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Authors (Organisation)	Mathilde Crepy, Michael Neaves (ECOS) Luana Ladu, Alexandra Gottinger (TUB) Eva Merloni, Enrico Balugani, Diego Marazza (UNIBO) Stefan Majer, Beike Sumfleth (DBFZ)
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Abstract

The increased production and consumption of biomass renewable based materials and fuels could lead to substantial changes in the way land is used. It is crucial, therefore, to adopt policy instruments in order to mitigate land use change resulting from environmental and social risks (e.g. loss of carbon stocks, loss of biodiversity, land grabbing). Based on an analysis of existing policies, as well as STAR-ProBio findings, this deliverable aims to deliver recommendations to policy makers when developing bioeconomy and in particular bio-based products related policies. It focuses on land use governance mechanisms enabling to mitigate the risk of the unwanted effects of land use change, whenever the use of renewable raw materials is promoted in policies and legislation.

The general approach of this policy overview was to distinguish between policies whose aim is to promote the use of biomass, and can hence be seen as a driver of land use and land use change, and on the other hand, policies laying down requirements on how land may be used. In particular we reflect on zoning and protected areas (1); monitoring mechanisms (2); mandatory targets and objectives on best practices and low impact products (3) caps on and bans of most impactful practices and high impact products (4); financial incentives and market instruments (5); and validation and assurance through certification (6).

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Executive Summary

The shift from a fossil- to a bio-based economy has been identified as a strategy to mitigate climate change. However, increased production and consumption of biomass based materials and fuels, could lead to substantial changes in the way land is perceived and used in a transforming economy. Understanding where this additional biomass could and will come from, and mitigating land use change resulting in environmental and social risks (e.g. loss of carbon stocks, loss of biodiversity, land grabbing), is therefore crucial.

This deliverable focuses on land use governance mechanisms that can mitigate the risk of the unwanted effects of land use change, whenever the use of renewable raw materials is promoted in policies and legislation. In particular, ILUC mitigation measures adopted as part of the EU biofuels framework provide useful experience in this regard. Based on an analysis of existing policies, as well as STAR-ProBio findings, this deliverable aims to deliver recommendations to policy makers when developing bioeconomy, and in particular bio-based product policies.

For the policy analysis, we distinguished between policies whose aim is to promote the use of biomass, and can hence be seen as a driver of land use and land use change, and on the other hand, policies laying down requirements on how land should be used. In particular we reflect on zoning and protected areas (1); monitoring mechanisms (2); mandatory targets and objectives on best practices and low impact products (3) caps on and bans of most impactful practices and high impact products(4); financial incentives and market instruments (5); and validation and assurance through certification (6).

Based on the policy review and the findings of previous StarPro Bio work, we identified outcomes and practices which have high and low land-use and land-use change impacts. The uptake of these best practices and avoidance of worst practices, can generally be fostered through financial mechanisms, or mandatory targets. Finally, trust in land-use policy instruments can be strengthened by monitoring frameworks and certification. We conclude this section by presenting a set of overarching recommendations.

The outcome of our work shows that the policy instruments only function when effectively combined: the assessment of quantified objectives needs robust monitoring tools. ; and before using financial incentives and fiscal mechanisms, it is crucial to clearly identify best practices to promote and worst to disincentive. Furthermore, transboundary and cross-sectoral approaches to sustainable land use should be promoted. Equally, integrating circular economy concepts within the bioeconomy for instance in finding ways to more easily operationalise the cascading use principle could be an effective way of mitigating pressures on land. Future research should focus on integrating these land use instruments more globally in the bioeconomy, while addressing the other drivers of land use changes starting with overproduction, increasingly land-intensive diets, food waste, single use and short-lived products and use of primary resources for energy purposes.

Introduction

The transition from a fossil- to a bio-based economy can help address several challenges such as contribute to mitigate climate change, address the depletion of fossil resources or re-dynamize rural areas (EU Bioeconomy Strategy, 2018). Increased production and consumption of bio-based products however require a higher share of biological resources; which in many sectors (e.g. bio-based plastics), currently mostly come in the form of agricultural crops (e.g. starch, sugar or corn) (European Bioplastic 2020). The anticipated growth of the bioeconomy could therefore lead to substantial changes in the way land is used, in order to make extra biomass available to bio-based industries. For instance, according to a report from the University of Wageningen (Martien van den Oever et al. 2017), while only 0,02% of the world's arable land is currently affected to the production of bio-based plastics, if all the plastic on the market today would be bio-based, this share would increase to 5%. This represents more than the size of the United Kingdom.

Understanding where this additional biomass could come from and the associated environmental and social risks, associated with land use change (e.g. loss of carbon stocks and biodiversity, land grabbing), is crucial. According to The Encyclopedia of Food Security and Sustainability, land use change can refer to two major processes: (1) a change in land cover associated with the expansion or contraction of the area of land used for different purposes (e.g., pasture, cropland, urban) or (2) a change in the type of management on existing land cover (e.g., changes in irrigation, fertilizer use, crop type, harvesting practices, or impermeable surfaces) (Davis et al. 2019)

Changes in land use practices have both positive and negative impacts (OECD 2017; 2018)

- on the climate: 1/3 of the anthropogenic greenhouse gas ever emitted come from changing land uses , which would in turn impact key parameters for land use such as soil fertility, soil carbon contents and the availability and quality of water resources; good land use management can be a CC mitigating strategy by promoting increases in carbon stocks;
- (on biodiversity): "Detrimental changes in land cover and land use are the leading contributors to terrestrial biodiversity loss. These changes generally occur slowly, but they are associated with declines in species diversity and populations, and can have a major impact on ecosystems." (OECD 2018)
- on the distribution of wealth – land and the buildings on it constitute 86% of the total capital in the OECD;
- on the attractiveness of cities and towns;

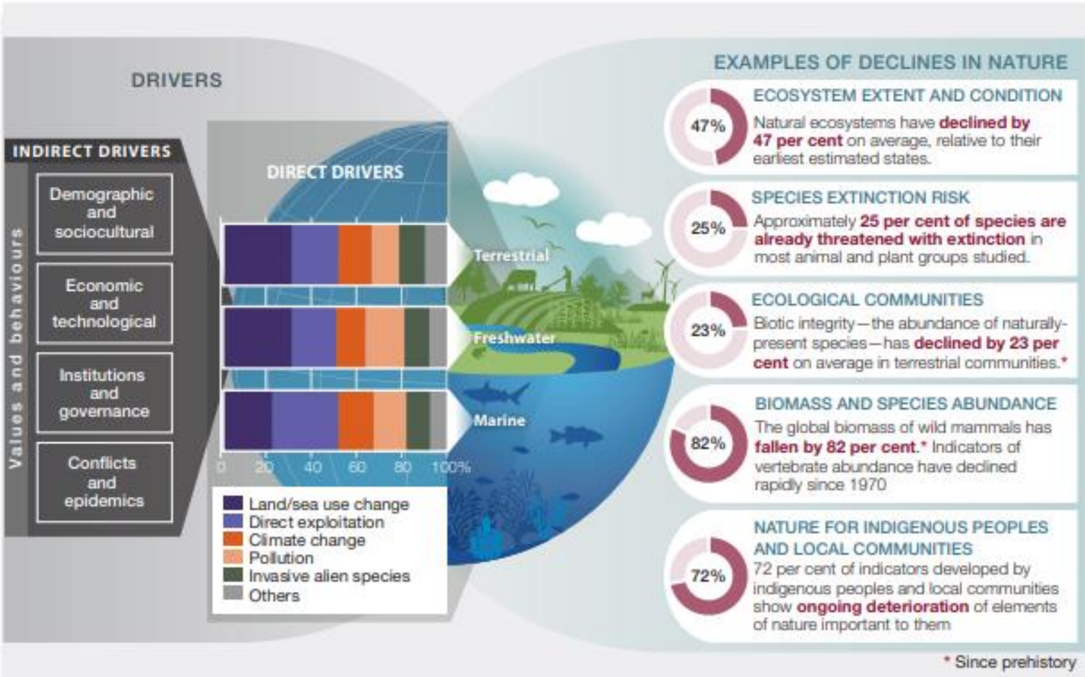

Figure 1: Declines in Nature; Source IPBES (2019)

Therefore, one of the keys to a smooth transition from a fossil- to a sustainable bio-based economy lies in addressing the challenge of biomass supply and competing uses of biomass. Policies directly promoting the use of biological raw materials on the one hand; and those addressing the way land is used on the other, have a very important role to play to promote sustainable land use practice, as well as prevent unwanted effects of land use changes (Kampman et al. 2010). These unwanted effects might indeed outweigh the environmental benefits a policy was initially pursuing. From a public acceptance point of view, managing indirect effects is key – as shown by the implementation of the Renewable Energy Directive (Transport & Environment 2018a).

This deliverable focuses on land use governance mechanisms enabling to mitigate the risk of the unwanted effects of land use change, whenever the use of renewable raw materials is promoted in policies and legislation. In particular, ILUC mitigation measures adopted as part of the EU biofuels framework provide useful experience in this regard. Based on an analysis of existing policies, as well as STAR-ProBio findings, this deliverable aims to deliver recommendations to policy makers when developing bioeconomy and in particular bio-based products related policies. This document is structured in the following three major parts:

- The first part includes the assessment of various policies and pieces of legislation focusing on land use and/or promoting the use of biomass address land use, direct and indirect land use change and their associated impacts. From this screening exercise, we propose ways to improve land use governance instruments used by EU policy makers

- The second part provides an overview of the results of previous research of the STAR-ProBio project, especially deliverable 7.2, to provide recommendations to policy makers on specific land-use governance measures.

- The third part provides a set of recommendations for policy makers regarding land use governance mechanisms in the context of the uptake of bio-based products.

1. Background and methods

1.1 Context

The EEA defines 'land' as "the planet's surface not covered by seas, lakes or rivers (…) Land can be covered by different types of vegetation (e.g. natural or managed grassland, cropland and wetlands) and artificial surfaces (e.g. roads and buildings)" (EEA, 2019). From the 13,7 billion hectares of land available worldwide the various types of land represent roughly the following proportion (see figure 2).

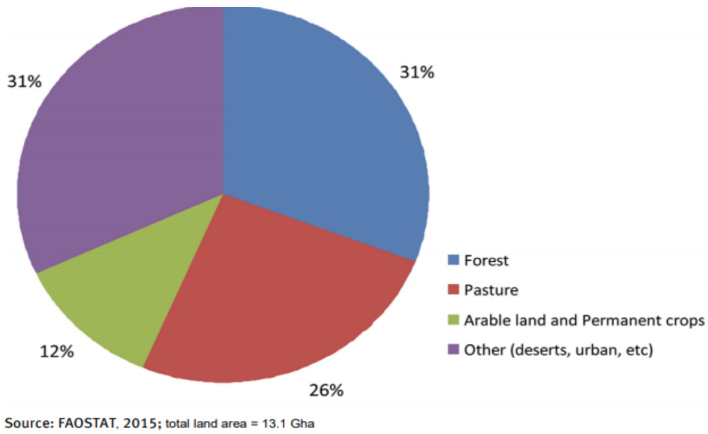

Figure 2: Global Land Use in 2010; Sources: GLOBALANDS (2015)

In the EU, the land repartition has remained stable since the 2000 (with some changes such as a slight decrease in agricultural land cover to the benefit of artificial surfaces, notably to expand cities). Land repartition is currently the following (EEA 2019):

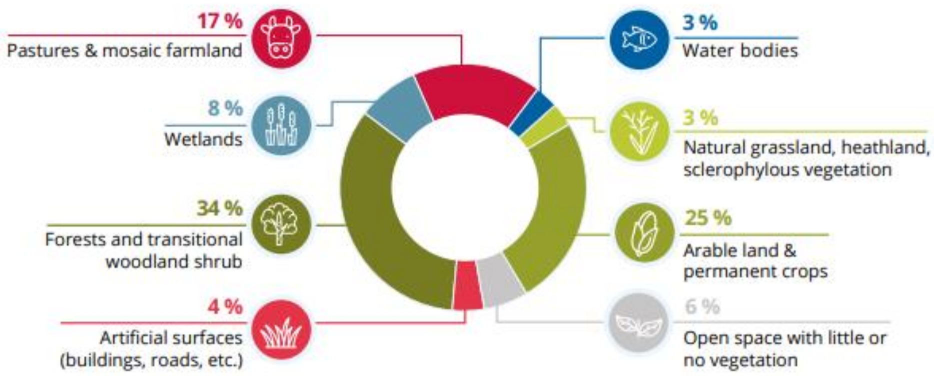

Figure 3: Land Cover in Europe; Source EEA (2019)

However, pressures on land are increasing, in particular due to human activities. An increasing share of the planet's land cover has been modified or is directly managed by humans: it is estimated that around 80% of Europe's surface area is shaped by cities, agriculture and man-managed forestry. From a global perspective, land use changed over the last decade, especially in terms of conversion of pasture land and urbanization. Between 2015 and 1992 2.7% of semi-natural and natural land (twice the size of Spain) has been lost to other types of land cover (see Figure 4) (OECD 2018).

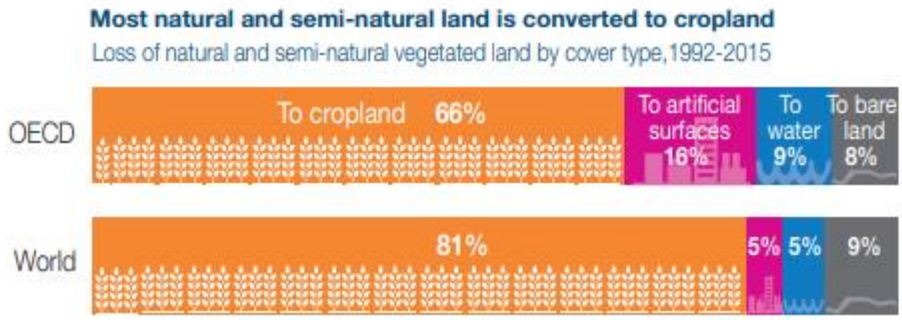

Figure 4: Loose of natural and semi-natural land, Source: OECD (2018)

The pressures on land are increasing due to:

- Demography (increase in food demand and expansion of the built environment)
- Changes in diets (bigger meals, increasingly relying on animal proteins),
- Climate, environmental changes and desertification (loss in productive land)
- Market policies promoting the increasing use of biological resources over fossil resources

The latter pressure is the object of this policy review.

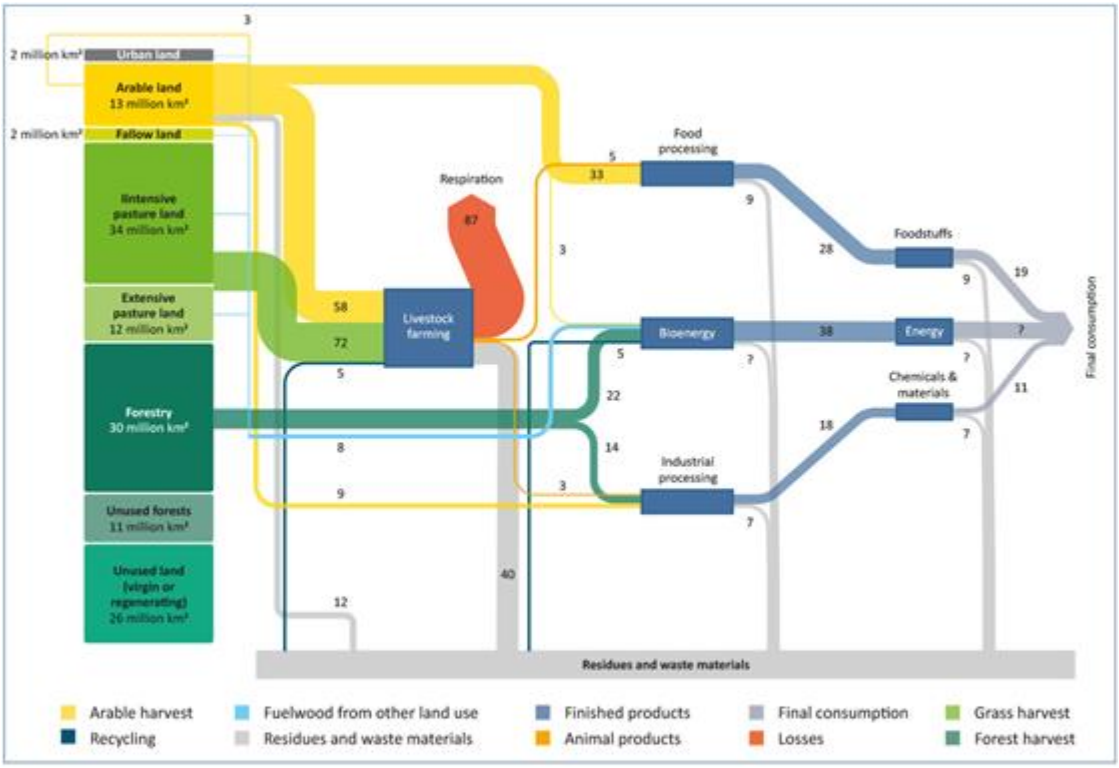

Figure 5: Global biomass flows; Source: Acatech (2019)

1.2 Research questions and methodology

For the purpose of this paper, a policy review has been carried, including around 30 international conventions, European and national legislation and other relevant reports or guidance documents such as scientific papers, and reporting tools addressing land use change and land use practices (see Annex 1). The aim was to understand (1) the objective of the policy intervention; and (2) the policy instrument(s) chosen and how it/they operated.

As shown in figure 6, the general approach of this policy overview was to distinguish between policies whose aim is to promote the use of biomass, and can hence be seen as a driver of land use, and land use change on the one hand, and the policies laying down requirements on how land may be used on the other hand.

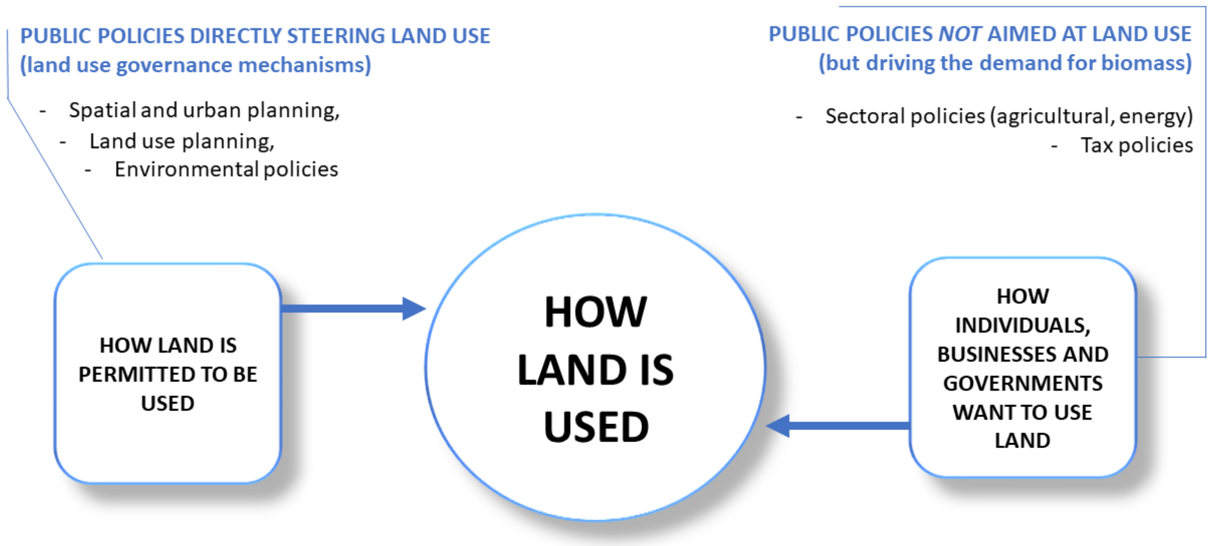

Figure 6: Land-use policies, according to their aim (adapted from OECD, 2017)

Regarding policies driving the demand for biomass for instance, the European Union has a wide-framework of policies that are stimulating the market for biomass per sector, including the Bioeconomy strategy (European Commission 2018), the Common Agricultural Policy (CAP), and the Renewable Energy Directive (RED) (2009/28/EC). The purpose of these policies is to increase the demand for renewable goods and services (food, materials or energy), however, they vary in terms of instruments used, and subsequent market impacts.

- The EU Bioeconomy Strategy aims at supporting the development of an economy based on renewable biological resources. The strategy uses objectives and financial support for Research & Innovation projects to further develop the bio-based industrial sector. Objectives within the 2018 revised EU Bioeconomy Strategy, remains based upon the original five objectives of the 2012 EU Bioeconomy Strategy listed below, also now utilises climate objectives within the Paris Agreement, as well as objectives from the EU Industrial Policy Strategy.

  Five objectives of 2012 EU Bioeconomy Strategy:

  - Ensuring food security,
  - Managing natural resources sustainably,
  - Reducing dependence on non-renewable resources,
  - Mitigating and adapting to climate change,
  - Creating Jobs and maintaining EU competitiveness.

Support for a sustainable bioeconomy as part of a circular economy is said to stimulate the creation of innovations and market-based incentives. In terms of direct support from policy makers, the relevant actions are said to include support for relevant funding programmes such as LIFE or the Horizon Programme, based upon the analysis of 'relevant' products for the bioeconomy.

- The Common Agricultural Policy (CAP) was launched in 1962 and soon became one of the EU's flagship policies. The European Commission indicates that the CAP 'aims to:
    - support farmers and improve agricultural productivity, ensuring a stable supply of affordable food;
    - safeguard European Union farmers to make a reasonable living;
    - help tackle climate change and the sustainable management of natural resources;
    - maintain rural areas and landscapes across the EU;
    - keep the rural economy alive by promoting jobs in farming, agri-foods industries and associated sectors'
- The RED was first adopted in 2009 as part of a 2020 climate and energy package, amended in 2015 and recast in 2018. The Directive establishes a common framework for the promotion of energy from renewable sources, notable through the promotion of renewable energy fuels in the transport sector, heat and power sectors ; which translated into support schemes for biofuels and biomass energy. It also sets mandatory national targets for the overall share of energy from renewable sources.

The second category of policies are those setting land-use governance mechanisms and are the focus of this deliverable.

In a second step, we looked at the various instruments used in policies to influence land use practices. The policy analysis focused on transnational (European and international) governance mechanisms, rather than national legislation on land use. In this regard, national, or local-specific aspects, such as permitting, and urban planning, are not covered (for national and local specific aspects, see D7.2). Certain biomass commodity types, such as algae, were also not included in this study. Nonetheless, the scope of this report allows providing horizontal guidance to policy makers and other stakeholders regarding all biomass segments.

2. Land use governance – Policy review

As part of this policy review, we looked at various mechanisms and land use governance instruments: from direct land planning tools, such as zoning and protected areas to financial incentives; from monitoring instruments to certification; from mandatory target on best practice to bans of high land impact products.

2.1 Zoning and protected areas

Zoning and characterisation of protected areas are among the most traditional land use policy instruments. A protected area is a "clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (IUCN 2008). Indeed, protected areas are created to set apart certain land areas with recognized attributes (such as endemic biodiversity, cultural value, high carbon content or specific ecosystems) from land use transformations. There is a whole range of restrictions which may apply to using protected land, the concept of 'protected areas' therefore covers a wide variety of aspects. Particularly used in conservation policies (Palomo et al. 2014), protected areas and zoning policies primarily rely on national legislations, although sometimes supported by EU and international policies.

In the EU, the most famous example is **Natura 2000**. The European Commission defines Natura 2000 as "a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types which are protected in their own right. It stretches across all 27 EU countries, both on land and at sea. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats, listed under both the Birds Directive and the Habitats Directive" (European Commission 2020a, DG Environment, website). The network currently covers 18% of the EU terrestrial land and is not solely based on a system of strict nature reserves from which all human activities would be excluded – most of these areas indeed remain privately owned. Member States are required to ensure that all the identified sites are managed in an ecologically and economically sustainable manner (European Commission, DG Environment, website).

Zoning and reference to protected areas are also used in other EU legislations, such as the **Renewable Energy Directive (RED)**. To comply with the Directive, biofuels, bioliquids and biomass fuels from agricultural biomass should not be produced from raw materials originating from:

- High Biodiversity land (as of January 2008), including (1) Primary forests; (2) Area designated for nature protection or for the protection of rare and endangered ecosystems or species (although exceptions can be provided if there is proof that the production of the raw material did not affect the conservation purposes) and (3) Highly biodiverse grasslands

- High Carbon stock land that changed use after 2008 from one of the following categories: Wetlands; Continuously forested land; and other forested areas with trees higher than five meters and canopy cover between 10% and 30%.

- Land that was peatland in January 2008

In doing so, the RED aims to avoid that biomass production for bioenergy applications causes biodiversity loss and significant GHG emissions arising from direct land conversion.

International land use governance instruments also rely on land zoning. The CBD, for instance, sets up protected areas and adopts other measures to protect valuable ecosystems with the overall aim of protecting biodiversity. This infers that practices infringing upon areas of rich biodiversity would not align with the objectives of the convention.

Effectiveness and limitations

In the last couple of decades, the number of protected areas has increased worldwide (Protected Planet 2018). Protected Planet provides detailed information on protected areas, updated monthly with submissions from governments, non-governmental organizations, landowners and communities. It is managed by the United Nations Environment World Conservation Monitoring Centre (UNEP-WCMC) with support from IUCN and its World Commission on Protected Areas (WCPA). According to the organization, worldwide, 15% of the terrestrial land is covered by protected areas (Protected Planet 2018). Although this is a rising number, the Aichi Biodiversity Target 11 of the Strategic Plan for Biodiversity 2010-2020 calls for a 17% target by 2020. One of the biggest challenges is the management and enforcement of protected areas. Indeed, "only 20% of the total coverage of protected areas reported in the WDPA has been assessed for management effectiveness according to the Global Database on Protected Areas Management Effectiveness." (Protected Planet 2018). In parallel, however, global biodiversity has dramatically declined (EEA 2019); and GHG emissions have continued to increase. These measures are hence obviously not enough to effectively stop the decline of biodiversity loss and climate change. Some further challenges of zoning and protected areas include the high monitoring costs , and the low and changing willingness to prioritise biodiversity protection and the fight against climate change over the exploitation of natural resources, as the dramatic changes in environmental policies in Brazil since the election of Jair Bolsonaro has shown (Abessa et al.2019). Furthermore, the definition of protected area varies from one country to another. The RED sets directly applicable requirements in this regard; such as no production on land that was peat after 2008, which helps to circumvent the national differences.

The implementation of the **Renewable Energy Directive** also enabled to shed light on a number of issues regarding the effectiveness of zoning instruments, but mostly regarding the limitations of zoning. Indeed, the main blind spot of the no-go areas criteria of the RED is that they only address where biofuels production comes from, and not where it is sending the production of what was on this land before (indirect effects or spillover to other sectors, nor regulated by the RED). Yet, according to the European Commission (European Commission 2019), these indirect effects are significant, particularly for soy in Latin America, and palm oil worldwide.

Currently, bio-based products placed on the EU market (except for bioenergy) do not have to fulfil any **specific requirement regarding the type of land the biomass** originates from. Representing a market push policy for biofuels and bioliquids, the RED can be considered as an important test case for the implementation of sustainability criteria for biomass at EU level. A sustainable bioeconomy will ensure that the use of biogenic resources for products does not exceed the time it takes for these resources to be regenerated. For land with high biodiversity stock and/or high carbon stocks whose stocks have taken very long time to build (e.g. peatlands, or rainforests), it is very important to **set priorities for the use of land**.

2.2 Monitoring Mechanisms

Besides the establishment of protected areas, the monitoring of land cover is a further common and important instrument for the sustainable management of land. Especially in the context of biomass production, monitoring tools are fundamental to ensure a sustainable use of land and avoid negative impacts on land and biodiversity. Furthermore, the implementation of monitoring tools helps to coordinate and optimize cultivation activity and consequently improve the agricultural supply chain. Hence, monitoring tools that fulfil these aspects are able to promote productivity in the primary sector; and at the same time ensure low land use change risks in regards to biomass production and promote sustainability. This section aims to give a brief overview of existing monitoring tools and indicators in relation to land-use change.

In order to reduce land-use change, the **LULUCF** (Regulation 2018/841) established different monitoring instruments. The monitoring tool distinguishes between six main land use categories:

Forest Land, Cropland, Grassland, Wetlands, Settlement and Other land. The accounting of emissions/removals for managed croplands is included. In LULUCF regulation the emissions from woody biomass and decreased removals from using agricultural residues are accounted for in the country that produces the biomass.

Commodity specific pieces of legislation such as **RED II** also relies on specific GHG emissions accounting rules. Under RED II, the accounting rules are linked to the calculation of a biofuels' carbon footprint. The objective of this calculation is to ensure that the use of biofuels results in GHG benefits compared to the fossil reference. The whole calculation is focussed on the final product, and as such, there is no direct relationship between the RED GHG calculation and any monitoring scheme for LUC or soil improvement. The carbon footprinting rules for biofuels are specified in the RED and can include land management practices, including greenhouse gas emissions savings from improved agriculture management, (e.g. no till, crop rotation, use of cover crops, the use of organic soil improver, etc.).

Despite the importance of environmental monitoring, it is argued that most countries measure bioeconomy in terms of economic factors, while social and environmental criteria are addressed only to a limited extent (FAO et. al 2019). The current plan to build a common **monitoring system for EU bioeconomy**, enacts as an important contribution to fill this gap in the future. In 2020, the European Commission's science and knowledge service, Joint Research Centre (JRC) published the Progress Report *`Building a monitoring system for the EU bioeconomy´*. This document presents the status of the development of the EU Bioeconomy Monitoring System during the first year since its inception and describes a set identified indicators and, as well as the scope of measurement. Besides basic indicators, which will result mostly from already existing data, processed indicators should ensure harmonisation across countries or sectors. A further indicator category will be system level indicators, which refer to product-based Life cycle analysis and environmental footprints, or consumption and consumer footprints. The report clearly underlines the importance of data availability and the identification of relevant and measurable indicators. In order to identify such indicators, the Food and Agriculture Organization of the United Nations (FAO) analysed 18 territorial monitoring approaches (see FAO 2019). The review provides a detailed list of environmental, social and economic indicators, mostly developed in relation to bioeconomy strategies and for the application on different scales (e.g. national). Several of these indicators address aspects, which are relevant to observe and analyse land-use change. One example is the criteria `promotion of sustainable intensification of biomass production´, which is measured by indicators for yield or agricultural productivity. In addition, `Land use change´ is measured by indicators such as change in cropland area, grassland area, non-arable land use. The report shows the diversity of different approaches that aims to measure the sustainability of bioeconomy. Furthermore, it indicates that measurement tools developed in the context of bioeconomy strategies provide important data to identify potential chances to increase yields and to evaluate potential impact on land.

The **Agri-Environmental Indicators (AEI)** were developed in 1998 in order to track the integration of environmental concerns into the Common Agricultural Policy (CAP) at EU, national and regional levels. These 28 indicators range from counting the agricultural areas under Natura 2000, to assessing the risk of pollution by phosphorus, to measuring fertilisers and pesticides consumption, to estimating soil erosion. These indicators do not explicitly include policy objectives, however the final commission communication on the indicators in 2006 (European Commission 2006) outline goals of integrating environmental concerns into the Common Agricultural Policy, with the indicators used a tool for consultation, and setting policy priorities:

- to provide information on the current state and ongoing changes in the condition of the farmed environment;
- to track the impact of agriculture on the environment;

- to assess the impact of agricultural and environmental policies on the environmental management of farms;
- to inform agricultural and environmental policy decisions;
- to illustrate agri-environmental relationships to the broader public.

A key commitment of the AEIs is to increase share of total agricultural land in the EU enrolled in the EU to increase scope and utility of indicators to manage the large portion of land under agri-environmental commitments (26.3%).

Among the indicators, there is one directly referred to the Land use Change and others that are indirectly connected to it, such as cropping and livestock patterns, tillage practices, intensification/extensification, soil erosion (Eurostat 2013). As far for the Land Use Change indicator, 5 sub-indicators have been selected by the EEA to address the rural development measures:

- Vegetation productivity that addresses trends in land surface productivity derived from remote sensing observed time series of vegetation indices.
- Landscape fragmentation pressure and trends in Europe that measures landscape fragmentation due to transport infrastructure and sealed areas.
- Land take in Europe that addresses the change in the area of agricultural, forest and other semi-natural land taken for urban and other artificial land development. Land take includes areas sealed by construction and urban infrastructure, as well as urban green areas, and sport and leisure facilities.
- Land recycling and densification that addresses the use of urban land for further urban development, whether that urban land is currently in use or not.
- Imperviousness and imperviousness change that is defined as the yearly average imperviousness change between two reference years, as measured by imperviousness change products.

Concerning the objective of this report, the indicator that can be applied to the change in land use caused by the bioeconomy industry development is the one for vegetation productivity. Its relevance is based to the fact that intensive human use manifests in the over-exploitation of certain ecosystem services (such as food, fibre, etc.) and in intensive land-use and land-use change that can cause an irreversible loss of e.g. the supporting ecosystem services (Hill et al., 2008) leading to ecosystem degradation. Although ecosystem degradation results from a combination of natural and socio-economic drivers, it is generally perceptible from long lasting loss of vegetation cover and biomass productivity over time and in space (Hellden and Tottrup 2008). However, although a specific methodology for calculation the Vegetation productivity is provided, as well as the policy context, no **specific target is foreseen.**

Monitoring mechanisms are primarily used in **climate policies**, in order to properly account for Greenhouse Gas Emissions due to LULUCF activities (i.e. afforestation, reforestation and deforestation since 1990). The 1992 UNFCCC first categorized carbon sinks and reservoirs. For instance, Article 4 of the UNFCCC requires all the parties to "promote and cooperate in the conservation and enhancement, (…) of sinks and reservoirs of all GHGs (…), including biomass, forests and oceans". While not explicitly referring to deforestation or land expansion, the document refers to carbon sinks (e.g. high carbon stocks land) several times and requests parties to monitor their state. Also, the document explicitly refers to forestry and agriculture as key climate change mitigation sectors. Greenhouse gas accounting obligations originate from the 1997 Kyoto Protocol, which was the first legal instrument to require member states to enforce quantifiable GHG emissions reductions. Under the Kyoto Protocol, Annex I countries are required to measure their annual GHG emissions resulting from LULUCF activities, and compare them against emission levels of 1990.

Effectiveness and limitations

A further international example that aims to improve transparency in land use is the Land Matrix Initiative (LMI), which provides data on large-scale land acquisitions. Among other information, the initiative collects data on agricultural intentions of land acquisition and Crops cultivated in percentage of area. Especially in such large-scale projects, data collection can be considered a challenge. Likewise, in the context of the initiative, it is calmed that a major issue in **data gathering** is that in some countries there are no procedures or the responsibilities are shared by a broad range of agencies and government levels and even official data sources in the same country can vary. (Nolte et al. 2016). Similarly, in the former mentioned JRC report on the progress of building a monitoring system for the EU bioeconomy (European Union 2020), it is mentioned that especially obtaining data on hybrid sectors (i.e. sectors combining bio-based and fossil-based activities) will be challenging and that there might be gaps in geographical availability.

Relevance for bio-based products

Currently, approximately 2% of the global agricultural area is used for the production of bio-based material (European Bioplastics 2020). To observe changes in this percentage and to avoid deforestation and the loss of natural habitats due to the conversion of land, a proper monitoring tool is needed. The identification of appropriate indicators and reliable, consistent data on soil quality and land use helps to assess the risks of increasing pressure on land on a regional, national and global level. The current effort to establish a monitoring tool for European Bioeconomy presents an important starting point. Within the forthcoming development of the indicators for the monitoring tool, special attention should be put to the inclusion of circularity indicators. This could help to find chances to improve the use of secondary raw material within the European bio-based economy, which plays an important role to diminish the pressure on land. The mentioned framework for the development the monitoring tool already emphasizes on circularity principles. This can be considered as a step in the right direction. However, as prior STAR-ProBio work packages showed, exporting biomass or bio-based products (e.g. from cotton or oilseed crops) from non-EU countries could increase the pressure on land and consequently cause deforestation (see D 9.1). This shows that global monitoring is essential to avoid negative externalities in other countries. Labels for bio-based products that declare the origin of the used biomass could be helpful to avoid these effects. This accounts not only for exported goods but also for bio-based products from Europe.

The existence of robust monitoring mechanisms is crucial to improve knowledge over time, to build databases on impacts of products and practices, ease comparison between countries and over time and to help ensure the enforcement of policies. A proper monitoring system is an enabling condition of the enforcement of mandatory targets and caps (e.g. in order to check progression towards a specific objective): which the two coming sub-sections focus on.

2.3. Mandatory targets and objectives on best practices and low impact products

Targets on 'sustainable' activities/products are widely used both in the EU and nationally. These targets can be **indicative**: this is the case of the one set in the 2008 European Commission Communication on Green Public Procurement, to have 50% of all public tendering procedures at EU level 'green' by 2010 (European Commission 2008). These targets can also **mandatory**: this is the case of the 25% recycled-content target applying to beverage plastic bottles by 2025 under the Single Use Plastic Directive (Directive (EU) 2019/904).

The main idea of targets and quantified objectives is to foster the implementation of best practices and low impactful products.

In this section we will provide an example of a set of mandatory targets applying to the transport sector (focusing on biofuel).

The Renewable Energy Directive contains many quantified targets and objectives that Member States have to comply with, while Member States are free to decide how they will achieve the target. In 2014, the European Union set its climate and energy objectives for 2030: **a greenhouse gas (GHG) reduction of at least 40% compared to 1990** levels and a minimum of a 32% share of renewable energy consumption across all sectors (European Commission 2014a). Despite this GHG emissions target, emissions from the transport sector increased by 2.2 % in 2017 compared with 2016. Emissions from EU-28 transport (including international aviation but excluding international shipping) in 2017 were 28 % above 1990 levels, despite a decline between 2008 and 2013 (EEA, 2018), and 2050 projection plan a further increase (Transport & Environment 2018b). Biofuels are one of the options considered to increase renewable energy and decrease the carbon intensity of the transportation sector. Through Directives such as the Fuel Quality Directive (Directive 2009/30/EC) and the Renewable Energy Directive and national legislation, the EU and its Member States have facilitated and incentivised their use in fuel blends (such as B7, B10, E10, E85). In 2009, the RED mandated that by 2020, **10% of energy used in the transportation sector should come from renewable energy sources**. In 2015, the Indirect Land Use Change directive amended the RED to introduce a **7% cap** on the contribution that conventional food and feed-based biofuels could make to the RES-transport target. The 2015 ILUC Directive (2015/1513) also aimed to promote non-food f **0.5% target for 'advanced biofuels'** fedstocks and wastes, introducing a non-binding (such as those made from straw and manure) and used cooking oil by 2020. Finally, the directive introduces the possibility for certain biofuels made from **non-food crops to be double counted towards the 10% target** (these are listed in Annex IX of the RED).

In June 2018, the EU Commission, Parliament and Council reached an agreement on the recast of the Renewable Energy Directive (REDII), which introduced a **target of 14% for the use of renewables in the transport sector**, and **3.5% advanced biofuels sub-target by 2030**. In line with the ILUC amendment, 'conventional' biofuels are capped at each member state's 2020 level with a maximum of 7%. The double-counting possibility remains for advanced biofuels. The Renewable Energy Directive therefore creates a hierarchy in the incentivised mechanisms:

1. the most favoured option is the placing on the EU market of advanced biofuels complying with listed sustainability requirements;

2. the second option (also incentivised compared to conventional fuels, but only up to 7% of the country biofuel share) is the placing on the market of food-crop biofuels complying with the RED sustainability criteria.

Effectiveness and limitations

Overall, the RED targets have been effective to drive the demand for biofuels in the EU: between 2004 and 2018, the amount of biofuels placed on the EU market was multiplied by 8 (EUROBSERV'ER 2019). Interestingly however, it seems that while Member States and the market had anticipated a massive growth of biofuels in the 2000's, long political discussions around the indirect effects of biofuels and the food versus fuel debates made the demand for biofuels stagnate between 2010 and 2016. The 2016 European Commission proposal for a RED II applying after 2020 seems to have brought back market certainty for biofuels, as biofuels figures have increased by 10% between 2017 and 2018 (EUROBSERV'ER 2019). These fluctuations show how important it is to set robust sustainability requirements in order to create market certainty.

The use of advanced biofuels however continues to remain limited: in 2019, they accounted for 1,2% of the total transport fuels. The vast majority of these are made from waste fats and oils (1%) while only a 6th of this proportion comes from agricultural and forestry residues (ETIP Bioenergy 2019). Recently, serious concerns were raised regarding the allegedly high proportion of fraudulent used cooking oil on the EU biofuels market (see Euractive 2019). The need for tight monitoring of the origin of the feedstock by certification schemes was highlighted by the European Commission as early as 2014 in a letter addressed to recognised schemes in 2014

(European Commission 2014b). This issue remains unsolved under RED II as waste and used cooking oil will continue to be eligible for double-counting.

Relevance for bio-based products

It is important to note that the **Bioeconomy Strategy neither defines best practice or sustainability requirements for bio-based products nor contains any mandatory targets** e.g. regarding the market share of bio-based products complying with listed sustainability requirements across various sectors.

Just like in the case of biofuels, for products, bio-based is not systematically more sustainable than fossil-based (InnProBio 2018). The sustainability performance of bio-based products would depend on biomass production practices, or added substances such as chemicals or solvents This is why, if policy makers would choose to incentivise bio-based products like they did for biofuels, they would first have to determine what sustainability performance they would want bio-based products to fulfil. As shown for biofuels, when setting targets linked to sustainability requirements, it is crucial to set robust and comprehensive sustainability criteria: the fact that the ILUC aspect was not initially considered undermined the credibility and marketability of biofuels. However, in line with the **cascading use principle**, the sustainability requirements applying to bio-based products during the biomass production phase should not be more stringent than those applying to biofuels, as it would otherwise risk diverting biomass production to less circular uses such as energy.

2.4 Caps on and/or bans of most impactful practices and high impact products

Caps and bans instruments are the counterpart to mandatory targets. While the latter is about promoting best products and practices, the first aims to minimise the use of high impact practice and worst performing products.

In this section, we took two real life examples from EU policies: the cap on high ILUC risk biofuels under the RED and the ban on illegally logged wood under the EUTR.

Taking high ILUC risk feedstocks out of the incentives of the RED

The Revised RED developed a methodology to characterise high impact feedstocks in order to ensure that they would no longer benefit from financial incentives if they would not be produced following low ILUC risks practices.

Article 3 of the delegated act adopted in line with Article 26 of RED II sets criteria to determine the high ILUC-risk feedstocks. These are the feedstock meeting the two following cumulative criteria:

- the average annual expansion of the global production area of the feedstock since 2008 is higher than 1% and affects more than 100,000 hectares;
- the share of such expansion into land with high-carbon stock is higher than 10%, in accordance with the following formula

Based on the Commission Report accompanying this delegated act, the only feedstock currently identified as high iLUC riskis palm-oil. This is because based on current (satellite) data, it has been shown that, from 2008 till 2016, cultivation area of palm oil had expended by more than 1% every year (4%) and that over 10% of such expansion (18% according to the study) has taken place on high carbon stocks land (European Commission, 2019). The feedstock in the second position in terms of expansion onto high carbon stock land is soy with 8% of the total expansion since 2008 (3% per year) on high-carbon stock land (European Commission, 2019).

Banning illegally harvested wood from the EU market under the EU Timber Regulation

The aim of the EU Timber Regulation (EUTR) is to ensure that timber and timber-related products on the European market are legal (WWF 2019). In doing so, the Regulation, which entered into force in 2013:

- prohibits the placing on the EU market of illegally harvested timber and timber products;
- requires EU traders to exercise 'due diligence';
- facilitates the traceability of timber products by requiring economic operators in the wood supply chain to keep records of their suppliers and customers (Regulation (EU) No 995/2010).

It can seem quite surprising to have to adopt a piece of legislation banning products illegally produced. Yet, in certain sectors like forestry, the risk of illegal practice is high, while the environmental or social impacts of such illegal practice can be massive (high climate and ecosystems impacts of cutting down forest or non-respect of land use rights). In such cases, it makes sense to make sure that economic operators in a value chain manage these risks responsibly by choosing credible suppliers: this is what is understood as 'due diligence'.

According to the European Commission, due diligence is "*how a business understands, manages and communicates about risk. This includes the risks it generates for others, and the risks it encounters through its strategic and operational decisions and actions." (European Commission 2020d, website)*

Due diligence is different from sustainability in that it only aims to mitigate significant risks, rather than implementing best practices. Indeed, while the use of sustainable forestry certified product (e.g. FSC compliant) helps to mitigate the risk of timber being illegally harvested, it does not lift the obligation of the customer to assess the risk of that timber being illegal due to a gap or failure in the certification scheme (NEPCON 2020a; website).

Effectiveness and Limitations

Since RED II will only start applying from 2021, it is still too early to assess the effectiveness and limitations of taking non-low ILUC risk certified palm oil out of the RED. Nevertheless (and since one of the focus of this deliverable is on social acceptance), one important difficulty when banning products or setting a cap is always that there is an element of subjectivity which makes policy makers draw the line somewhere. When determining high ILUC risk feedstocks, a high number of stakeholders (over 60,000 replying to a public consultation) asked the EU to lower the threshold so as to include soy in the list of high ILUC risk feedstocks. In fact, the study accompanying the delegated act on high and low ILUC risks biofuels from the European Commission (European Commission, 2019) shows a particularly high divergence depending on the country of cultivation in the case of soy: in Brazil 14% of its cultivated area expansion since 2008 took place onto forests (hence fulfilling the criteria to be considered high ILUC risk there), while only 1% of such expansion took place in forests in other regions of the world. Evidence on the national divergences in this regard should continue to be gathered in order to map out ILUC risks in a more granular way.

Regarding the due diligence mechanism required under the EUTR, a recent study by WWF (WWF 2019) on the implementation of the EUTR by 16 member states, found that half of surveyed Member States lacked criminal sanctions for EUTR infringements and at least 10 Member States were not systematically carrying out checks on due diligence systems and timber legality - showing in this case that assessing and mitigating risks might be sub-optimal,

Can they be transposed in the bio-based product context?

The two real life examples listed in this section are all about **mitigating what has been identified as the main environmental risks for a specific commodity** : in the case of biofuels - it is mitigating the risk of biomass production resulting into the destruction of tropical forests and high carbon stock land ; in the case of timber, it is making sure that illegal logging does not occur.

As highlighted, due diligence is a r**isk mitigation tool and a widely applied concept across sectors**, but its meaning varies from sector to sector. The certification body NEPCon lists the following risks which would need to be managed by supply chain actors in a due diligence exercise, in biomass supply chains such as palm oil, or soy (NEPCON 2020b, website):

- The environment

a. Environmental regulations on water use, chemical management etc must be met
b. Regulations on protected sites and species must be met
c. High Conservation Value ecosystems must be preserved

- Social issues

a. Staff must be legally employed
a. ILO fundamental conventions must be adhered to
b. Health and safety regulations must be met
c. Indigenous and traditional rights must be respected

- Business issues

a. Land tenure must be legal
b. Farm registration laws and management rights laws must be met
c. Taxes and fees must be paid, including royalties, value added taxes, sales taxes, income and profit taxes and other fees
d. Information disclosure laws must be met

- Conversion

a. New farms must not be established after November 2005 [1] on natural forests or other ecosystems
b. Fires must not be used to drive land conversion

- Genetically-modified organisms

c. GMOs must not be used commercially

Recently, the European Union, as well as various national governments were called to require **all economic operators placing products on the EU market or active in the EU to carry out human right and environmental due diligence assessment**. The aim of such assessments would be to identify, prevent, mitigate and account for adverse corporate impacts (abuses of human rights, including land use rights, environmental damage, including with respect to climate and biodiversity). In the meantime, the EU also carried out an in-depth study on the issue, which might lead to the adoption of a generic due diligence regulation for products entering the EU market (European Union 2020). The above indicative list **could serve as a basis for bio-based products supply chains,** should a horizontal due diligence regulation ever be adopted.

2.5 Financial incentives and market instruments

Land use decisions related to these commodities are largely driven by economic factors. Finance laws, from both public and private sources, drive economic activity that contributes either to the sustainable or unsustainable use of natural resources. Land use needs additional investment to make it environmentally sustainable, and able to meet increasing biomass demands while protecting nature and reducing emissions of greenhouse gases. New farming and forestry techniques could halt the expansion of the agricultural frontier and, at the same time, enhance productivity to yield more from the same area. The challenge is to find ways to incentivise this change, providing governments and farmers with the resources to make a large-scale transition to more sustainable land use (Girling and Bauch, 2017).

This is why the market-based instruments can play a relevant role in the land use policy framework. Market-based instruments (MBIs) are policies that address market externalities, such as greenhouse gas emissions, by "closing the (welfare-reducing) gaps between private and social costs (and/or benefits) [of private actor-driven] market activities" (de Serres, Murtin, Nicoletti 2010). They are also referred to as economic instruments that incorporate the external costs of production or consumption in the price. Hence, these instruments help strengthen the competitiveness of green versus Business-as-Usual (BAU) activities, to minimize existing barriers, and to create incentives to shift land use activities towards greener outcomes.

Therefore, market-based instruments can be considered as indirect regulatory instruments, which influence stakeholder' behaviour by changing the market signals rather than through explicit directives (Driesen, 2006; Gupta et al., 2013). There are a wide range of types of market-based instruments including taxes, trading schemes, offset schemes, subsidies and grants, accreditation systems, stewardship payments and tax concessions.

2.5.1 Typology and examples of market-based instruments

There are two main families of MBIs:

1 Price-based: With price-based instruments, governments set a price on goods and services to reflect environmental and social costs. This price may be expressed as a subsidy, to reflect positive environmental and social benefits, or as a cost, to reflect negative environmental impacts, resulting in market changes. Examples are **loans, taxes/charges, grants and subsidies, equity, deposit refund systems, feed-in-tariffs, etc.**

2 Quantity-based instruments: With quantity-based instruments behavioral changes are influenced by specifying the 'amount' of new rights/obligations and allowing the market to set their price. Examples are **tradable permits/emissions trading schemes.**

Compared to other regulatory instruments, market-based instruments may involve the following advantages (INTOSAI 2014):

- Improvement of price signals, by giving a value to the external costs and benefits of economic activities, so that economic actors take them into account and change their behaviour to reduce negative and increase positive environmental and other impacts.
- Improvement of the flexibility for the industry in meeting objectives and thus lower overall compliance costs (EEA 2005).

Beside public instruments, to move towards more sustainable land use systems, also private investments are crucial. On one hand, it is essential to attract private capital, from both domestic and foreign sources and, on the other hands, there are also **risk mitigating instruments**, designed to reduce risks to make investments appeal to a wider range of investors (Girling and Bauch, 2017). These risk mitigating instruments can be:

- Insurance

- Partial credit guarantee

- Off-take agreements

Furthermore, there are other instruments that have not typically been regarded as market-based instruments. For instance, **liability and compensation schemes** that, in the environmental context, recognise the rights of the public to environmental goods, specially placing responsibility on who is in charge of an environmental damage, for restoring or compensating it (EEA 2005). This can produce a number of economic impacts and to affect the market, and they can therefore be classed as economic or market-based instruments.

Another example is represented by the **Green Public Procurement (GPP)** that is one direct way for governments to influence the market to provide more environmentally friendly goods though implementing green criteria

Finally, the **ecolabelling schemes** that provide information on products and their environmental and health impacts from their production and their use (e.g. organic farming labelling, eco-labels). They can help consumers to choose more environmentally friendly products and services, leading to a consumption shift.

Several tools and guides are available to support policymakers and other change-makers understand who finances what, and what the best solutions could be to maintain and grow forests sustainably (Rosenberg et al., 2018), such as:

- LAND-USE FINANCE tool: provides standardised guidelines and templates for countries and jurisdictions interested in understanding financial lows associated with land use
- LIFT tool: helps jurisdictions build sustainable landscape project pipelines and mobilise sources of finance.
- NDC Quick-start guide to NDC implementation: identifies steps that countries can follow to identify NDC financing needs and financing options. It may provide a useful check list for policy makers.
- LEDS GP Resource guide for NDC finance compendium of country reports and case studies, guides and toolkits: some of the resources included here may be useful for policy makers.
- UNDP's Investment and Financial Flow Analysis (I&FF) supports countries to cost the investment and financial flows needed to mitigate/adapt to climate change.

Market-based instruments can be implemented in a systemic manner, across an economy or region, across economic sectors, or by environmental medium, such as water. These instruments are mainly used in environmental policies to incentivise production and consumption changes while giving them flexibility in how they do so.

Many EU environmental policies include market-based instruments. For instance, as far for the land use issue, the price-based market-based instruments are included in the Common Agricultural Policy while the quantity-based instruments are represented by the EU European Trading System (ETS) that operates following a 'cap and trade' mechanism.

Furthermore, financial incentives are foreseen within the EU Bioeconomy Strategy and in the Renewable Energy Directive 2018/2001/EU (REDII). While the EU Bioeconomy Strategy aims at supporting R&D actions towards sustainability (i.e Horizon 2020), the REDII provides subsidies or incentives, exemptions or quota mechanisms for targeting the use of renewables by 2030 to 32% of overall energy use as a means to reduce GHG emissions.

2.5.2 The European Trading System (ETS)

The European Trading System (Directive 2003/87/EC) represents the most prominent EU-wide policy to reduce GHG emissions (Parag and Fawcett, 2014) and it operates following a 'cap and trade' mechanism. It first sets a cap on overall GHG emissions, covering only 45% of total emissions, including the industrial sector such as the production of chemicals and polymers. However, it does not apply to many sectors, including agriculture, food industry, and transport (European Commission, 2016). Moreover, due to its market-based nature, the ETS defines CO2 prices in a highly variable system, with changes that often depend on market conditions (e.g. limited industrial production due to recent economic recession), rather than actual greening measures (Camanzi at el., 2017).

The cap for 2020 was set to reduce emissions by 20% compared to 1990. For 2030 it sets a reduction by 45% compared to 1990.

All 11,000 EU installations covered under the cap have to monitor their GHG emissions and surrender as many EU ETS allowances as they have emitted tones of CO2 equivalent. In the meantime, installations can buy ETS allowances, or receive them for free. If they have more allowances than they emit, they can keep these for the future, or sell them on the EU ETS allowances online platform market.

Effectiveness and limitations

EUTS Emissions trading (ET) offers a dynamic incentive and can help ensure that a given target is met, if combined with appropriate allocation of emission allowances. The price of allowances is, however, uncertain and determined by the market. Therefore, the costs of pollution abatement are uncertain, and excessive costs could occur (Fullerton et al. 2010). ET can lead to significant **additional administrative** tasks and burdens and greater needs for monitoring, verification and enforcement, the costs of which need to be taken into account in any consideration of whether ET schemes are the sensible solution. An argument against permits is that formalising emission rights is effectively giving people a **license to pollute,** and this can be considered to be **socially unacceptable.**

When using a transferable-permit system, it is very important to accurately measure the initial problem and also how it changes over me. This is because **it can be expensive to make adjustments** (either in terms of compensation or through undermining the property rights of the permits) (OECD 2008).

2.5.3 The Common Agricultural Policy (CAP)

With an annual budget of roughly €59 billion, the CAP is reformed to strengthen the competitiveness of the sector, promote sustainable farming and innovation, to support jobs and growth in rural areas and to move financial assistance towards the productive use of land. It achieves these objectives by financing a range of support measures through the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD), notably:

- income support through **direct payments** ensures income stability, and remunerates farmers for environmentally friendly farming and delivering public goods not normally paid for by the markets, such as taking care of the countryside (Regulation (EU) 1307/2013)
- **market measures** to deal with difficult market situations such as a sudden drop in demand due to a health scare, or a fall in prices as a result of a temporary oversupply on the market (Regulation (EU) 1308/2013)
- **rural development measures** with national and regional programmes to address the specific needs and challenges facing rural areas (Regulation (EU) 1305/2013)

The Multiannual Financial Framework (MFF) 2014-2020, (the European Union's seven year spending plan) allocates 38% of its total amount to the CAP to finance expenditure for market measures, direct payments and rural development programmes.

Direct payments

The European Union (EU) provides farmers with income support or "direct payments" to

- function as a safety net and make farming more profitable
- guarantee food security in Europe
- and assist them in the production of safe, healthy and affordable food
- reward farmers for delivering public goods not normally paid for by markets, such as taking care of the countryside and the environment

These payments are fully financed by the EU, and account for over 72% of overall CAP spending. This equates to spending of more than €41 billion a year for direct payments. With the 2013 reform, EU countries have to allocate **30% of their income support** to **agricultural practices beneficial for the climate and the environment**, notably soil quality, biodiversity and carbon sequestration – the so-called "Greening" measures.

Three criteria/obligations to receive the **"Greening":**

1 **Crop diversification**: a greater variety of crops makes soil and ecosystems more resilient.

2 **Maintenance of permanent grassland**: grassland supports carbon sequestration and protects biodiversity (habitats).

3 **Ecological focus areas**: Ecological Focus Areas (EFA), for example trees, hedges or land left fallow that improves biodiversity and habitats.

Direct payments are granted to farmers in the form of a basic income support based on the number of hectares farmed (generally between €100 and €500 and/or 0.3 ha to 5 ha respectively). However, the greening rules do not apply to farmers who opted for the small farmer's scheme, for administrative. As the RED II stands that the feedstock that is produced by small holders (<2 ha ownership) is a low ILUC risk feedstock, in the same direction, the CAP foresees voluntary scheme for small farmers (<5 ha), a simplified direct payment scheme granting a one-off payment to farmers who choose to participate. The small farmers scheme includes simplified administrative procedures, and participating farmers are exempt from greening and cross-compliance sanctions and controls.On the other hand, **organic farmers automatically receive a greening payment for their farm, as they are considered to provide environmental benefits by the nature of their work.**

Furthermore, up to 5% of the national allocation for direct payments can be used for top-up payments to farmers in these Areas with natural constraints (ANCs), that are areas where farming is handicapped by natural or other specific constraints. This option has been applied so far only by Denmark as from 2015, and Slovenia as from 2017. The **rural development programmes** is the main instrument to support farmers in these areas (see next page).

Market measures

Market measures aim at stabilizing agricultural markets and prevent market crises from escalating, at boosting demand and help EU agricultural sectors to better adapt to market changes. Market measures are used to address the situation if normal market forces fail - for example, if there is a sudden drop in demand because of a health scare or a fall in prices because of a temporary oversupply on the market. In such cases, the European Commission can activate market support measures providing farmers with a range of tools for around 5% of overall EU farm spending. This part of the budget – funded through the EAGF – also includes elements such as promotion of EU farm products and the EU school schemes.

An interesting aspect is that market measures support Producer organisations (POs) or associations of producer organisations (APOs) since they are important players in the supply chain. However, it recognizes the importance only in the food supply chain and not in the whole agricultural supply chain. By working together, farmers can reduce transaction costs and collaborate when processing and marketing their products, as much in the food industry as in the biobased one.
This Regulation mentions also the fights against unfair trading practices (UTPs) when relationships in business-to-business deviate from good commercial conduct. However, this is applied only in the food supply chain and not at agricultural level. Often farmers and small operators in the agricultural supply chain do not have sufficient bargaining power to defend against UTPs.

Rural development programmes

- Programme priorities

Member States and regions define the measures they want to be co-financed in their Rural Development Programmes that draw up based on the needs of their territories. Funded through the EAFRD, the rural developments measures should address at least four of the following six common **EU priorities**:

- fostering knowledge transfer and innovation in agriculture, forestry and rural areas
- enhancing the viability and competitiveness of all types of agriculture, and promoting innovative farm technologies and sustainable forest management
- promoting food chain organisation, animal welfare and risk management in agriculture
- restoring, preserving and enhancing ecosystems related to agriculture and forestry
- promoting resource efficiency and supporting the shift toward a low-carbon and climate-resilient economy in the agriculture, food and forestry sectors
- promoting social inclusion, poverty reduction and economic de The broader Rural Development policy objectives are further articulated through six priorities, providing a basis for implementing the policy.

The broader Rural Development policy objectives are further articulated through six priorities, providing a basis for implementing the policy.

- Priority 1: Knowledge Transfer and Innovation
- Priority 2: Farm Viability and Competitiveness
- Priority 3: Food Chain Organisation and Risk Management
- Priority 4: Restoring, Preserving and Enhancing Ecosystems
- Priority 5: Resource-efficient, Climate-resilient Economy
- Priority 6: Social Inclusion and Economic Development in rural areas

In general, the Rural Development Programmes covers projects such as on-farm investment & modernisation, installation grants for young farmers, agri-environment measures, organic conversion, agri-tourism, village renewal, or providing broadband internet coverage in rural areas. Accounting for almost 25% of CAP funding, these measures are generally co-financed by national, regional or private funds and generally extend over several years.Through rural development programmes, EU expenditure on agri-environment measures is expected to total 25 billion EURO over the course of the 2014-2020 period.

- Focus areas

As far for the programme priorities, some of the Focus Areas cover the Land Use Change Factor Risks, such as:

- Focus area 4B: it is designed to improve Improving water management, including fertiliser and pesticide management. The target is to manage 15.1% of agricultural land and 4.2% of forestry land to improve water management.
- Focus Area 3B: it is designed to help farms to prevent and manage risk. This can be supported through financial contributions of various kinds, such as for insurance premiums and/or for mutual funds to cover losses caused by climate changes, diseases, pests or environmental incidents.
- Focus Area 2 A: it is designed to improve economic performance of all farms, farm restructuring and modernisation, restoring and enhancing the competitiveness of farms confronted with major challenges such as low and fluctuating prices, and concentration. The target is to mobilise 47.2 billion EUR of public and private investment to support 335,000 farms.
- Focus Area 5A: it is designed to increase the efficiency of water use by agriculture. Most of the support provided is devoted to physical investments in more efficient irrigation systems. The target is to mobilise 4 billion EUR of public and private investments to improve irrigation systems in 15% of the EU irrigated land.
- Focus area 4C: it is designed to prevent soil erosion and improve soil management. The target is to manage 14.3% of agricultural land and 3.5 % of forestry land to improve soil management and/or prevent soil erosion.
- Focus Area 5E: it is designed to support actions that foster carbon conservation and sequestration in agriculture and forestry. One of the main ways in which the RDPs aim to achieve this goal is through investments in forest area development and improvements in the viability of forests. The target is to mobilise 4 billion EUR of public expenditure to support 2 % of the EU agricultural land in contributing to carbon sequestration and conservation.

Farm advisory systems (FAS)

All member states of the European Union (EU) have a Farm Advisory System (FAS). This system supports farmers to understand and meet the EU rules for environment, public and animal health, animal welfare and the good agricultural and environmental condition (European Commission 2020c, website). This includes rules on the financing, management and monitoring (EU regulation 1306/2013). The FAS provides several information about:

- obligations at farm level ("cross-compliance");
- the "greening" agricultural practices;
- measures for farm modernisation, competitiveness building, sectorial integration, innovation and market orientation and for the promotion of entrepreneurship;
- requirements for water protection, efficient and sustainable water use;
- use of plant protection products;
- integrated pest management.

The FAS may also provide other information on the promotion of farm conversion and diversification of their economic activity, the risk management and appropriate preventive actions, the minimum requirements for agri-environment-climate payments and for fertilisers and plant production products and the information related to climate change mitigation and adaptation, biodiversity and protection of water.

However, the FAS do not provide any specific **information/requirements for sustainable bio-based production to the farmers**.

Effectiveness and limitations

The Common Agricultural Policy (CAP) is the main agricultural policy framework of the European Union. The overall budget for the CAP 2014-2020 was set at EUR 408 billion, of which initially 76% were allocated to Pillar 1 (covering market related expenditure and direct payments), and the remaining 24% to Pillar 2 (covering the rural development programme).

Although direct payments and market measures have traditionally been viewed as distinct support measures from rural development programmes, they are increasingly being combined to provide the most effective and tailor-made support for farmers across the diverse range of EU agriculture.

Relevance for bio-based products

Market-based instruments are relevant to support agriculture and industry in the transition process from fossil-based European industries towards low carbon, resource efficient and sustainable ones.

In particular, the CAP, although it does not contain/impose any specific measure related to non-food Bio-economy sectors, already considers and supports some agricultural measures aimed at increasing the crop yield in a sustainable way through direct payments, market measures and rural development programs. This will ensure the reduction of LUC and ILUC risk due to the potential expansion of the bio-based industry.

There are many tools available for governments and investors to incentivise sustainable land use, each appropriate for different circumstances. There is no doubt that these instruments can work. In many cases, these are the same tools that have been used to develop current industries, including agriculture and renewable energy. It remains to be seen whether they will be used effectively to address the pressing challenges of food security, climate change and deforestation.

2.5.4 The Renewable Energy Directive (RED)

As seen in the previous section, the EU RED sets national targets on the use of biofuels. Directives generally set performance criteria for EU Member States who can choose the instruments best suited to their national context to fulfill them. The achievement of the biofuels targets is largely met thanks to financial and fiscal incentives, varying from one country to another. A 2018 study from the ICCT compared the policy instruments adopted by 6 EU countries to meet the RED targets: Denmark, Germany, Italy, the Netherlands, Sweden and the United Kingdom, all apart from Denmark being among the top 10 consumers of transportation in the EU. The study compares national financial strategies to incentivise the use of advanced biofuels, as reported in the below summary table:

Table 1: summary table for the six select EU member states analyzed

	Biofuel share in transportation fuel[54]	Overall biofuels mandate	Mandate for advanced biofuels (target year)	GHG Reduction quota (target year)	Cap on conventional biofuels (target year)	Price for non-compliance
Denmark	5.75%	(5.75%)	0.9% (2020)	n.a.	n.d.	n.d.
Germany	5.9%	n.a.	0.05% (2020) 0.5% (2025)	-6% (2025)	6.5% (2018)	€470 per tCO_{2e}
Italy	4.8%	7.15%	0.9% (2020) 1.85% (2022)	n.a.	6.7% (2022)	€75 per GJ €150 per GJ (advanced biofuels)
The Netherlands	7.75%	15.4%	1.0% (2020)	n.a.	5.0% (2020)	n.d.
Sweden	31.2%	n.a.	n.a.	-21% diesel (2020 -4.2% gasoline (2020) -40% both (2030)	n.d.	€380 per tCO_{2e} (gasoline) €476 per tCO_{2e} (diesel)
United Kingdom	6.0%	9.6%	0.2% (2020) 2.8% (2032)	n.a.	4.0% (2020) 2.0% (2032)	€9.5 – 11 per GJ €51 – 57 per GJ (development fuels)

n.a. = not applicable
n.d. = not defined

Table 1: ADVANCED BIOFUEL POLICIES IN SELECT EU MEMBER STATES: 2018 UPDATE, Source ICCT (2018)

2.5.5 The EU bioeconomy strategy

Adopted by the European Commission in 2012, the European Bioeconomy Strategy aims to pave the way to a more innovative, resource-efficient and competitive economy that reconciles food security with the sustainable use of renewable biological resources for industrial and energy purposes. The transition from fossil-based European industries towards low carbon, resource efficient and sustainable ones is a major challenge. It entails the transformation of conventional industrial processes and products into environmentally friendly bio-based ones, the development of integrated bio-refineries and the opening of new markets for bio-based products. The market-based instrument adopted to achieve this mail goal is represented by the Horizon 2020 programme that makes available over €4 billion to support bioeconomy-related research and innovation actions. In particular, within the pillar 2 Societal challenge, two mail calls support projects that are in line with the European Bioeconomy Strategy:

- the call "Innovative, sustainable and inclusive Bioeconomy" , opened in 2014 with a budget of 44.5 million. "Innovating for sustainable Growth: a Bioeconomy for Europe";
- the calls "Sustainable Food Security" (138 M€ in 2014) and "Blue Growth" (100 M€ in 2014) that contribute to cover other important areas of the Bioeconomy.

Some important measures for promoting the Bioeconomy in the Eu are reported in Table 2:

Key Points	Policy Measures	Concrete Implementation	Budget in Euro	Timetable	Sources
a) Promoting innovation	R&D	Horizon 2020 Call "Food security, sustainable agriculture, marine and maritime research, and the bioeconomy"	2,8 bn.	2014–2020	Horizon 2020 (website)
		Horizon 2020 Calls "Climate action, resource efficiency and raw materials", "Secure, clean and efficient energy", "Health, demographic changes and well-being" und "Inclusive, innovative and secure societies".		2014–2020	Horizon 2020 (website)
	Key enabling technology	Horizon 2020 "Industrial Leadership and Competitive Frameworks", promotes the development of bioeconomy-relevant technologies, e.g. biotechnology, material science		2014–2020	Horizon 2020 (website)
	Clusters, Public-Private-Partnerships	SPIRE: chemical PPP (Horizon 2020 "Resource efficiency")		2014–2020	http://www.spire2030.eu
		BIC Bio Industries Consortium (Horizon 2020 "Bioeconomy")	1 bn.	2014–2020	http://biconsortium.eu
b) Commercialization	Financing and venture capital	Horizon 2020 "Industrial Leadership and Competitive Frameworks", promotes SME innovation and access to venture capital		2014–2020	Horizon 2020 (website)
c) Demand-side instruments	Public procurement	Public Procurement Network (Horizon 2020 "Bioeconomy")			Horizon 2020 (website)

Table 2: Important measures for promoting the in the EU, Source Biooekonomierat (2015)

Research and innovation will provide the means to reduce the Union's dependency on fossil resources and contribute to meeting its energy and climate change policy targets for 2020. Investments in research and innovation under this societal challenge will support Europe in contributing to food security, climate protection and sustainability. It will also enable Europe to take leadership in the concerned markets and will play a role in supporting the goals of the Common Agricultural Policy, the European Bioeconomy Strategy, and more broadly of the Europe 2020 strategy and its flagship initiatives 'Innovation Union' and 'Resource-efficient Europe'.
Altogether, the budget for these calls will serve to further implement the Bioeconomy in Europe where at least five countries (Finland, Germany, Ireland, Sweden and Norway) already have approved strategies at governmental level.
For 2021-2027, the Commission has proposed to allocate €10 billion under the Horizon Europe programme for food and natural resources.

Furthermore, with the purpose to reinforce the Bioeconomy industry, the EU and the Bio-based Industries Consortium (BIC) built up the **Bio-based Industries Joint Technology Initiative**, a public-private partnership, investing a total of €3.7 billion in bio-based innovations over 2014-2020.

Effectiveness and limitations

Concerning the **Horizon 2020** programme that supports the EU bioeconomy strategy, the first interim report developed by the EC in 2017 shows that Horizon 2020 is an attractive and well performing programme (European Union 2017). In the first three years of programme implementation, EUR 20.4 billion – just about one fourth of the total Horizon 2020 budget - has been allocated to 11,108 signed grants. Horizon 2020 has so far attracted more than 100,000 applications, representing a **65% increase** in the annual number of applications compared to its predecessor, the 7th Framework Programme (FP7). In particular, the Societal Challenges pillar allocated EUR 7.4 billion to 2941 projects.

Horizon 2020's efficiency has been enhanced compared to FP7 through the creation of a Common Support Centre ensuring the harmonised implementation of Horizon 2020's rules for participation across the different actors implementing the programme. Horizon 2020's efficiency has also improved compared to FP7 through the large-scale simplification of the rules of participation, to the satisfaction of stakeholders. Furthermore, Horizon 2020 projects already produce new knowledge, strengthen capabilities, and generate a wide range of innovation outputs including new technologies, products and services: 563 firms introducing innovations new to the market (56% SMEs), 471 new to the company (53% SMEs); 70% of SMEs aim at new to the market innovations; more than half of SME Instrument Phase 2 beneficiaries have already reached the market. Every euro invested under Horizon 2020 brings an estimated GDP increase of 6 to 8.5 euros (EUR 400 to EUR 600 billion by 2030)

Relevance for bio-based products

On the other hand, the EU bioeconomy strategy, through the Horizon 2020 program, financed several projects for the sustainability assessment of the bio-based products production. As the bio-based is an emerging industry, it will be very important to reinforce the role of the public-private partnership, such as the Bio-based Industries Joint Technology Initiative, to leverage capital markets and additional private and public funds (e.g. synergies with EU Structural Funds) to top up existing public and private commitments.

2.6 Validation and assurance through certification

In the spirit of liberalism behind the development of international trade law, products placed on the market generally do not need to be third party certified, or to fulfil specific sustainability requirements. Exceptions fall under the scope of WTO's Technical Barrier to Trade (TBT) and should be justified (e.g. measures to protect human, animal, or plant life or health, the environment and the consumer) (WTO 2020, website). These TBT measures are of two categories: technical regulations (mandatory product characteristics or their related processes and production methods) and conformity assessment procedures (mandatory procedures for sampling, testing, inspection, evaluation, verification and assurance of conformity, registration, accreditation, etc) (see European Commission 2020b, website). Mandatory third-party certification falls under this second category. Being an exception in international trade, the European Commission uses the 'principle of proportionality' when selecting conformity assessment options, in the selection of conformity assessment options, as explained in its Guide to the implementation of directives based on the New Approach and the Global Approach: "*directives take into consideration, according to the principle of proportionality in particular, such issues as the type of products, the nature of the risks involved, the economic infrastructures of the given sector (such as the existence or non-existence of third parties)* (…) '*The principle of proportionality also requires that the directives should not include unnecessary procedures, which are too onerous relative to the objectives" (European Communities 2000).*

Having said that, EU policy makers have made use of certification schemes for compliance purposes (known as 'co-regulation') in the last decade, as shown by the adoption of the Renewable Energy Directive or the EU Timber Regulation (Ugante 2013). As highlighted by Ugarte et al (2013), "*the idea of 'co-regulation' is that states set out sustainability criteria for certain economic sectors and recognise private control mechanisms that assure compliance with those sustainability criteria. States opt for co-regulation because their direct control is limited to the boundaries of the state jurisdiction"*. More detailed information on co-regulation mechanisms can be found in Deliverable 9.3.

Requiring goods placed on the market to be third-party certified means that the burden of proof to show compliance is shifted: under the usual EU single market rules, manufacturers self-declare that their products are compliant and market surveillance authorities may carry out tests on these products to check compliance ; while when third-party certification is required, supply chain actors need to proof to a third party that their product is compliant before placing it on the market. It provides additional assurance that measures are in place and lower the risk of free riders (STAR-ProBio 2019c, Deliverable D7.2). However, when private certification schemes are this independent third party, it also means that the implementation check is 'outsourced' to market actors, which is rather unusual (Stattman et al, 2018).

A certification scheme revolves around (at least) three key institutions: the standard setter, the certification body and the accreditation body (FAO, 2003). The standard setter develops the criteria, rules for traceability, verification and any other component needed to establish a certification scheme. The certification body, which is an independent entity, checks whether the criteria of the standard(s) are fulfilled by an economic operator, generally through operational audits (ISO, 2020). The accreditation body is another independent entity and ensures that the certification body is competent to check conformance with the standard (ISO, 2020).

The RED

In the Renewable Energy Directive, economic operators bringing biofuels onto the EU market have to prove compliance with the RED sustainability requirements using a private voluntary certification scheme recognised by the EC or a national scheme (the latter being not very common), independently from whether biofuels are produce within the EU or imported (Stattman et al. 2018). While compliance with the RED sustainability criteria is not mandatory for the placing of biofuels on the market, to be eligible for financial incentives and/or avoid carbon taxes put in place by Member States. The RED has been an extremely powerful instrument to push the demand for certified biofuels and bioliquids: in 2013 already, a total of 86.5% of the EU's biofuel consumption was certified in the Mid-term evaluation of the Renewable Energy Directive (European Commission 2015) and over 99% in 2017 (EUROBSERV'ER 2019)

The big novelty with the RED is the recognition mechanism (sort of a 'meta-standard', see Stattman et al, 2018) which the European Commission set up. Indeed, since they were plenty of biomass sustainability certification schemes, the recognition mechanism aimed to explicitly identify (by means of a European Commission Decision valid for 5 years) the private certification schemes which could be used to show compliance with the RED, in order to ensure a harmonised understanding and implementation of the sustainability criteria.

The revised RED (RED II) widened the sustainability requirements, adding the need to prove that low ILUC risk practices were observed if high ILUC risk feedstocks were used. These will have to be integrated in the recognised certification schemes. So far, only a limited number of actors (such as RSB) have focused on low ILUC risk-specific rules.

Effectiveness and limitations

There are several lessons to be learnt from the co-regulation mechanism developed under the Renewable Energy Directive.

First, co-regulation is a cost-effective way of ensuring compliance with legislation, not only for market actors, but also for the public authorities usually responsible to check compliance.

Second, certification remains a free market. In the case of the EU biofuels policy, legislation dramatically drove the market for the certification, encouraging the development of numerous competing schemes. Even when recognised by the European Commission, these schemes have different levels of stringency, of good governance, of sustainability requirements and of auditing practices (see the results of the SAT-ProBio benchmarking platform). In a way, the Renewable

Energy Directive and its recognition mechanism set no more than a lowest common denominator, and have created a market push for the 'low bar' certification scheme (ISEAL, 2017). In a very fragmented biofuel certification landscape, Stattman et al showed that the EU biofuel governance sometimes led to "race to the bottom" (Stattman et al, 2018) and underlined the need to give more space and value to **initiatives setting best practices**, e.g. by modulating financial incentives according to the sustainability performance of biofuels.

Third, the recognition mechanism developed by the European Commission has turned out to be one of the cornerstones of the RED. In a special report dated 2016, the European Court of Auditors concluded that "because of weaknesses in the Commission's recognition procedure and in the subsequent supervision of voluntary schemes, the EU certification system for the sustainability of biofuels (was) not fully reliable" (European Court of Auditors 2016). The Court of Auditors' hence recommended that the European Commission adapts future recognition exercises by carrying out **more comprehensive assessment** on the requirements of voluntary schemes (e.g. significant risk of negative socioeconomic effects, such as land tenure conflicts, forced/child labour, poor working conditions for farmers, dangers to health and safety, and of ILUC emissions; compatibility checks with EU environmental requirements for agriculture; evidence of the origin of waste and residues used for the production of biofuels). The Court of Auditors also highlighted the **need for governance checks on the schemes** in aspects such as transparency, inclusiveness of various stakeholders (and potential risks of conflict of interest), accessibility of the standards (some recognised schemes' standards are not publicly available).

Relevance for bio-based products

Co-regulation mechanisms are an innovative and cost-effective way to widen the scope of sustainability requirements outside of one's jurisdiction. In a globalised world with highly complex value chains, these mechanisms are likely to continue to expand. Bio-based products seem to be appropriate goods to be subject to policy instruments similar to biofuels. Building on the lessons learnt from the RED however, **co-regulation mechanisms need to ensure a solid common basis for certification schemes** (by means of a recognition mechanism), while making sure that **continuous progress and most sustainable practices are encouraged**.

In addition, as pointed out in Deliverable 9.3, since the development of sustainability criteria in the Renewable Energy Directive, standards have been created that set out similar sustainability criteria for non-RED-related products (including for biomass more broadly). **More clarity for market players and public and private users** (consumers, companies, authorities, etc.) would be helped through an assessment of where updates and revisions are needed in legislation and standards, and of **how to integrate certification schemes as a sign of conformity**.

3. Lessons learnt from STAR-ProBio

Direct and indirect land-use change was addressed in several work packages of the StarProBio project (see table 3). In the graph (figure 6) we summarized results and recommendations of former research activities. The general approach of this review is to distinguish between policies that have an effect on the demand for biomass and policies that manage land use. As shown in the figure, while land use policies aim at ensuring a sustainable use of land by proposing diverse policy instruments and sustainability requirements, market-oriented policies increase pressure on the use of land, for example, by promoting the use of biomass as feedstock. Standards, certifications and other policy instruments, such as the adoption of cascading principles or the use of waste as a feedstock, could be proposed to minimize the risks related to direct and indirect land use change.

From the STAR-ProBio Market Assessment research (WP 5) resulted that for both businesses and end-consumers, information on the origin and type of raw material influences their buying decisions. In addition, land use rights and food security were considered important socio-economic principles to be included in sustainability assessment frameworks.

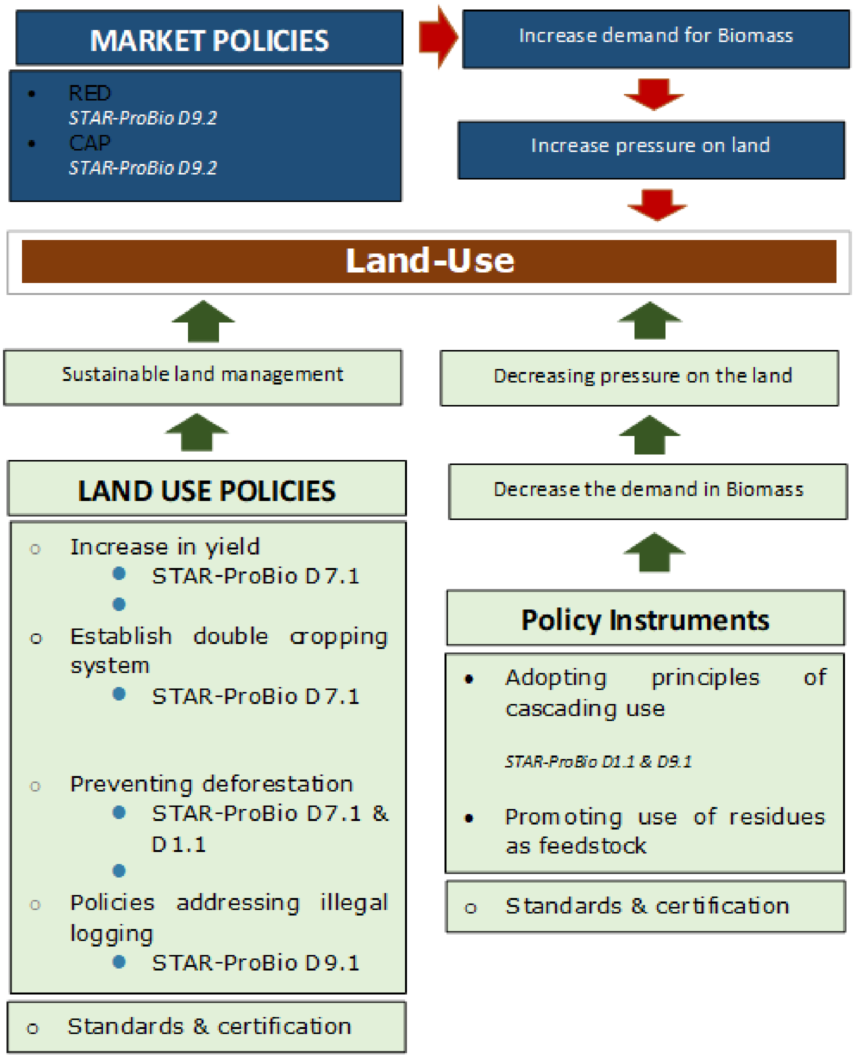

Figure 7: Related findings from previous StarProBio work

Table 3: Results and recommendations of STAR-ProBio deliverables related to LUC and ILUC

Land Use Policies		
Objectives	**Instruments**	**Description**
Improve productivity	establish double cropping system	Increasing demands for dedicated crops for specific bioeconomy sectors may increase the attractiveness of **double cropping systems**. This could reduce the amount of additional land to be converted. STAR-ProBio_D7.1: 20: 1763 - 20: 1965 (0)
	increase in yield	INTENSIVE MARGIN: Potential **improvement of yield** with respect to the yield in the baseline when crops and/or agricultural residues are used for bio-based products Increase in feedstock demand for biofuels will lead to increase of area cultivated (area expansion) and/or an intensification (yield increase) (Wicke et al., 2014). In fact, as crop price increases, the economically-optimum spending on all inputs ($ per tonne of crop) increases, and this, in general, can be expected to mean higher yields per tonne of crop(Mulligan et al., 2010). In this term, price influences yield variation in both short- and long-terms. In short-terms and in case of prices increase, agricultural yields may be improved by applying more N fertilizers (increasing amount and/or improving the timing of application), through better weed and pest management and switching varieties grown. Longer-term influences are due to price- induced technological progress, as more R&D are triggered by positively trending prices (Mulligan et al., 2010; Wicke et al., 2014) STAR-ProBio_D7.1: 18
preventing deforestation and loss of natural habitats	Preventing deforestation	A very important aspect is the political framework for the protection of natural areas. Negative iLUC consequences such as **deforestation or the loss of natural habitats** can happen because there is a lack of an appropriate land use policy or appropriate protection and control measures.

		STAR-ProBio_D7.1: 20: 1062 - 20: 1356 (0) Address the protection of forests and grassland, sustainable forest management and restrictions STAR-ProBio D1.1: 45
	Policies addressing illegal logging	**Illegal logging** causing deforestation, Biodiversity loss: Risk is not equally high around the globe, there are hot spots, especially rainforests located in developing regions STAR-ProBio-D9.1: 28 Guarantee of **no deforestation after a certain cut-off date** STAR-ProBio D1.1: 52
soil protection	warning for crops responsible for higher soil erosion	On this basis it can be concluded that specific crops used in the bioeconomy and specifically to manufacture biobased products are not all equal. **A specific emphasis and warning should be put on those crops responsible for higher soil erosion.** STAR-ProBio_D7.1: 23 Sustainable yields: ensure that crops do not affect the regeneration capacity of the acreage (also an environmental issue) STAR-ProBio_D5.1: 19
Standardization and certification	Standardization and certification	Regarding sustainable biomass, interviewees highlighted the **importance of environmental criteria for the cultivation of land, the role of land use and transparency regarding the origin of the biomass, and to consider the environmental effects of transportation**. Transparency of farming practice, in particular regarding the use of pesticides is also important.

		STAR-ProBio_D9.2: 27 Frameworks for agricultural production systems should include **measures to maintain soil qualities** and services. This includes, amongst others, requirements regarding the **maintenance of soil organic carbon, protection from soil erosion, water management practices**, etc. STAR-ProBio_D7.1: 20 As experts described, Assessment measures and thresholds have to be provided for existing standards, (e.g. EN16751)l. In particular, suggestions to specify the assessment regarding Land use rights was proposed. STAR-ProBio D1.1: 71
Other Policies		
Improving conditions for cascading use	Greater consideration of the end of life phase in policies: End of life options is one of the most repeated keywords in existing policies, however, those options focus mainly on biomass production and processing. A significant gap remains in the options for the end of life phase of products. In particular, end of life scenarios that include cascading, recycling, etc. are not adequately reflected in policies. EoL criteria are sporadically used (e.g. minimum recycled content in product, implemented waste management, intended cascade use). Furthermore, **increased cascading use** might require a greater cross compatibility among policies and recognition between certification systems. STAR-ProBio-D9.1: 37 Generally, criteria aiming to address sustainability aspects related to different forms of after-use-phases criteria are only sporadically used so far. Examples which could be found are criteria such as: minimum recycled content in a product, implemented waste management, **intended cascading use**, etc. STAR-ProBio D1.1: 57	

	Regarding environmental issues, the **cascading use of biomass resources** lacks indicators. In this context, cascading use of biomass is defined as the sequential use of biomass for several applications before ending with an energy production step. Recycling of biomass between the different steps will be a key indicator in this regard and as such needs to be developed. STAR-ProBio D1.1: 59
Promoting use of residues	The option to make **PLA of residues** also promotes goals such as biodiversity as well as the protection of forests and nature in general. STAR-ProBio_D9.2: 27 The Waste Framework Directive promotes the waste hierarchy as a guiding principle. This hierarchy sets out a preference for waste prevention, followed by the sequence reuse, recycling, recovering energy and finally landfill. The **hierarchy does not explicitly address biodegradation or composting**, although they are captured by the 'recycling' element. STAR-ProBio considers that within the recycling element, there is another hierarchy: mechanical recycling is the preferred option in terms of material use and preservation, chemical recycling comes next and finally organic recycling (aerobic composting and anaerobic digestions). STAR-ProBio_D9.2: 11
Standardization and certification	**Increased cascading** use might require a greater cross compatibility & recognition between the certification systems (EoL issue) STAR-ProBio D1.1 **EOL criteria** (e.g. minimum recycled content in product, implemented waste management, intended cascade use (EoL issue) STAR-ProBio D1.1: 64

	CE Delft (2017) suggests that a sustainability scheme for bio-based plastics could set targets for GHG emission reduction with a view to minimise (in)direct land-use change. STAR-ProBio_D9.2: 17 Sustainable biomass of food packaging is taken into consideration by existing certificates, such as ISCC PLUS and Bonsucro and should be considered as best practices for further certification schemes. STAR-ProBio_D9.2: 27 **The End-of-life (EOL)** stage is one of the most important environmental aspects to be considered in the sustainability assessment of bio-based products. In this regard, STAR-ProBio (2017) found, for example, that recyclability is not significantly reflected by certification frameworks for bio-based products so far. More specifically, STAR-ProBio (2017) identified gaps related to EOL scenarios (cascading recycling, etc.) and EOL criteria, e.g. minimum recycled content in product, implemented waste management and intended cascade use. The most appropriate EOL option for a bio-based product is product specific. Therefore, it is important to account for the different EOL options and properly communicate the recommended EOL option to the end-consumer. The results described in this report show that this is an imported issue that needs to be integrated into sustainability certification and standardisation. STAR-ProBio_D5.1, P. 11 The interview results provide manifold input to support the bio-based economy by further standardisation. They also include suggestions to demand more obligatory **criteria for products containing biomass, especially from outside the EU**, regarding the protection of forests, grassland as well as the consideration of indigenous people and their rights and legality. STAR-ProBio D1.1: 67 Nevertheless, NTA 8080:1 describes specific limitations concerning new understandings and new issues such as "cascading ILUC, carbon debt" and how the use of woody biomass can be avoided. It is suggested to conduct activities to overcome this gap on a European level instead of a national one only. As mentioned earlier, CENT/TC 383 plans to make changes to the EN 16214-series on sustainability criteria for biomass for energy use to include the revised standards references to the 2015 ILUC Directive modifying both the FQD and the RED. Although experts highlight that these changes are still under development, the

	revised versions will explicitly refer to ILUC. Therefore, this work could be a starting point for standardisation activities for bio-based products, including the determination of assessment measures and thresholds. STAR-ProBio D1.1: 46

Market policies with potential risk of leakage effects	RED	The soon to be revised RED applying after 2021 will expand sustainability criteria to all sectors of bioenergy including heat and power production from solid, liquid and gaseous biomass. This is an important first step to address **leakage effects** as well as potential market barriers, which result from a limitation of mandatory sustainability requirements to a single sector of the bioeconomy (see STAR-ProBio, 2017a). The RED is an example for an approach where public regulations recognise private initiatives, such as voluntary certification schemes, as a way to prove compliance with mandatory criteria. In this regard, certification schemes and labels beyond the biofuel sectors could be potentially used to show compliance with sustainability criteria. Precondition for this is the official recognition of the scheme or label by the EU. This report will analyse the needs for an update of the regulatory framework to better support bio-based products, the need for harmonization of regulations, which address different bio-based products with inconsistent requirements and also to what extent RED criteria are relevant for bio-based products. STAR-ProBio_D9.2: 10 The issue of potential **leakage effects** is related to topics such as indirect land use change or food security risks. The rationale behind is that due to the different regulations and bindingness of sustainability certification between the different sectors of the bio-based economy, pressure e.g. regarding land resources could be shifted from sectors with strong mandatory sustainability requirements in the respective field (such as the definition of "no-go- areas" as in the renewable energy directive 2009/28/EC) to sectors with no mandatory sustainability requirements (all sectors other than the sector of biofuels for transportation). Furthermore, these differences in the regulatory framework lead to substantial differences regarding the principles, criteria sets and indicators certification frameworks between the various sectors of the bio-based economy. As a consequence, compatibility and mutual acceptance between existing frameworks from different bioeconomy sectors are often missing. This can lead to additional burdens and barriers for market actors in the bio-based economy. While, to some extent a differentiation of the certification frameworks seems to be desirable, the definition of a consensus for minimum sustainability criteria for all sectors of the bio-

		based economy would be an important step to reduce negative leakage effects and unnecessary administrative burdens for market actors. STAR-ProBio D1.1: 54 The introduction of mandatory sustainability requirements in the renewable energy directive has addressed a number of pressing and highly relevant sustainability issues related to a large-scale rollout of biofuels for the EU transportation sector. As a consequence, some of these pressing sustainability issues such as the conversion of natural land or forest into cropland has been shifted to other sectors of the bio-based economy which are not directly addressed by mandatory sustainability requirements. These **leakage effects**, which are related to different topics such as indirect land use change, carbon depth or food security risks are still intensively discussed in the EU bioenergy sector. STAR-ProBio D1.1: 55
	CAP	The common organization of the markets in agricultural products (CMO) pillar of the CAP is based on Regulation (EU) No 1307/2013, determining measures on fixing certain aids and refunds related to the common organisation of the markets in agricultural products and Regulation (EU) No 1308/2013) for the market measures. It includes measures addressed to big stakeholders, normally organized in producer's organizations to improve relevant markets (European Parliament Think Tank, 2018). Four EU countries (France, Italy, Portugal and Spain) included mulch films as a possible CMO environmental measure. This facilitates for example the receipt of subsidies for the use of biodegradable mulch film, which is usually more expensive than traditional fossil-based films. Currently, only the above mentioned four countries as main European producers of vegetables use high quantities of mulch films and therefore have strong interests in such measures. STAR-ProBio_D9.2: 44

Assessment of low-ILUC risk (building on deliverable 7.2)

A further important contribution in terms of land-use change comes for the previous STAR-ProBio research in the context of Task 7.2. In order to support the current strategy of the European Commission, the task focuses on iLUC mitigation measures and presents two concepts, for solutions to assess and certify low iLUC risk biomass. In regard to the EU RED directive and the EU RED recast the task discussed additional measures to assess the iLUC risks.

Throughout the recent years, a large number of literature was published on iLUC and iLUC estimations (Laborde 2011; Valin et al. 2015). Several authors have conducted estimations and assessments related to the GHG emission implications from iLUC scenarios resulting from EU biofuel targets (European Commission 2009, 2018). The assessments available have been important and useful to support the impact assessment for EU policies, especially in describing the existing dynamics (e.g. regarding trade flows, land demand and land use change) of the affected markets and the potential change induced by policy targets, which can create additional demands. Recent studies reviewing iLUC modelling work show, that the different models not only produce very different results, but also have different assumptions and set up, so that estimated iLUC effects vary widely across approaches, making it difficult to use them for policy making (Mulligan et al. 2010; Marelli et al. 2011; Edwards et al. 2010) and (Woltjer, et al. 2017). Even though the general results regarding the magnitude of GHG emissions from iLUC differs between the various studies available, two broader, general conclusions can be derived:

- The associated iLUC risks and the emissions from iLUC seem to differ significantly between biofuel feedstocks and technology pathways, which are suitable to fulfil a policy target (e.g. for biofuels or other biobased products).
- The iLUC risk and the associated impact of a biofuel (or a bioeconomy) policy is determined by both the overall demand for biomass induced by the policy and the type of biomass (and conversion technology) to satisfy the target. Thus, the observation from available literature can provide policy makers with the scientific fundamentals to develop well-balanced targets and strategies. Furthermore, in case the models used for the estimation of iLUC effect allow for more differentiated answers, also, more detailed and educated LUC mitigation strategies and policies can be developed.

With the 2015 amendment of the EU RED directive, and the EU RED recast for the timeframe of 2021 to 2030, the EU Commission has adapted its policy framework for the promotion of biofuels, trying to address the above-mentioned aspects. The introduction of a cap for biofuels from conventional agricultural crops was aiming to limit the overall additional demand for crops produced on agricultural land. Secondly, the commission introduced a risk-based approach, which shall allow for a differentiation of the iLUC risks of biofuels.

A meaningful implementation of this concept into the policy framework for biofuels or even the EU bioeconomy requires appropriate and robust tools, which can be used to make the necessary differentiations regarding iLUC risks and can verify potential claims for low iLUC or additional biomass. Especially the latter was a focus point in T7.2, which has explored options to implement the concept of additionality for the production of low iLUC risk biomass into certification schemes. In this sense, T7.2 has discussed six groups of additionality measures and their potential verification with the help of a certification. The six groups of additionality measures analysed are:

- Increased agricultural crop yields,
- Biomass cultivation on unused land,
- Increased livestock production efficiencies,
- Improved by-product integration,
- Reduction of biomass losses,
- Increasing use of waste.

Policy instruments and measures supporting this strategy of additionality and the identification and use of low iLUC risk biomass need to address **two objectives**.

Firstly, the production of additional biomass with one of the above mentioned strategies (or any other) will likely be associated with additional costs (compared to the already used resources). In most cases, these additional costs for the utilisation of the biomass is the reason why the biomass is currently unused. Thus, relevant amounts of additional, low iLUC risk biomass will only be available, if appropriate instruments are in place which will allow for either **a price premium for this biomass** or other **compensations which make the production of this biomass economically feasible**.

Secondly, as pointed out in D7.2, all of the potential additionality measures for the production of low iLUC risk biomass can be associated with negative trade off effects, which can cause negative impacts on aspects such as soil, biodiversity, etc. One example is the **production on unused land**, which requires a sound definition of the term unused in order to protect other, important functions or existing rights associated with the potentially unused land. The second important function of the policy framework are instruments for the **verification of the overall sustainability of the products produced from low iLUC biomass**. This can be done for example with concepts such as the SAT-ProBio framework and an extended sustainability certification for the different sectors of the EU bioeconomy. Furthermore, it seems important to constantly **monitor the effects of a growing Bioeconomy**. However, **robust tools and verification approaches** are needed, to support the implementation of this framework and to avoid free riders (i.e. projects certified as low iLUC without introducing effective additionality practices). Otherwise, a low iLUC framework would lose integrity and acceptance and fail to create the necessary incentives for good projects.

The System Dynamics indirect Land Use Change (SydILUC)

The System Dynamics indirect Land Use Change (SydILUC) model is a dynamic causal-descriptive model that estimates future global land demand based on projection of bio-based production policies. It works on a global scale, with yearly time steps, so that the uncertainty related to land use allocation and short-time market changes are eliminated. As factors that can reduce the iLUC Risk, the model accounts for: use of co-products, use of residues, use of degraded or abandoned land, market effects, changes in agricultural yields, and use of waste as an alternative biomass for bio-based material production.

The case studies of the STAR-ProBio project focused on bioplastics, so the bio-based material taken into consideration for the SydILUC model were bioPLA, PBS and PUR, while the biomasses taken into consideration were: maize, soy beans, and sugar beet pulp. In order to test the model, it was assumed that a policy would be put in place where the fossil-based plastics in use would have to be substituted up to a prescribed percentage with bioplastics (for the specific policy targets see deliverable 7.2)

The sensitivity analysis conducted on the SydILUC model, version 35, which is the version used to implement the ILUC risk tool (see deliverable 7.2), allows to provide suggestions for policy recommendation on how to manage and reduce iLUC risk. This was done for each of the biomasses considered in WP7 of the Star-PROBIO project. The methodology and detailed findings of the sensitivity analysis is reported in the Annex 1.

The main findings of the sensitivity analysis are:

1. In the case of maize:

a. There is moderately low risk of ILUC for maize; actually, this looks the more promising biomass between the three proposed here.
b. The use of residues, as a strategy to reduce ILUC risk, has very high uncertain effects. Hence, it is difficult to recommend it.

c. The increase in agricultural yields has the potential to control for the ILUC risk, up to a point of reducing it to very low levels even in the case of the complete substitution of EU plastics. However, (a) increase in agricultural yields is difficult in EU, since they are already very high (the "yield gap" is narrow) – however it is possible to increase them in other countries of production, , i.e. a possible strategy to decrease risk of ILUC is to actually be sure that the crop is produced abroad, in a country where the gap is larger and agricultural yield improvement is possible; b) increase in agricultural yield can decrease soil quality and increase soil erosion, and this is not yet properly modelled in the model. So, this policy should go together with sustainable soil protection policies as well.
d. The increase in yields of bioplastic produced by raw biomass has a very clear effect on ILUC, reducing it. This can be achieved not only by researchers finding new, more efficient pathways, but also: (a) decreasing raw material loss by increasing value chain efficiency; (b) decreasing raw material needed to obtain bio-plastic by promoting waste-to-bioplastic synthesis as part of the main biomass-bioplastic synthesis– even getting few percentage of bioplastic from waste has a high potential of reducing ILUC risk.
e. If part of the bioplastic is obtained by a waste-to–bioplastic synthesis independent from the biomass-to-bioplastic synthesis, then the reduction in ILUC risk results from the reduction of the production target for that particular biomass (maize in this case).

2. In the case of soybean:
a. There is a high risk of ILUC for the use of soybeans, but not as high as in the case of sugar beet pulp.
b. Two possible policies to decrease the ILUC risk are the increase in agricultural yields on one hand, and the increase of industrial yields of bioplastic synthesis on the other hand. However, both strategies show high uncertainty.
c. A sure way to decrease ILUC risk, at least from the results of the model, is the increase in yield of food from the raw biomass. However, this has not to be only due to better conversion of the raw material (i.e. using also less edible parts as food), but also to the decrease in raw biomass waste along the value chain (decrease food waste). This effect is marked for soybeans due to the direct competition of use for bioplastic with food.

3. In the case of sugar beet pulp:
a. The model tells us that this is the biomass with the highest risk of ILUC, between the 3 analysed here.
b. The only way to control ILUC risk is to increase the industrial yields of bio-plastic synthesis from raw biomass.

National and local specific aspects

These findings result from the application of the SydILUC model on a global scale. However, it is necessary to make other considerations on the factors that influence the ILUC risk at national (I) and local level (II) for specific biomass. In particular:

I. National level

At national level, in the case of maize in China and USA the larger iLUC risk reductions:

a. for China, are obtained from **agricultural yield increases**, since it is a very influential parameter in the model and there is good range for improvement

b. for the USA, where yield rates are already close to maximum potentials, the **use of co-products** is the most promising strategy to reduce iLUC risk.

In the case of soybean in Brazil and Argentina, due to the similarity between the two countries and their production systems, the best ILUC reduction strategies are the same:

a. the most influential low iLUC risk strategy is the production on **abandoned/degraded land**. However, such land should be carefully certified, since there is a high risk of expanding on otherwise natural land. **Increased chain efficiency and increase in agricultural yields** are also valuable risk strategies. Due to the large erosion patterns in these two countries, and the low land protection given by soybean cultivation, better land practices seem to have little impact on iLUC risk.

In the case of sugar beet pulp in Germany and Russia the relative iLUC risk level of production of PLA or PBS from soybean is lower than that estimated for the same production of PLA or PBS from maize in USA and China. However, iLUC risk is a relative measure, consistent only within a certain biomass; to compare different biomasses, the estimated land use expansion should be used instead. When this is done, the estimated ILUC for sugar beet pulp is 2 to 3 orders of magnitude larger than that of maize (tables 11 and 13 in deliverable 7.2). In this case, the most promising low iLUC risk strategies are:

a. the production on reclaimed land and the increase in industrial yield efficiency. This is due to the relatively small effects of agricultural yields on overall production.

II. Local level

In Iowa, the biggest USA producer of Corn, the farm can:

- increase its yield in this year by ~0.16 t ha^{-1} $year^{-1}$ after the implementation of the **yield improvement measure** of better adapted crop varieties and improvements in plant breeding
- produce additional low iLUC risk biomass on the former abandoned land; however, the quality and quantity of such land is sub-optimal.

In Romania, where corn production is not completely mechanized, many fields are still managed by hand or using animal power, so the farm possibility to decrease the iLUC risk for biomass production is:

- To improve the yield, the farm implements the measure of reduced tillage and soil conservation. By application of this yield improvement measure, the farm can increase the corn production in accordance to the concept of sustainable agricultural intensification (Scherer et al. 2018)

- To expand on the abandoned land, which is relatively abundant in Romania. Such land was state owned during the communism government, and has since been privatized; however, the process is not concluded yet. Moreover, the decrease of the population could result in the increase of individual farms sizes.

The large variability in how, where and why different biomass are cultivated, and on their role in the global market, suggests the need to analyse at least the most used biomasses in detail, and to try to create categories of biomasses with similar characteristics and possible iLUC effects.

4. Policy Recommendations

In this deliverable, we addressed various land use governance instruments used primarily in EU environmental and sectoral policies. We also considered previous deliverables of the STAR-ProBio project in order to take the most important findings with relation to land-use policies into account.

The development of a sustainable bio-based economy can be supported by a number of policy instruments. First it is important to clearly identify outcomes and practices which have high and low land-use and land-use change impacts, in order to mitigate/avoid the first and promote the latter (4.1). The uptake of these best practices and/or avoidance of worst practices can be fostered through financial mechanisms, or mandatory targets (4.2). Finally, trust in land-use policy instruments can be strengthened by monitoring frameworks and certification (4.3). We conclude this section by a set of overarching recommendations (4.4).

4.1 Instruments identifying good and bad practice

The development of a policy framework for sustainable bio-based products can first rely on instruments enabling economic actors to identify and manage the main environmental and social risks in a specific supply chain. **Due diligence mechanisms** can be of great help to **filter out the most environmentally and socially harmful goods and practices** (such as those produced infringing and land use rights or protected areas) and **improve information sharing** between suppliers and clients. As national governments and the EU are increasingly looking into cross-sectoral mandatory due diligence requirements for products placed on the market, the EU Timber Regulation mechanisms have proven to be effective in **increasing control** over wood supply chains, although implementation should be **more harmonised**. **Mandatory due diligence could be one of the starting points of a sustainable (bio-based) product policy.**

Moreover, policy instruments such as the development of protected areas aiming to mitigate the adverse impacts of direct land use change are powerful conservation tools, although costly to manage and very dependent on local context. **Support given to bio-based products as part of EU policies should be directed to products whose biomass feedstock does not originate from high biodiversity and high carbon stock land**. In order to **overcome local divergences, an internationally agreed classification of what 'high biodiversity' and 'high carbon stock' areas** entail facilitates such implementation.

However, no-go areas are only appropriate to address direct land-use change. To address indirect land use change, EU policies are now focusing on ensuring that 'risky' feedstocks have been produced following low-ILUC risk practice. Deliverable 7.2 showed that the **implementation of an iLUC risk framework (SydILUC model, iLUC Risk tool and LIIB) provides interesting opportunities to foster a general development towards improved land use and gains in productivity in agriculture more generally**. This is especially the case, if the logic of this framework would be expanded to the whole EU bioeconomy in the future. This would also **help mitigating the risk of leakage effects from one sector to another** due to unharmonized land use governance from one biomass application to another. Building on the CDM of the Kyoto Protocol, the RED secondary legislation contains the concept of 'additionality', to identify that increase in biomass production while not leading to land expansion. Proving additionality under the two frameworks creates an additional economic value (the carbon credit under the CDM and the low iLUC certification under the RED 2). Nevertheless, additionality should be further specified in policies. STAR-ProBio deliverable 7.2 for instance proposes six additionality measures. In the case of maize, at global level, the increase in agricultural yields has the potential to control for the ILUC risk, up to a point of reducing it to very low levels even in the case of the complete substitution of EU plastics. However, increase in agricultural yields can decrease soil quality and increase soil erosion, therefore policy recommendations should go together with soil production policies as well.

4.2 Instruments facilitating the uptake of good practice and disincentivizing bad practice

Market-based instruments are crucial to support the transition towards a sustainable bio-based industry. Improvements of existing instruments include the following:

1. Although the CAP considers and supports the implementation of agricultural measures and aims at increasing the crop yield in a sustainable way through direct payments, market measures and rural development programs, it should also not contain/impose specific measures related to non-food Bio-economy sectors that are not considered yet. And yet, the EU bioeconomy strategy and CAP are highly complementary in principle, but the current exploitation of potential synergies is largely delegated to the implementation stage of the CAP, hence to country and local programming authorities. To make both policies effective, and to bring about constructive synergies, the **availability of bridging concepts allowing for territorial-level integration of chain and ecosystem services views is key** (Viaggi, 2018). Combining instruments into a financial mechanism is crucial. While individual instruments may not be exactly innovative in their design, innovation can come in combining these instruments to create the package of incentives needed to drive sustainable land use (Lambin and Meyfroidt 2011)

2. Market measures provided within the CAP should support Producer organisations (POs) or associations of producer organisations (APOs) not only in the food supply chain but in the whole agricultural supply chain. POs and APOs are important players in the supply chain and by working together, they can reduce transaction costs and collaborate when processing and marketing their products, as much in the food industry as in the bio-based one.

3. In line with the previous point, market measures provided within the CAP mentions the fights against unfair trading practices (UTPs) only in the food supply chain and not at agricultural level. Often farmers and small operators in the agricultural supply chain do not have sufficient bargaining power to defend against UTPs and they need specific support.

4. The CAP provides a farm advisory system (FAS) for all countries in the European Union. The FAS helps farmers to better understand and meet the EU rules for environment, public and animal health, animal welfare and the good agricultural and environmental condition (GAEC). The **FAS should provide information/requirements** to the farmers also for sustainable biobased production.

5. To **reinforce the role of the public-private partnerships**, such as the Bio-based Industries Joint Technology Initiative, to leverage capital markets and additional private and public funds (e.g. synergies with EU Structural Funds) might be a good strategy to top up existing public and private commitments.

6. Concerning the EU-ETS, one of the main changes for the third phase (2013-2020) from the previous two phases is to **include more sectors**. Agriculture must be one of them, since it is not included yet.

7. **Combining instruments** into a financial mechanism is crucial. While individual instruments may not be exactly innovative in their design, innovation can come in combining these instruments to create the package of incentives needed to drive sustainable land use.

4.3 Instruments building knowledge and trust

The existence of robust monitoring mechanisms is crucial to improve knowledge over time, to build databases on impacts of products and practices, ease comparison between countries and over time and to help ensure the enforcement of policies. A proper monitoring system is for instance an enabling condition for the enforcement of mandatory targets, in order to check progression towards a specific objective. Building trust in a system, and notably in the implementation of rules can be done thanks to certification, where an independent third party checks conformance against a set of requirements through audit.

Monitoring mechanisms should first be improved at global level to avoid negative effects of exported biomass or bio-based products (e.g. from cotton or oilseed crops) from non-EU countries. In order to identify risk of land use change and avoid negative externalities in other countries, global monitoring is essential. In addition, labels for bio-based products that declare the origin of the used biomass could be helpful to avoid these effects. This accounts not only for exported goods but also for bio-based products from Europe.

The development of a monitoring tool for European Bioeconomy, should ensure the **inclusion of circularity indicators.** This could help improve the use of secondary raw material, which plays an important role to diminish the pressure on land. The framework for the development of the monitoring tool for European Bioeconomy already emphasizes circularity principles. This can be considered as a step in the right direction. However, diminish definitional barriers to classify waste and residuals are needed in order to gain consistent data and enable the use for bio-based products. It is equally important to develop a **common understanding and definition of certain indicators bias** in the monitoring outcome in order to overcome categorisation issues and minimise 'grey areas' when reporting data. Also, data access and availability should be eased as much as possible, for instance through common platforms, where both raw and processed data are available.

Agri-Environmental Indicators (AEIs) provided to monitor and drive the Rural Development Program funds, only contains a specific indicator on Land Use Change but this is not really connected with the risk factors connected with the bio-based industry. It is more related to reducing and managing sustainable urban development. Only the calculation for the vegetation productivity is provided, but no specific target is foreseen. The risk factor identified in the SydILUC model (see deliverable 7.2) may support the inclusion of new specific Agri-Environmental Indicators to support the sustainable development of the bio-based industry. More generally, the focus should be put on aligning and creating synergies between the data gathered under pieces of legislation and policy instruments. For instance, synergies between a sustainable bio-based products monitoring framework and the CAP could be fostered by using farm advisory systems which should provide information/requirements for sustainable bio-based production to the farmers.

Finally, as indicated in deliverable 9.3, more coherence is needed between legislation and standards/certification schemes where the latter could be used to assess conformity with legislation. Indeed, the development of sustainability criteria in the RED has given a push to biomass certification (including non-RED-related products). It would be very useful to carry out an **cross-cutting assessment on the integration of certification schemes as a sign of conformity** in various product policies in order to assess its appropriateness to bio-based products.

4.4 Other overarching recommendations

This deliverable goes through a number of policy strategies and interventions aiming to guide how land is used and what for. **All the listed instruments need each other to fully function**: the assessment of quantified objectives needs robust monitoring tools and accurate data gathering, before using financial incentives and fiscal mechanisms, it is crucial to clearly identify best practices to promote and worst to disincentive. Given their complementarity - for instance, protected areas are not appropriate to tackle indirect land use, while risk-based approaches such as that of the RED might be - we recommend the **combined use of these tools for effective sustainable bio-based product policy framework**.

Also, **transboundary and cross-sectoral approaches** to sustainable land use should be promoted. Indeed, one of the issues with leakage effects is that markets are volatile (Deliverable 7.1). If regulations change in one country, products will be exported to another country, with looser regulations. Yet, trade instruments are among the few tools which can help in gaining influence on land use practice outside one's jurisdiction. The bioeconomy should be addressed as a whole, according to underlying priorities regarding what the biological resources should be primarily used for, and how. This would give a unique and clear signal to market actors to change practice accordingly.

Equally, **integrating circular economy** concepts within the bioeconomy for instance in finding ways to **more easily operationalise the cascading use principle** could be an effective way of mitigating pressures on land.

Finally, and maybe most importantly, this deliverable only looked at one possible driver of land use change arising from an increase in the demande of biomass for bio-based products. An effective land use strategy as part of the bioeconomy should **address the other key drivers of land use changes starting with overproduction, increasingly land-intensive diets, food waste, single use and short lived products and use of primary resources for energy purposes**. At the same time, it should account for **threats to land availability**, such as desertification. A 2018 report from the Court of Auditors pointed to the fact that there was no shared vision in the EU about how **land degradation neutrality** should be achieved by 2030 and as a result, recommended the European Commission to aim 'at a better understanding of land degradation and desertification in the EU; assesses the need to enhance the EU legal framework for soil; and steps up actions towards delivering the commitment made by the EU and the Member States to achieve land degradation neutrality in the EU by 2030' (European Court of Auditors 2018).

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Regulation (EC) No 1306/2013 of 17 December 2013 on the financing, management and monitoring of the common agricultural policy and repealing Council Regulations (EEC) No 352/78, (EC) No 165/94, (EC) No 2799/98, (EC) No 814/2000, (EC) No 1290/2005 and (EC) No 485/2008

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Annex 1 - Policy review

Document	Scope (G)	Author	Status	Scope (S)	Policy Instrument
1992 UNFCCC	International	UN	Binding	Climate	Target (non-quantifiable)
1997 Kyoto Protocol	International	UN	Binding	Climate	Target (regional, quantifiable), Accounting, Market Instrument
2015 Paris Agreement	International	UN	Binding	Climate	Target (global, quantifiable), Accounting, Market Insrument, Financial Incentive
1992 UN CBD	International	UN	Binding	Biodiversity	Target, No-go-area
Cartagena Protocol	International	UN	Binding	Biodiversity	Target
Nagoya Protocol	International	UN	Binding	Biodiversity	Target, Financial Incentive
UN CCD	International	UN	Binding	Soil	Target (regional)
UN SDGs	International	UN	Voluntary	General	Target (global, hardly measurable)
2012 EU Bioeconomy Strategy	European	EC	Voluntary	Economy	Target, Financial Incentives
2018 Rev. EU Bioeconomy Strategy	European	EC	Voluntary	Economy	Target, Financial Incentives
2009 RED	European	EU	Binding	Energy	Target (quantifialbe), Accounting, Market Instrument, Certification, No-go-area
2015 ILUC amendment	European	EU	Binding	Energy	Target (quantifiable), Accounting (ILUC), Market Instrument, Low ILUC risk biomass
2018 RED II	European	EU	Binding	Energy	Target (quantifiable), Accounting, Market

					Instrument, Certification, No-go-area, Low ILUC risk biomass
2019 DA High & low ILUC risk	European	EU	Binding	Energy	Accounting, Certification, Low-ILUC risk biomass, High ILUC risk
2014 Common Agricultural Policy	European	EU	Binding	Agriculture	Financial Incentives
Agri-environment indicators	European	EU	Voluntary	Agriculture	Accounting
2019 EU 2050 Decarbonisation S.	European	EC	Voluntary	Climate	Target
2009 EU Emissions Trading System	European	EU	Binding	Climate	Target (regional, quantifiable), Accounting, Market Instrument, Certification
2009 LULUCF Regulation	European	EU	Binding	Climate	Target (quantifiable), Accounting
2009 Effort Sharing Decision	European	EU	Binding	Climate	Target (national, quantifiable), Accounting, Market Instrument
2018 Effort Sharing Regulation	European	EU	Binding	Climate	Target (national, regional, quantifiable), Accounting, Market Instrument
2013 Adaptation Strategy	European	EC	Voluntary	Climate	Target
2015 Circular Economy Action Plan	European	EC	Voluntary	Economy	O
2018 Waste Framework Directive	European	EU	Binding	Waste	Target (quantifiable)
7th Environment Action Programme	European	EC	Voluntary	Environment	Target
2013 EU Timber Regulation	European	EU	Binding	Forestry	Target, (regional, quantifiable), Certification
German Bioeconomy Strategy	National	GER	Voluntary	Economy	Target, Financial Incentives

German Land Use Action Plan	National	GER	Voluntary	Soil	Target
Italian Bioeconomy Strategy	National	ITA	Voluntary	Economy	Target, Financial Incentives
Sustainable Agriculture Initiative	International	SAI	Voluntary	Agriculture	Certification
FAO Land Tenure Principles	International	FAO	Voluntary	Human Rights	Target, Accounting

Annex 2 - Sensitivity analysis of the SydILUC model version 35 for policy recommendations – package 7.3

1. Introduction

This report shows the finding of the sensitivity analysis conducted on the SydILUC model, version 35, which is the version used to implement the ILUC risk tool. The objective of the analysis is to provide suggestions for policy recommendation on how to manage and reduce ILUCr risk. This was done for each of the biomasses considered in WP7 of the Star-PROBIO project, namely Maize, Sugar Beet Pulp, Soybean.

The study went through three steps:

1. Identify the relevant factors to analyse by performing a global sensitivity analysis;
2. Study each relevant factor effect on iLUC risk for each bioplastic case in each biomass;
3. Briefly comment the results.

The BB products analysed were three bio-based plastics, i.e. PLA, PBS, PUR.

2. Global sensitivity analysis indices:

The sensitivity of ILUC risk to every relevant input variable was estimated using the first order sensitivity indices, as delineated in Saltelli 2008, "Global Sensitivity Analysis. The Primer". The first order sensitivity index is based on the analysis of the model output variance with respect to some input factor, as:

$$SZi=VZi(EZ\sim i(Y|Zi))V(Yitot) \quad (2.\ 30)$$

1. Where Y is the model output, Zi is input factor i for the model with i going from 1 to n=number of input factors considered in the analysis; Y|Zi is the output of the model when changing all factors while keeping factor i on a fixed value; EZ~i(Y|Zi) is the estimated value (the mean) of the model output when changing all factors while keeping factor i on a fixed value; VZi(EZ~i(Y|Zi)) is the variance of the means obtained for a set of possible values for the fixed factor; V(Yitot) is the variance of the output when changing all the factors at the same time. In this case, the output of the model is the ILUC risk, and the input factors depend on the biomass analysed.

Larger sensitivity means larger relevance of that particular factor, i.e. the ILUC risk depends strongly on that particular factor. In case of a linear model, the sum of the first order sensitivity indices of all factors should be equal to one. In case the sum is less than one, the difference is an index of non-linearity. Non-linearity means that the factors are interfering among them, so changing one without changing them separately will yield different results than changing them together.

2. Maize:

The factors considered where divided into:

I. Factors that could be managed by policies:

a. Target production of bioplastics by 2050;
b. Fraction of co-products used as substitution for the feed sector;
c. Yield of BB product obtained from the biomass – this can be increased by research (getting better chemical synthesis pathways) or by policy (less waste along the supply chain);
d. Yield of feed product obtained from the biomass – same as above;

e. Market factors – in case market policies are considered, econometrically determined functions relating price to supply/demand may be changed by regulation, subsidies and taxation;
f. Agricultural yield trend for the biomass – increasing yield can be a policy priority, as it seems that yields could be improved by better land management, spread of knowledge and machinery, better connectivity of rural land;
g. Use of residues to substitute the biomass in the synthesis of BB products;

II. Uncertain factors:
. Market functions and parameters are statistically determined, and affected by uncertainty;
a. Yield gap is also determined statistically and not by direct measurements;
b. Residue production and synthesis parameters are also relatively uncertain.

Factors relevant for policies are explored fully in their possible (realistic) range of values; factors not important for policy but affected by uncertainty are varied in their uncertainty range. The resulting sensitivity analysis, obtained from a 10^5 sample size, is shown in Figure 1. It is clear that the yield of conversion of biomass cultivated into feed is the most important parameter. The second most influential parameter is the yield trend. Then, in order of relevance, the use of residues, the conversion of biomass cultivated into bio-based product, and the target production of bio-based product. The sum of all sensitivity indices equals 0.49, indicating a high rate of non-linearity of the model.

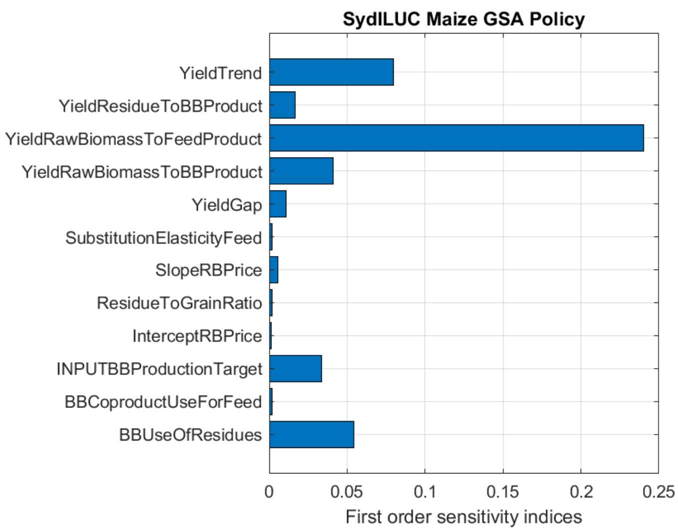


Figure 1: first order sensitivity indices for the Maize biomass.

3. Soybean

The factors analysed for the soybean biomass are mostly the same as for maize, with the only difference that it appears residues have high ligning content, making them not very interesting for the synthesis of PURs. Moreover, there are no study available exploring this possibility. Hence, the use of residues were not taken into consideration. :

I. Factors that could be managed by policies:
a. Target production of bioplastics by 2050;
b. Fraction of co-products used as substitution for the feed sector;
c. Yield of BB product obtained from the biomass – this can be increased by research (getting better chemical synthesis pathways) or by policy (less waste along the supply chain);
d. Yield of feed product obtained from the biomass – same as above;

e. Market factors – in case market policies are considered, econometrically determined functions relating price to supply/demand may be changed by regulation, subsidies and taxation;
f. Agricultural yield trend for the biomass – increasing yield can be a policy priority, as it seems that yields could be improved by better land management, spread of knowledge and machinery, better connectivity of rural land;

II. Uncertain factors:

. Market functions and parameters are statistically determined, and affected by uncertainty;
a. Yield gap is also determined statistically and not by direct measurements.

The resulting sensitivity analysis, obtained from a 10^5 sample size, is shown in Figure 2. In this case, the most important factor is the target production of PUR synthesized from soybean biomass. The second most important parameter is the yield of BB coproduct synthesized form soybean biomass. Yield trends and the yield of conversion of biomass to feed are also non-negligible. The sum of all sensitivity indices equals 0.9, showing that the model is mostly linear. Since the main difference with respect to the maize model analysis is the fact we are not considering the residues, this indicates that the interaction of residues and main biomass is responsible for most of the non-linear behaviour of the SydILUC model.

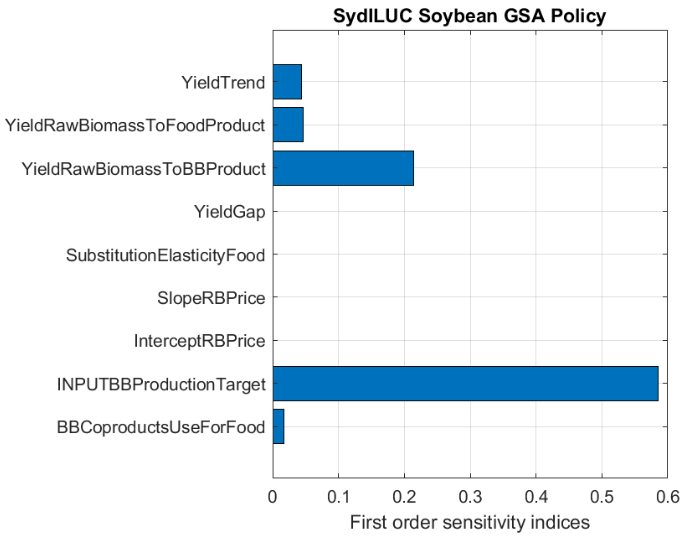


Figure 2: first order sensitivity indices for the Soybean biomass.

4. Sugar Beet Pulp

In the case of sugar beet pulp, we are already talking about an agricultural residue (sugar beet proper is used 97% to obtain sugar), hence the agricultural residues are not considered in the model simulation. Moreover, sugar beet is predominantly a European crop, with a controlled price driven by the market of sugar, so there is no correlation between market prices and availability of the resource. Therefore, the market part of the model was also not considered. Since these are the two main feedback loops in the model, we expect the model to behave linearly in this case. The analysed factors have been:

I. Factors that could be managed by policies:

a. Target production of bioplastics by 2050;
b. Fraction of co-products used as substitution for the feed sector;
c. Yield of BB product obtained from the biomass – this can be increased by research (getting better chemical synthesis pathways) or by policy (less waste along the supply chain);

d. Agricultural yield trend for the biomass – increasing yield can be a policy priority, as it seems that yields could be improved by better land management, spread of knowledge and machinery, better connectivity of rural land;

II. Uncertain factors:

. Market functions and parameters are statistically determined, and affected by uncertainty;

a. Yield gap is also determined statistically and not by direct measurements;

The resulting sensitivity analysis, obtained from a 10^5 sample size, is shown in Figure 3. The results are much easier to interpret than for the other biomasses. There are only two relevant factors: the target production of bio-based products by 2050 and the yield of bio-based product obtained from sugar beet pulp. The sum of the sensitivity indices equal one: the model was perfectly linear, as expected.

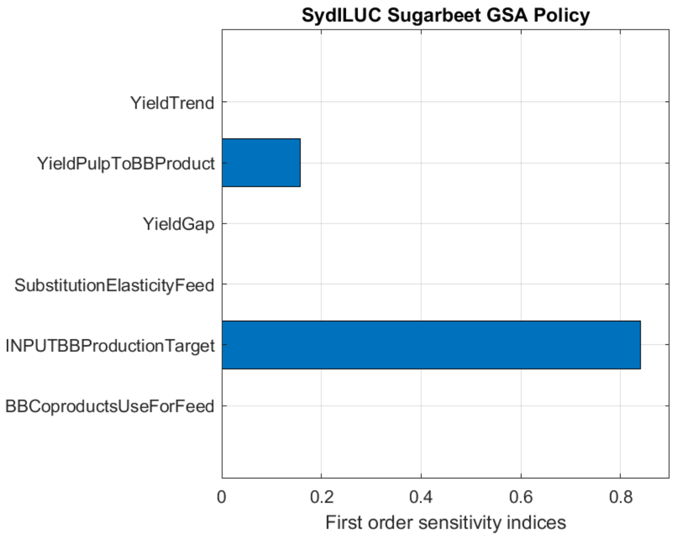


Figure 3: first order sensitivity indices for the sugar beet pulp biomass.

3. Local sensitivity analysis

Local sensitivity analysis refers to the activity of analysing the effects of the change in the output of a model when changing only one of its factors, while the other remain fixed to a determined value. The set of values on which the factors represent a state of the system. Therefore, the sensitivity analysis assess the effect of changing the factors only with respect to this "starting state of the system".

In this specific case, local sensitivity analysis analyses the effects of different factors (which can be manipulated by policy) on the ILUC risk related with the production of a specific bio-plastic, assuming that the state of the bio-based production does not change too much. The reference state (**baseline**) for the analysis was chosen to be the present state of the bio-based production market, with projection to substitute the whole plastic by 2050. The results of the local sensitivity analysis are more robust for factors that had large first order sensitivity indices in the GSA analysis presented in the previous section.

This analysis was conducted only on the most important factors identified in the previous section. Other factors are also changed in order to estimate uncertainty of the results (this also increases the robustness of the results).

1. Maize

The One at A Time analysis shows that the results are generally robust to uncertainty in the parameter, safe for the use of residues. Yield raw biomass to feed is also very uncertain for values less than 0.5, which is quite low and hardly realistic: the goal would be an increase, not a decrease in yield. From the graphic, an increase in yield of feed from biomass would actually increase the ILUC risk. There is a clear inverse dependency between agricultural yields and ILUC risk, as there is between yield of bio-bases products and ILUC risk, even though less marked. The increase in bio-based production target has a direct relationship, and it is quite robust; however the effect of increasing the production of bioplastic is much smaller than that of increasing agricultural yields and bio-based yields from raw biomass, meaning that there is chance of controlling the ILUC risk.

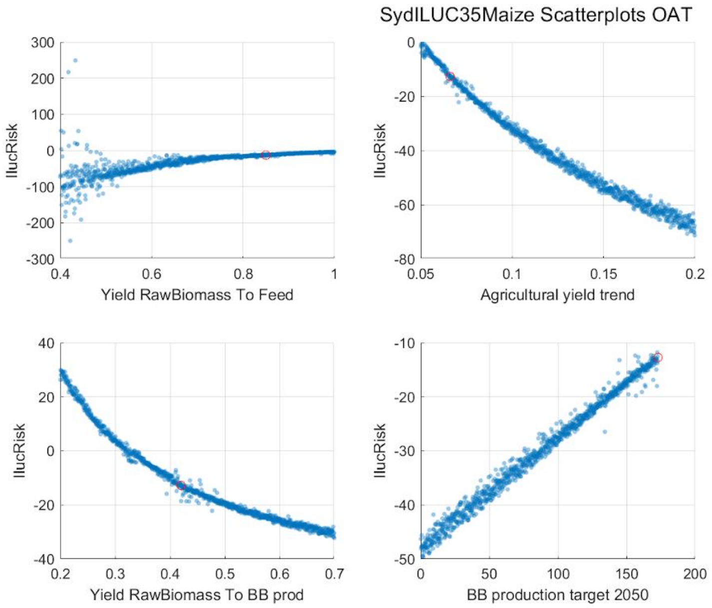


Figure 4: OAT analysis of the Maize SydILUC model, baseline is PLA 2017 market data. The red circle represent the baseline.

2. Soybean

In the case of soybean, the robustness of the examined factors is low, in general, apart for the effects of food yield from the raw biomass, which has a very big impact on ILUC risk. The target of increased production of bio-plastics has also a strong impact, but the graphic shows heteroscedasticity, meaning that uncertainty increases when increasing the target. The actual effect of the two main policies (agricultural and industrial yield increase) is not very clear from the graphics, showing that they are highly uncertain. That said, these latter factors do have a potential of reducing ILUC risk of 300-50 units, with the potential of controlling the effect of increased production in bio-plastic production.

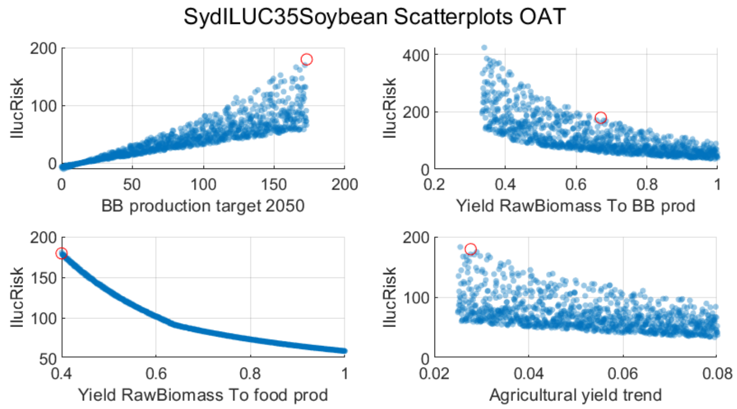


Figure 5: OAT analysis of the Soybean SydILUC model, starting point is PUR 2017 market data.

3. Sugar beet pulp

In the case of sugar beet pulp, since the model is linear, the analysis is completely robust, i.e., there is no interaction between different factors. The graphics are, therefore, very easy to read: the industrial yield increase has a very strong effect in reducing the ILUC risk, while the increase in bio-plastic production increases the risk. Other factors are not relevant.

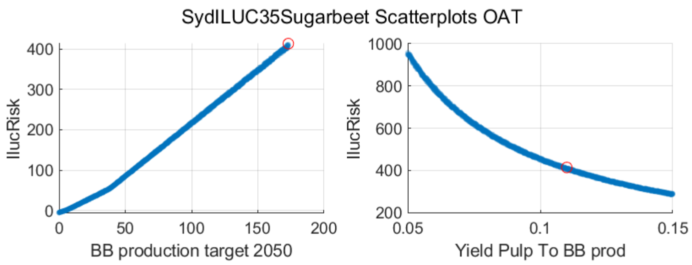
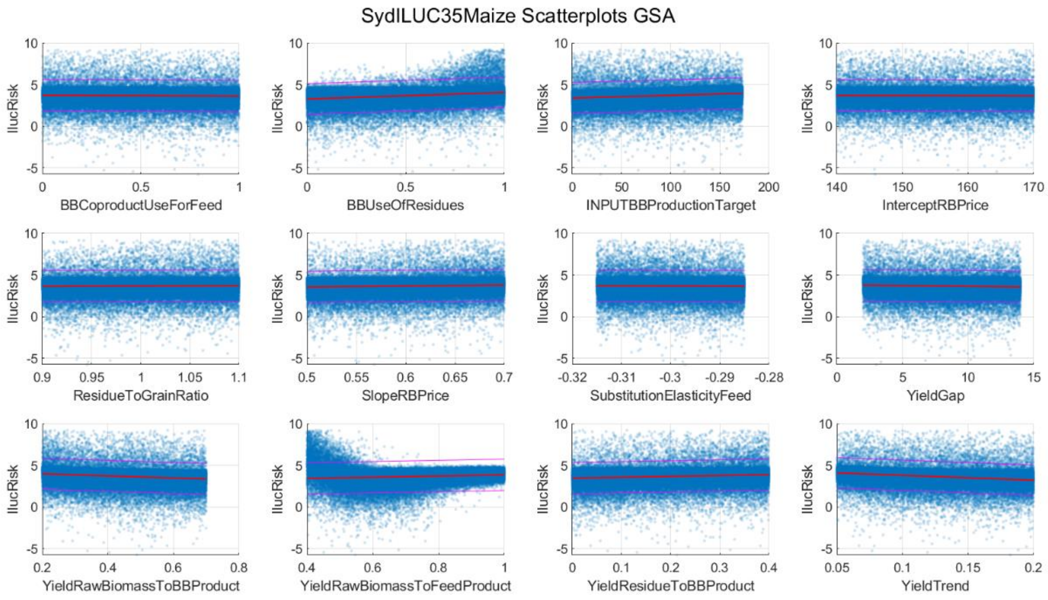


Figure 6: OAT analysis of the Sugar beet pulp SydILUC model, starting point is PLA 2017 market data.

4. Appendix A: global sensitivity analysis scatterplots


SydILUC35Maize Scatterplots GSA
IlucRisk
BBCoproductUseForFeed
BBUseOfResidues
INPUTBBProductionTarget
InterceptRBPrice
ResidueToGrainRatio
SlopeRBPrice
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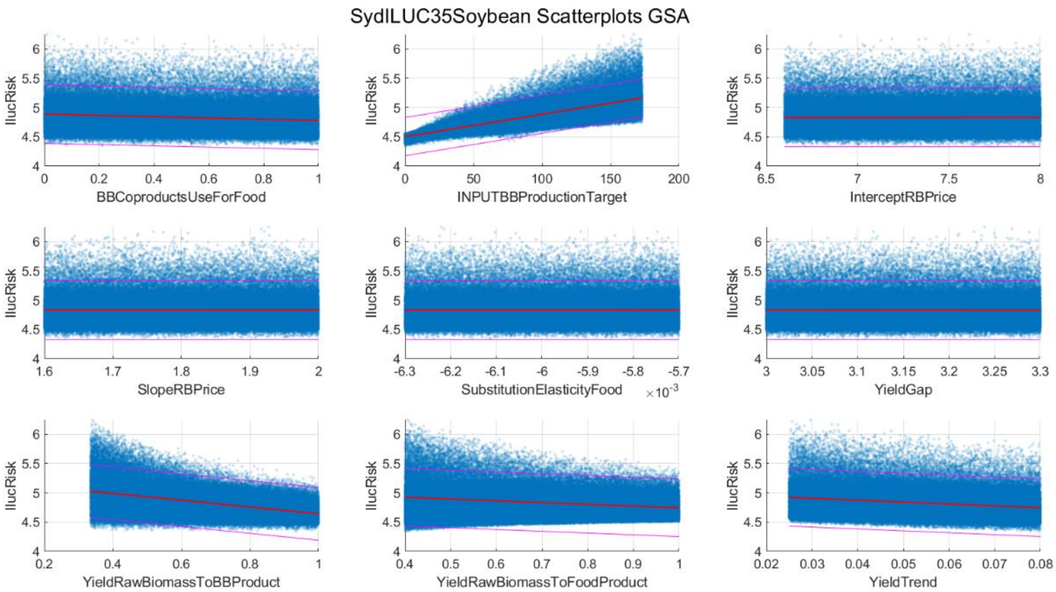
SydILUC35Soybean Scatterplots GSA
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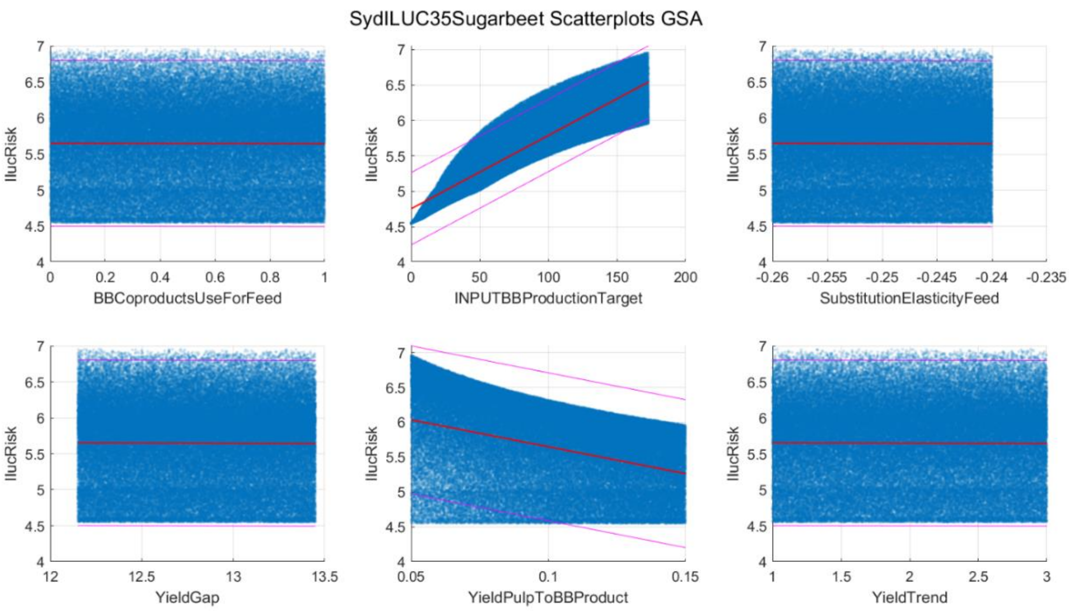
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