven by technological advances in the life sciences (Oborne, 2010; OECD, 2009). At the other end of the spectrum are the critical visions from the political ecology perspective on hegemonic structures with severe social impacts on food security, environmental justice and other human needs (Robbins, 2011). Somewhere in between is the socio-technical paradigm where humanity aims at sustaining a certain level of economic growth while reducing environmental and social impacts by enhanced system knowledge, resource efficiency and effective policies and legislation. All perspectives, however, need to be aware of the risks and potential impacts related to the limited but unknown carrying capacity of natural ecosystems and the need for a holistic assessment of the impacts related to a societal transformation towards a more bio-based economy (McCormick and Kautto, 2013).

Assessing positive and negative economic and ecological impacts with a systems perspective

Transforming the economy towards bio-based pathways primarily aims at mitigating greenhouse gas emissions by the replacement of fossil fuel-based products with bio-based products. However at the same time, **researchers and practitioners around the world are increasingly pointing at the negative environmental and social impacts that are occurring as a result of this substitution, particularly in terms of land use and related impacts** (Hasenheit et al., 2016). Impacts related to the EU bioeconomy are, in principle, not very different from those associated with agriculture. However, feedstock for the bioeconomy, such as rapeseed, soy and palm oil for biodiesel; maize and sugar cane for ethanol; and cotton for clothing or sugar and maize crops for bioplastics, are generally produced in monocultures on large-scale farms which are increasingly located in tropical and sub-tropical regions (Smolker, 2008).

Important for the assessment of potential impacts is the reference context to which the new state is compared: when impacts of the bioeconomy are compared with undisturbed ecosystems in the natural environment, there will be negative impacts. But when impacts are compared with activities or products in the fossil-based economy, the net-impact may be positive. Important in such assessments is that the complexity of the system changes need to be taken into account and true impacts to be approximated with proven scientific methods. Up till now, specific impacts are only taken into account in a limited number of case studies, and **a consistent systems perspective on positive and negative economic and ecological impacts related to the bioeconomy is generally lacking, both in scientific literature and in practice**. In part, this is related to the lack of robust databases and methods, both on ecological, economic and social aspects of the bioeconomy (SAT-BBE, 2013). Meaningful comparisons are further complicated as absolute impacts in the bioeconomy differ with local environmental conditions of agricultural production and are thus hard to aggregate, for example, at the level of the global bioplastics industry.

As a result of the complexities in assessing impacts, full assessments of positive and negative impacts associated with activities and products in the bioeconomy are beyond the scope of this report. Nevertheless, this chapter will zoom in on a number of reported[2] impacts associated with land use and land management in the several key countries producing biomass for the EU bioeconomy. The purpose of the analysis is then to identify general 'impact' patterns and to raise awareness on potential negative environmental and social impacts in the context of further expansion of the EU bioeconomy in a global context. This is particularly relevant as approximately 65% of the EU's non-food cropland footprint lies outside the EU (see chapter 2) and, hence, makes it urgent to assess the EU bioeconomy from the perspective of global environmental and social justice (Martinez-Alier et al., 2016; Robbins, 2011).

4.2 POTENTIAL ENVIRONMENTAL IMPACTS OF THE EU BIOECONOMY

The current scale of production of food and non-food biomass has large and deep impacts on our environment. As a result, a transition towards a stronger bio-based foundation of the EU economy needs to take into account potential negative environmental and social impacts and the related risks for societies at the local and global level. The United Nations Environment Programme (UNEP) (Bringezu et al., 2014) identifies six key impact areas in relation to biomass production and land use: (1) Deforestation, (2) Soil degradation, (3) Water scarcity and water pollution, (4) Biodiversity loss, (5) Climate change and (6) Social impacts.

For some impact categories, notably biodiversity loss, nitrogen pollution (water pollution) and global warming, it has been suggested that humanity is approaching critical levels of disturbance and pollution at the global scale (Steffen et al., 2015). However, as these 'planetary boundaries' are approached by all human economic activities together, it is practically impossible to carve out the specific pressure and impacts of the EU bioeconomy on these critical issues. By examining the six key impact areas, we aim at showing typical patterns of impacts that are most likely associated with land use in an expanding bioeconomy.

Deforestation: deforestation for the use of land to produce biomass is widespread and is linked with impacts such as losses of long-term carbon stocks, biodiversity, water filtering and storage capacities and leads to a broad range of social impacts for people dependent on forests for their livelihoods. The EU was the largest importing region of deforestation embodied in crop and livestock products over the period 1990-2008, with 36% of the worldwide total. In terms of crops, the largest areas of deforestation were embodied in oil seeds from Brazil, Argentina, Paraguay, Malaysia, and Indonesia, largely related to the food part of the bioeconomy, but increasingly replaced by non-food products (Prieler et al., 2013). Forested areas are highly affected by the trend towards large scale land investments, including profit-oriented land grabs for food and non-food purposes. Between 2000 and 2010, about 24% of these global land investment were located in forested areas - representing 31% of the total surface of land acquisitions between 2000 and 2010 (Anseeuw et al., 2012). As will be shown in the next sections, deforestation is the key pressure mechanism of a variety of environmental impacts.

Soil degradation: Soil degradation related to the bioeconomy involves the reduction in soil organic matter as a result of soil compaction, water and wind erosion, salinization (from irrigation) and from permanent soil losses when land is converted into built up areas related to the bioeconomy (Hasenheit et al., 2016). Soil degradation tends to occur as a result of land management or land use activities that are not adjusted to local soil and/or climate conditions. As farm operations producing biomass for the bioeconomy are generally large scale and tend to apply standardised land management techniques, vulnerable soil conditions tend to be overlooked and land degradation is reported to occur after a limited number of harvests, especially in regions with lower quality soils (Kilasara, 2014).

Water scarcity and water pollution: water scarcity is an emerging issue at local or regional scales in many countries, largely because of the overuse of watersheds in agricultural concentration areas (Lutter et al., 2016; Williams, 2012) and because land and water are often subject to different regulatory systems and different governmental responsibilities. Mekonnen and Hoekstra (2011) show that oilcrops and fibre crops have the largest water footprint per unit of production, and that soybeans (biodiesel) and sorghum (bioethanol) have the highest water footprint per unit of (bio)energy. Palm fruit and sugar cane show to have the lowest water footprint per unit of energy output but, in the case of palm fruit, its high yields require large amounts of water per hectare. Water pollution for the production of biomass is largely related to crops that require relatively high fertiliser and pesticides applications in monocultures, in particular cotton (textiles), and sugar cane and starch crops (bioenergy, bioplastics) (Hasenheit et al., 2016).

FOOTNOTE:

2 Reported in published case studies, country reports and expert presentations.

Biodiversity loss: Several studies support the link between consumers in developed countries and biodiversity threats in exporting countries such as Brazil (e.g. soy), Indonesia and Malaysia (palm oil) (Lenzen et al., 2012). As the EU bioeconomy imports considerable volumes of high-yielding crops from tropical regions in Southeast Asia, South America and Africa, it is co-responsible for moving the agricultural frontier further into pristine natural areas. Land use change from tropical forests into cropland results in significant impacts on, and deterioration of, biodiversity hotspots (Myers, 2003; Myers et al., 2000). Half of the six million hectares of global forest loss between 2000 and 2012 has been associated with palm oil expansion in Southeast Asia, which contains four of the world's distinct biodiversity hotspots. (IUCN, 2016) confirms the link between the expansion of palm oil plantations and severe risks of biodiversity loss, by for example, urging them to move the Bornean Orangutan from Endangered to Critically Endangered – the highest risk category assigned by the IUCN Red List.

Climate change: The footprint perspective shows that the EU bioeconomy is likely to be a considerable driver of land-related greenhouse gas emissions at the global level (Noleppa and Cartsburg, 2016). As with biodiversity loss, deforestation is the main driver of losses in ecosystem-related carbon stocks (Oertel et al., 2016). One of the reasons for this is that embodied land imports from the southern hemisphere into the EU may significantly contribute to climate change as due to higher bacterial activity in warmer climate zones, soil respiration is higher than in cooler regions. Thus, the expansion of palm oil plantations after logging and burning of forests in tropical Asia is a particular driver of land-related greenhouse gas emissions.

It should be noted that biomass and biofuel, both imported into the EU and domestically produced, from supply chains that are certified to be deforestation-free may still lead to greenhouse gas emissions as a result of indirect land use changes (ILUC). ILUC means that previous land users of the cropland, which is now being appropriated by certified land users, leads to further conversions of previously uncultivated territory. A recent study (Ecofys et al., 2015) shows that, when the EU increases its biofuels consumption in a situation where all other land use activities remain constant, large ILUC and related greenhouse gas emissions would occur – the greenhouse gas emissions are particularly significant when this happens at the expense of drainage of peatland in Southeast Asia for palm oil.

Exact calculations of both direct and indirect land use change and related greenhouse gas emissions are complicated by the lack of global databases of land use changes, of clear standards to calculate and allocate such greenhouse gas emissions to land users and the general knowledge gap concerning the complexity of local drivers of land-related emissions (Goh et al., 2016).

Social impacts: significant, sometimes severe, social impacts are being reported in relation to non-food biomass consumption in the EU, especially in the poorest countries in the Global South. The emergence of the bioeconomy in developed markets – with its link to fossil oil markets – has resulted in more volatile prices of commodity crops on local and world markets (Spratt, 2013). Furthermore, the bioeconomy is known to attract land investors in developing countries, in search of profitable returns or feedstock from cheap land resources (Arezki et al., 2015). The frequency with which social impacts are reported in relation to the bioeconomy seems to correlate with the number of land investments in the concerned developing countries (Arezki et al., 2015; De Schutter, 2011). Investors are mainly from China, India, Korea, Egypt, the Gulf States and Brazil, as well as OECD countries - mainly EU Member States and the US (Kay et al., 2015).

Following the substantial role of biofuels in the food price spike in 2007, the unclear role of speculative transactions in the financial markets as well as the increase in land deals in developing countries, it has been stressed that biofuels and biomaterials should not compete with food security (Afiff et al., 2013; Spratt, 2013; UNEP, 2016). In practice, however, no bi- or multilateral agreements exist as to when and where land is not available to use for non-food purposes. As a result, vulnerable socio-demographic groups continue to be deprived of their right to use agricultural land for their livelihoods or to be confronted with increasing food prices as a result of the commodification of land, crops and labour (De Schutter, 2011). A World Bank report confirms the correlation between high levels of land investment intentions and 'weak land governance and protection of local land rights' (Arezki et al., 2015). Furthermore, the European Economic and Social Committee (Kay et al., 2015) sees a serious risk arising from the concentration of land in the hands of large non-agricultural investors and agricultural firms and assesses food safety and soil degradation to be at risk in the poorest countries in the Global South; concerns which are also shared by the FAO and the UNEP. Finally, a potential increase in the gender gap is anticipated in the Global South with further advancement of the industrial bioeconomy, as a lack of formal land tenure and involvement in decision making processes is likely to exclude rural women (Global Forest Coalition 2013 in: (Hasenheit et al., 2016)).

4.3 IMPACT ANALYSIS IN THE COUNTRIES SUPPLYING THE EU BIOECONOMY

In this section, we will focus on a number of supplying countries and highlight impacts from selected (embodied) biomass flows to the EU. These are palm oil (biofuels) from Indonesia, sugar cane and cassava (bioplastics) from Thailand, jatropha (biofuels) from Tanzania and rapeseed (biofuels) from the EU. Furthermore, in Annex 3, the review is complemented with reported environmental and social impacts in other key regions supplying biomass or final products to the EU bioeconomy, including 'traditional' bioeconomy products such as textile products, rubber and leather which embody the majority of the non-food cropland footprint.

The reported social and environmental impacts are collected from scientific (modelling) analyses, empirical quantitative research and individual case studies in the Web of Science. The reported impacts do not provide a complete overview, nor do they give an accurate picture of the situation in the countries where land related to the EU bioeconomy is being used. But by systematically including reported impacts related to a variety of bioeconomy activities in different supplying countries, a more aggregated picture of the type and frequency of (potential) social and environmental impacts related to the (potential expansion of the) EU bioeconomy can be given in the conclusions section.

4.4 SELECTED BIOMASS FLOWS AND POTENTIAL COUNTRY/REGIONAL IMPACTS RELATED TO THE EU BIOECONOMY

Table 7 shows the main supplying countries/regions in terms of appropriated land areas by the EU bioeconomy (hence, from a footprint or consumption perspective). In line with the findings in chapter 2, it shows the importance of vegetable oils for EU biodiesel as it is supplied by nearly all regions except the USA – and, hence, is likely to be most adversely associated with negative social and environmental impacts of the EU bioeconomy. Rubber and fibre crops also take an important share in the non-food bioeconomy.

TABLE 7 SUPPLYING COUNTRIES/REGIONS OF PRIMARY BIOMASS PRODUCTION (EXCLUDING ANIMAL PRODUCTS) TO THE EU BIOECONOMY

COUNTRY/REGION	FEEDSTOCK FOR THE EU BIOECONOMY	CROPLAND FOOTPRINT EU (1,000 HA)
China	Vegetable oils (mainly rapeseed), sugar & starch crops (mainly maize), fibre crops (mainly cotton)	2,496
Indonesia	Vegetable oils (biodiesel), rubber	2,015
Rest of Asia	Vegetable oils (biodiesel), fibre crops (cotton), rubber, alcohol	4,576
USA	Maize (bioethanol), fibre crops (cotton), vegetable oil (biodiesel)	1,832
Africa	Vegetable oils (biodiesel), Fibre crops (cotton),	1,562
EU	Rapeseed oil	6,990

SOURCE: OWN COMPILATION.

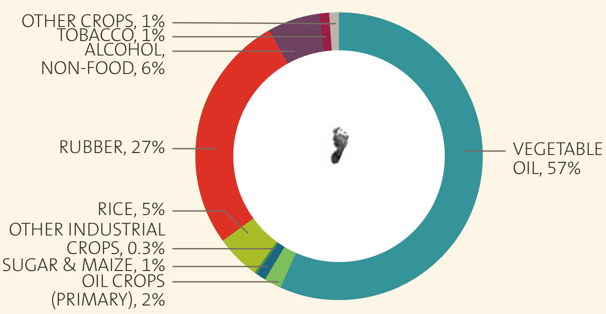
The country footprints as illustrated in the following country examples are based on own calculations using the economy-environmental database EXIOBASE (Tukker et al., 2013; Wood et al., 2015).

CASE STUDY 1. PALM OIL FROM INDONESIA

Indonesia is the world's largest palm oil producer and the EU's main supplier of palm oil and biodiesel. Figure 4.1 shows the commodity composition in the non-food bioeconomy footprint of the EU in Indonesia. It can be seen that vegetable oils account for the largest cropland areas appropriated by the EU in Indonesia. Other products mainly involve rubber, but also e.g. rice by-products for fertiliser or biofuel (Samuel, 2013). Although not further pursued for the purpose of this report, it is not likely that these products are directly exported to the EU, but rather embodied in final products consumed by the EU.

In 2011, Indonesia supplied 39% of biodiesel imports into the EU, making the EU the single largest 'customer' of the country's biodiesel (Fernz, 2012; Pichler, 2014). Biodiesel production in Indonesia is largely based on palm oil. Guided by a national expansion strategy, local governments in Indonesia continue to appropriate pristine rain forest for the conversion towards commercial palm oil and, to a lesser extent, rubber tree plantations. These plantations are mainly located on Sumatra and Kalimantan, but also on less developed Islands such as Papua, which is home to one of the world's largest rainforest areas (Pichler, 2014).

FIGURE 4.1 SHARE OF CROPLAND (%) IN THE NON-FOOD EU BIOECONOMY FOOTPRINT IN INDONESIA



SOURCE: OWN CALCULATIONS.

As a result, tropical forests in Indonesia are being destroyed at a faster pace than in other regions (Petrenko et al., 2016), posing a serious concern about the role of the state and other stakeholders, including the EU bioeconomy, in the appropriation of nature (Pichler, 2014).

In terms of other environmental impacts, palm oil is a crop that requires large amounts of fertilisers and nutrients and, together with its open canopy structure, contributes significantly to greenhouse gas emissions as a result of carbon losses from the (warmer) soil. Business-as-usual palm oil expansion, which increasingly replaces tropical forests with monoculture crop systems, depletes biodiversity, destroys old growth rainforest, and causes air pollution relating to slash and burn practices. Furthermore, much of the rainforest in Indonesia grows on carbon-rich peatland, the destruction of which adversely affects both biodiversity and the climate (Petrenko et al., 2016).

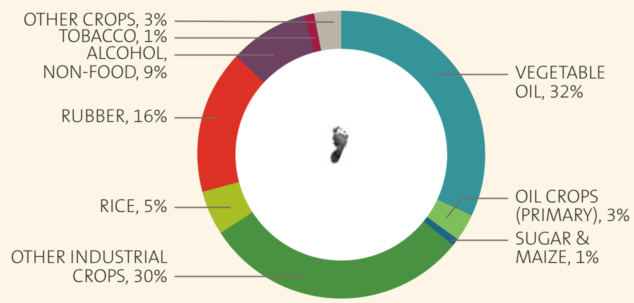
In relation to social impacts traditional land users experience land losses and restrictions on their land use rights in relation to the expanding palm oil sector (a.o. Pichler, 2014). Native customary rights are often ignored when plantations are established, leading to conflicts between indigenous peoples and palm oil companies and to serious human rights abuses. Over 700 ongoing land conflicts have been identified by the Indonesian NGO Sawit Watch, highlighting how the oil palm industry is able to take advantage of weak land tenure laws to displace indigenous communities, often separating them from the land they depend on for survival (FoEE, 2016).

Land use change and related impacts (including greenhouse gas emissions and biodiversity loss) from increasing biofuel consumption in the EU are linked to growing demand and investments by international supply chains and should therefore be allocated to the final consuming regions, in this case the EU. Research shows that reductions in greenhouse gas emissions as a result of fossil fuel substitution by bioenergy, in particular biodiesel, are largely compensated by increasing land-related emissions from the conversion of forest into palm oil plantations (Ecofys et al., 2015). It is clear that business-as-usual expansion of the Indonesian palm oil industry will come at a great environmental and social cost, which runs counter to international policy agreements such as such as the UN global sustainability goals (United Nations, 2015).

CASE STUDY 2. SUGAR CANE AND CASSAVA FROM THAILAND

On the basis of sugar cane and cassava, Thailand's bioeconomy strategy centres around bioethanol production and it has an ambition to become one of the world's primary bioplastics hubs (Chemanager, 2013; Theinsathid et al., 2011). Furthermore, sugar cane is becoming an increasingly important material for the fermentation industry to yield green chemicals, which also serve as components for bio-plastics production. Finally, the production of bio-based polymers from sugar cane promotes the use of green energy as the cellulosic leftover from sugarcane extraction is burnt to yield steam to run sugar mills (Groot and Borén, 2010). As a result, Thai sugar cane and cassava have become cost competitive sources for first generation bioplastics, and are starting to attract European investments in bioplastics production capacity (Corbion web communication, 2016). With respect to the environment, Thailand's bioeconomy strategy has fuelled expansion and intensification of agricultural production. This expansion, which has relied extensively on land use change of diverse natural resources into large-scale monocultures of sugar cane, among other commodity crops, associated with land degradation and a loss of natural habitats, reduced water quality and increased levels of pollution. Increasingly, land use change involves the conversion of more fragile soils. In terms of social impacts, local smallholders in agriculture are reported to not have been lifted out of poverty as economic growth has largely benefited actors in international activities and trade (Salvatore and Damen, 2010).

FIGURE 4.2 SHARE OF CROPLAND (%) IN THE NON-FOOD EU BIOECONOMY FOOTPRINT IN ASIA*



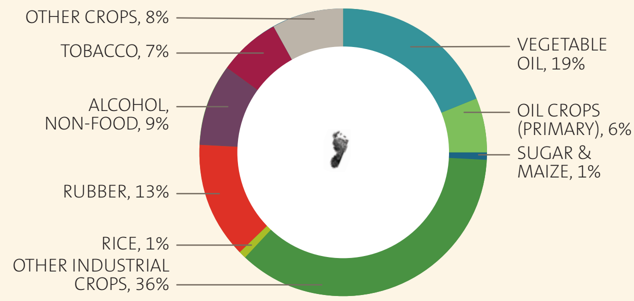
SOURCE: OWN CALCULATIONS.
*: EXCLUDING CHINA AND INDONESIA.

CASE STUDY 3. JATROPHA FROM TANZANIA

In Africa, jatropha, cotton and rubber are the main crops contributing to the EU non-food bioeconomy land footprint. Negative social and environmental impacts are mostly associated with land grabs by foreign investors, including investors and operators from the EU. Reported land deals in the Land Matrix[3] show that an equivalent of nearly 5% of Africa's agricultural area has been acquired for non-food purposes between 2000 and 2010. Foreign land investments mostly involve medium to high quality cropland in a limited number of countries that are poorly integrated into the world economy and have a high incidence of hunger and weak land institutions (Anseeuw et al., 2012).

In Tanzania, jatropha is increasingly grown in plantations for the supply of biodiesel and contributes to the EU bioeconomy land footprint in Africa. Jatropha, a fast growing, woody perennial, has been promoted on claims regarding its ability to grow on degraded land without irrigation or fertilisation (Arora et al. 2013). As a result, Tanzania has become a major target country for large scale land acquisitions by EU and other foreign investors in jatropha plantations (Anseeuw et al., 2012). Such land grabs by private operators are promoted as win-win situations for local populations and investors (Exner et al., 2015). However, these practices leave the state, or poor communities, with vulnerable ecosystems or degraded land, which is structurally limited in yields and, hence, makes land use a struggle of the poor over access to land (Arora et al., 2013; Exner et al., 2015).

FIGURE 4.3 SHARE OF CROPLAND (%) IN THE NON-FOOD EU BIOECONOMY FOOTPRINT IN AFRICA



SOURCE: OWN CALCULATIONS.

JATROPHA FROM TANZANIA CONTINUED...

Method Kilasara (2014), a Soil Professor at the Sokoine University of Agriculture, argues that environmental and social problems in Tanzania are mainly related to the fact that Tanzania has a small area of high quality soils and a vast area of medium and low quality soils. As the high-quality land is occupied, new investments focus on the medium quality lands. These soils are among the oldest soils in the world and are highly compacted; there is a need for innovative, mostly organic techniques to revive and 'air' the soil.

Most importantly, these soils need a tailor-made approach by specialists as individual land plots are host to a variety of soil problems. Contractors manage large-scale bioenergy investments with standardised land management approaches resulting in declining yields over time, until the project does not generate sufficient returns on the investment and is halted by the investor. Another case study on Jatropha oil plantations in Tanzania (Segerstedt and Bobert, 2013) confirms that high yields are only possible on the limited area of high quality soils.

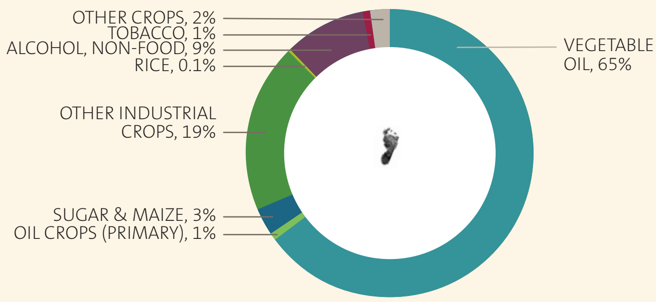
CASE STUDY 4. RAPESSEED FROM THE EU

As the final example, we illustrate the composition of the non-food bioeconomy footprint related to the production of different crops within the EU itself.

The main feedstock in the EU bioeconomy is rapeseed for biodiesel. France and Germany are the largest producers and nearly all central and eastern European Member States are growing suppliers (Carré and Pouzet, 2014). (Milazzo et al., 2013) looked at the use of rapeseed for the supply of biodiesel in comparison to petro-diesel. With respect to its environmental performance, the authors find rapeseed to significantly reduce (up to 65%) greenhouse gas emissions when compared to petro-diesel. However, this is excluding emissions for land use change, which are modelled to be significant and may cancel out potential greenhouse gas savings of biofuels (Ecofys at al., 2015). Furthermore, due to its low energy return, the production capacity is limited by land area constraints. In small quantities, rapeseed proved beneficial for energy conservation, but at higher levels, the crop becomes detrimental in terms of acidification, nitrification of soils and surface water and ozone depletion. Finally, depending on the location, rapeseed significantly contributed to eutrophication and energy balances where unfavourable when compared to perennial crops (Milazzo et al., 2013).

High yielding crops such as sugar and potato starch crops prove to have less detrimental impacts when compared to imported palm fruit (Ecofys et al., 2015), in particular when used as biomaterials (Carus and Dammer, 2013). Shifting to domestic feedstock in the EU bioeconomy could therefore be regarded a potential pathway to reduce social and environmental impacts of the bioeconomy in tropical and subtropical regions, provided EU consumption patterns change in order to set domestic cropland areas free for such purposes, a trend which is already visible but currently leading to increasing abandoned land (Terres et al., 2015).

FIGURE 4.4 SHARE OF CROPLAND (%) IN THE NON-FOOD EU BIOECONOMY FOOTPRINT IN THE EU



SOURCE: OWN CALCULATIONS.

4.5 CONCLUSIONS FROM CHAPTER 4

Social and environmental impacts related to activities in the bioeconomy clearly differ between countries and projects within them. However, some overarching patterns have emerged from the review of case studies, modelling studies and reports (some of which are detailed above) involving land use and biomass production in different countries supplying the EU bioeconomy.

Table 8 shows an indicative summary of the impact categories per country as reported in the various available case studies. The countries in Southeast Asia report to be most affected by negative social and environmental impacts. All other countries show to be moderately affected and the EU the least. Note that the aggregated impact assessment refers to what was found in the selected case studies, and do not mean that certain negative or positive impacts are entirely absent from a country/region if not highlighted in that case study.

Social impacts are reported in all countries supplying the EU, except for the US and the EU itself. This can be regarded as a clear indicator of weak land tenure and a poor representation of vulnerable socio-demographic population groups in developing countries. Social and environmental inequalities in relation to the expanding bioeconomy have been associated with both direct and indirect land use change effects as a result of expanding EU supply chains under certification schemes.

Negative social impacts can also be linked to large-scale land investments, or land grabs, by actors in the non-food bioeconomy, often by non-agricultural investors interested in short-term profits and, increasingly, by non-western states. These structures have been reported in relation to EU biomass demand for biofuels and bioplastics (GSI, 2008; Van Teeffelen, 2013). The risks for exclusion or deprivation of vulnerable population groups is high. Food security, the most critically impact category of all, is explicitly reported in China although nearly all reviewed case studies in countries reporting on issues with land tenure (and with large groups of poor people), make reference to competition with land areas for food.

In terms of environmental impact categories, water and soil pollution is the most frequently reports negative impact, which relates to the relatively high fertiliser and pesticides use in crops such as palm fruit, cotton, sugar cane and maize. Another important negative environmental impact is water scarcities, related to the water footprint of high yielding crops in subtropical and temperate climate regions.

At the product level, EU biodiesel proves to be most detrimental because imported palm oil and, to a lesser extent, soybeans embody considerable impacts in terms of deforestation, biodiversity loss, water scarcities and climate change as a result of peatland conversions in tropical regions – all negative impacts that need to be taken into account when valuing the overall impacts related to EU consumption of these products. Also for bioethanol, US-based research shows that the net positive effect on climate change tends to be marginal or even neutral when production, transportation and land use change emissions are taken into account, resulting in negative trade-offs when adverse impacts on water and quality and availability occur.

Biomass production for bioplastics, chemicals and other bio-based applications are, due to their limited scale, less directly associated with adverse environmental impacts. However, related to the generally large scale of operations, both in primary production and in further processing, there is a clear risk of increasing social and environmental impacts on vulnerable socio-demographic in countries and regions with less formal or understood land tenure systems in the Global South.

To conclude, this analysis indicates that the EU non-food bioeconomy and society is associated with significant social and environmental impacts in other countries, largely as a result of demand for cost-competitive feedstocks from tropical or sub-tropical regions. In those regions, governance frameworks often are less effective than in the EU, thus leading to more severe impacts than for a similar type and scale of development in the EU. When indirect land use changes are also taken into account, it can be concluded that development of the EU bioeconomy requires changes in land intensive consumption patterns. **To be able to assess the role of the EU bioeconomy towards low carbon pathways while safeguarding social and environmental justice at the global level, effective measuring and allocation frameworks are urgently needed and to be implemented at the global level.**

TABLE 8 | SUMMARY OF REPORTED NEGATIVE ENVIRONMENTAL AND SOCIAL IMPACTS RELATED TO ACTIVITIES IN THE BIOECONOMY (● = REPORTED)

IMPACT	CHINA	INDONESIA	MALAYSIA	THAILAND	TANZANIA	ETHIOPIA	USA	EU	#
Deforestation		●	●			●			3
Biodiversity loss		●	●	●					3
Water scarcity	●	●	●	●		●	●		6
Water/soil pollution	●	●	●	●		●	●	●	7
Soil degradation			●	●	●				3
Climate change	●	●	●	●			●		5
Social impacts	●	●	●	●	●	●			6
Food security	●								1

SOURCE: OWN COMPILATION BASED ON LITERATURE RESEARCH (THIS CHAPTER AND ANNEX 3).

5. CONCLUSIONS

This report assessed the global land demand for non-food products related to the European bioeconomy. It analysed the historical development in the past 20 years as well as expected future trajectories in two sectors, and evaluated potential social and environmental impacts resulting from bioeconomy developments.

The assessment highlighted the growing importance of non-food products, being the fastest growing demander of agricultural land on the globe. Europe plays a crucial role in determining global developments, being the biggest consumer region of non-food products in terms of its related land use, but only the fifth largest producer. Thus, a high dependence of the expanding European bioeconomy on agricultural areas in other world regions, most notably in Asia, can be observed.

For the assessment of future trends, a particular focus was set on two commodities: biofuels and bioplastics. It is seen that various biofuel policies, such as the current (at the time of writing of this report) Renewable Energy Directive´s target of a maximum 7% limit on first generation biofuels in the transport sector by 2020, provide an incentive to expand global and EU production and use of biodiesel and bioethanol. Related global land requirements to satisfy increasing demand are expected to grow rapidly in the coming 20 years. Land requirements related to bioplastics production are around a factor of 100 smaller compared to those from biofuel production. However, with growth in production expected to more than triple between now and 2019, the land area required for global bioplastics production is expected to reach 1.4 Mha before 2020. Furthermore, bioplastics are becoming a concern for waste prevention and end-of-life management, with issues related to recyclability, biodegradability and compostability.

The growing amount of land and biomass consumed by the EU bioeconomy adds to the already high land demand for food supply and indicates a growing pressure on planetary boundaries and issues related to global justice when it comes to a fair distribution of biophysical resources. In this report, an explorative review of existing studies has been carried out to analyse the environmental and social impacts related to an expanding EU bioeconomy. These impacts include, for example, increased water scarcity and nutrient pollution, but also potential negative climate impacts, in particular due to deforestation in tropical regions, driven by a growing demand for raw materials for the bioeconomy. Social impacts may arise due to the dislocation of vulnerable socio-demographic groups in developing countries, such as subsistence farmers with unclear land access rights and the commodification of land and food crops.

5.1 RESEARCH RECOMMENDATIONS

Given the far-reaching global implications of an expanding European bioeconomy, **robust methods and indicators need to be developed and applied, in order to properly assess Europe's resource use as well as the related environmental and social impacts from a consumption (or footprint)** perspective. The quantitative results presented in this report are based on the latest advancements in footprint modelling to assess the land demand of non-food products. However, there is still significant room and need to expand the methodology in terms of including other commodities of key importance (e.g. timber and forest areas) as well as updating the calculations for the most recent years. Furthermore, methodologies to estimate the environmental and social impacts related to the European consumption of non-food bio-based products in regions all over the world are almost entirely missing. In order to take into account the regional differences in environmental and social conditions within producing countries, footprint methods need to move from the aggregated national to detailed regional or even local levels. Significant investment into research is therefore required to develop appropriate methods for analysing the potential environmental and social impacts of current policy and industry strategies related to the expansion of Europe's bioeconomy.

Deforestation due to the cultivation of soy used for biofuels in Brazil, near the Xingu park.
© Jan Gilhuis

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NATURAL RESOURCES FORM THE BASIS FOR ALL HUMAN ACTIVITIES. IN ORDER TO PROVIDE GOODS AND SERVICES, OUR ECONOMIES AND LIFESTYLES, REGARDLESS OF CONSUMPTION LEVELS, ARE DEPENDENT ON A CONSTANT INPUT OF NATURAL RESOURCES. THESE RESOURCES COMPRISE RAW MATERIALS, ENERGY AND WATER – AND LAND. A BIOECONOMY CAN BE GENERALLY DEFINED AS 'AN ECONOMY WHERE THE BASIC BUILDING BLOCKS FOR MATERIALS, CHEMICALS AND ENERGY ARE DERIVED FROM BIOMASS-BASED RESOURCES, SUCH AS PLANT AND ANIMAL SOURCES' (MCCORMICK AND KAUTTO, 2013). A RAPIDLY GROWING SHARE OF GLOBAL AGRICULTURAL AREAS IS DEVOTED TO THE PRODUCTION OF BIOMASS FOR NON-FOOD PURPOSES. THESE PRODUCTS INCLUDE, FOR EXAMPLE, OIL CROPS FOR THE PRODUCTION OF BIOFUELS, FIBRE CROPS FOR TEXTILE PRODUCTION AND CEREALS FOR BIOFUELS AND BIOPLASTICS.

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