

Europe's expanding non-food bioeconomy is heavily dependent on foreign land areas

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A rapidly growing share of global agricultural areas is devoted to the production of biomass for non-food purposes. The EU plays a major role as a processing and consuming region of cropland-based non-food products while at the same time relying heavily on imports. Two thirds of the cropland required to satisfy the EU's non-food biomass consumption are located in other world regions, giving rise to potential impacts on distant ecosystems. If the EU Bioeconomy Strategy is to support global sustainable development, a detailed monitoring of land use displacement and spillover effects is decisive for targeted and effective EU policy making.

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Over the past 15 years, many governments and international organizations have developed strategies and initiatives to foster an economy that increasingly uses bio-based materials, chemicals, and renewable energy sources. These efforts are driven by the need to reduce greenhouse gas emissions and fossil fuel dependence, with the expectation that a bio-based economic transformation will contribute to economic development and employment both in urban and rural regions.

The European Union (EU) is particularly active in promoting bio-based transformations and seeks to respond to global social-environmental challenges through its Bioeconomy Strategy. The bio-



economy has been envisioned as an important component for smart and green growth while simultaneously achieving the EU's climate and other environmental targets and the 2030 Agenda. But the sustainability of the EU's expanding bioeconomy has also been questioned. Evidence is rising that an expanding industrial bioeconomy, for example, causes direct and indirect land use change, thereby generating greenhouse gas emissions, and has implications for water quality and quantity. Imports of feedstock for the EU bioeconomy can thus have negative consequences for ecosystems in distant places.

Global land footprint assessments for non-food products

The importance of footprinting approaches has been widely acknowledged in national and regional sustainability assessments to account for possible land use displacement and leakage effects [1]. Research so far focused on the land footprint of food consumption and of different dietary patterns or the overall land footprint of countries without distinguishing food from non-food uses. With our recently published article, we fill this research gap for the European Union by analysing its role in the global non-food bioeconomy. Our study implements a hybrid top-down accounting approach to track the demand for cropland embodied in biomass flows along global supply chains by linking the biophysical LANDFLOW model (Tramberend et al., 2019) with the multi-regional input-output (MRIO) model EXIOBASE 3 [2].

Compared to other models, the product detail of the results is significantly increased, while ensuring the comprehensive coverage of all economic activities worldwide. A particular strength of the LANDFLOW model is that it specifies non-food uses of each agricultural product, which was a prerequisite for this study. By linking EXIOBASE to a biophysical accounting model, non-food flows can be traced to the final consumer, instead of being truncated and allocated to those countries, where the industrial processing takes place.

To grant full access and foster transparency, all data, R scripts, and supplementary files to reproduce this study as well as all presented maps and figures can be found on GitHub: https://github.com/fineprint-global/eu_bioeconomy_footprint/.

65% foreign land areas for EU's non-food consumption

While the vast majority (86%) of cropland embodied in the EU's food consumption in 2010 stemmed from the EU itself [[3]), for the case of non-food products only 35% (9.9 Mha) were based on domestic land resources. The remaining 65% of the cropland (18.3 Mha) was imported from outside the EU-28. Large amounts of embodied land (7.3 Mha) were also imported to serve manufacturing processes in the EU.

With 2.7 Mha of embodied land, China was a major supplying country for the EU, accounting for almost 10% of the EU's non-food cropland footprint, mainly in the form of oil crops, maize, and fibre crops, or products derived therefrom. Indonesia, with 2 Mha, also provided large areas, largely related to palm and coconut oil. The group Rest of Asia-Pacific, including Malaysia, Bangladesh, the Philippines and Thailand, among others, supplied Europe particularly with vegetable oils, rubber, fibre crops and non-food alcohol. Northern America also played an important role as an exporter of maize for industrial uses (e.g. in the form of starch or ethanol).

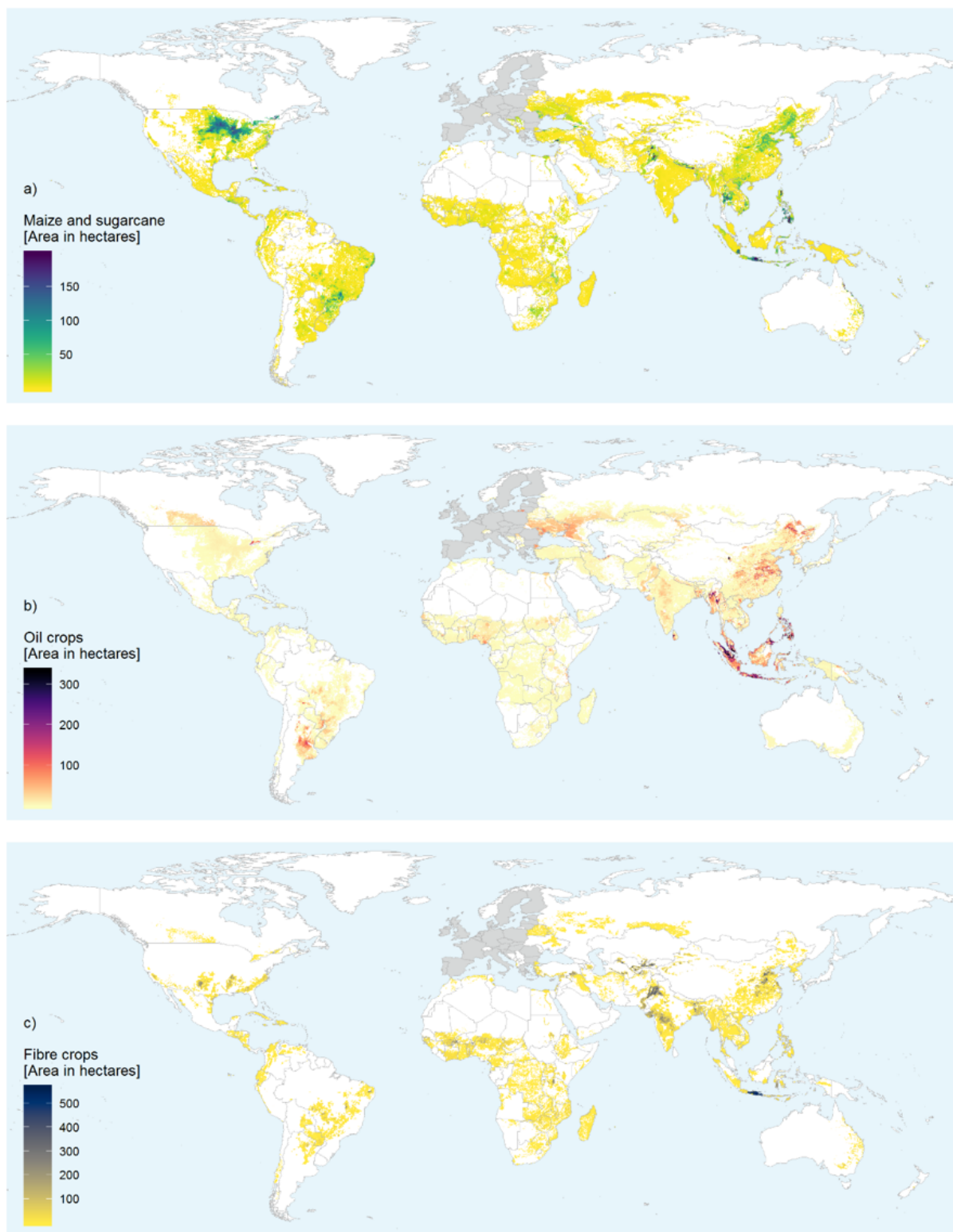


Figure 1: European Union's non-food related cropland use outside the EU in hectares per grid cell for a) maize and sugarcane, b) oil crops, and c) fibre crops. The colour scale indicates the number of hectares of cropland used by the EU in each grid-cell (5 arcminutes)



In 2010, more than one third of the EU's cropland footprint for non-food products was related to vegetable oils and oil crops, which are mainly consumed in the form of biofuels, detergents, lubricants and polymers. This is more than double the embodied land of this category in 1995. Increasing consumption of vegetable oils was a main determinant for the overall growth of the EU non-food cropland footprint.

Figure 1 provides a probability distribution of the EU's footprint over a fine-scale grid for selected crops: a) maize and sugarcane, which together represent more than 90% of the global ethanol feedstock and in addition are used for material purposes e.g. in the production of adhesives or bioplastics; b) oil crops, which is the biggest crop category in the EU's non-food cropland footprint; and c) fibre crops, mainly represented by cotton used in the textile industry. Spatially explicit footprint maps allow identifying regional hotspots, such as the maize plantations in the Great Plains of the US, or sugarcane in south-central Brazil. Malaysia and Indonesia are known as the world's largest palm oil producers. They are also the key regions for the EU's foreign oil crop demand, with particularly the Indonesian provinces of Riau and North Sumatra standing out, whereas Central and East Java show the highest EU demand per hectare for sugar cane and fibre crops. The extensively irrigated area around the river basins in the north-eastern part of the Indian subcontinent is another key region for the supply of cotton used in the EU.

Consistent spatially explicit supply chain and footprint assessments are essential to fully capture the spatiotemporal heterogeneity of biomass production and related impacts, such as deforestation, biodiversity loss or water scarcity, which differ greatly between production regions.

Social and environmental implications

Particular attention should be given to the non-food sector, as it is the main driver of growing biomass demand, in recent years particularly due to increasing vegetable oil demand for fuel use. The EU's high external non-food land footprint indicates that a big part of the environmental impacts related with the EU's consumption occur in other world regions. Our findings show that the EU increasingly sources non-food biomass feedstocks from tropical regions, which have been identified as hotspots of both deforestation and biodiversity loss.

Several studies have indicated that the European Union's consumption-based cropland use is already beyond a globally equitable limit [4,5]. Anthropogenic land modification, in particular deforestation, has already transgressed the planetary boundary for land system change, causing increasing pressure on climate and biodiversity. Many global energy and land use scenarios envision that the systemic change towards a bio-based economy will be more heavily reliant on terrestrial ecosystems and land resources. The expanding bioeconomy will then add to the already high land demand for food supply, resulting in growing pressure on planetary boundaries.

Europe's global responsibility

Our analysis highlighted the increasing importance of non-food products, being the fastest growing source of direct and indirect demand for agricultural land in the EU, as well as globally. Europe therefore plays a crucial role in determining global developments. If the European bioeconomy were to promote sustainable development at global scale, tools need to be in place that monitor trade-induced land use spillover and displacement effects that emanate from the region's energy,



agricultural, and bioeconomy policy programs. Environmental footprint measures, such as the land footprint, together with global environmental targets, can guide the EU in its process of implementing the Sustainable Development Goals, and provide the data basis to monitor and review progress.

Citation

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