White Paper for Grassland Opportunities

- Discussion Document

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GO-GRASS

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Grassland is an important type of land use in Europe, covering a large area and providing ecosystem services such as carbon sequestration, enhancing biodiversity and protecting water.

To boost the development of a bio-based economy and contribute to the EU's goal of achieving net zero emissions by 2050, there is a need for business models that can be replicated in a variety of locations and contexts, with relatively low levels of investment, risk and technical sophistication. A wider range of rural entrepreneurs need to get involved in the emerging bio-based business sector, including farmers and forest owners (and their associations), policy makers, small rural businesses, and advisors. This is key to diversifying and revitalising the rural economies and creating quality jobs in rural areas.

Executive summary

In this context, the GO-GRASS project aims to create new business opportunities in rural areas based on grassland, and to support their replication throughout rural communities in the EU. Since October 2019, the project connects 22 partners from 8 countries, which are developing small-scale demonstration sites of a circular agro-food system in four EU regions (Denmark, Germany, Sweden, and the Netherlands). The partners are developing solutions and sustainable products using grass and green fodder such as paper and packaging, animal bedding, organic protein, biogas, and biochar. The project is testing and replicating the technologies and business models in regions of Spain, Romania, and Hungary.

Preliminary results from GO-GRASS provide relevant data and lessons for policies that promote the bioeconomy at field level and support good practices for the development of innovative and replicable grass-based business models. Policy makers can stimulate grassland valorisation and new opportunities for farmers and rural businesses in the following ways:

Measures at EU level

- Design policies that promote opportunities for diversification in the sense of new grass-based value chains, diverse demand patterns and business models and markets.
- Maintain the area of grasslands at Member State level as part of the greening measures of the CAP.
- Remove contradictory and restrictive legislation which currently limits the potential of carbon removal through grasslands.
- Recognise the importance of carbon content in grassland soils and show willingness to increase this in agricultural soils.
- Create the possibility for farmers to work on increasing the carbon content of their soils at a feasible and understandable administrative level.
- Create financial incentives to encourage land manager engagement in carbon farming. A formalised carbon credits system as proposed by the EU Carbon Removal Certification can help to increase the market for grass as a resource for the bioeconomy. Carbon credits can reduce the selling price for grass and, hence, increase demand.
- Develop monitoring systems to identify trade-offs in ecosystem services and reduce the environmental footprint of new business activities.

Measures at national and regional levels

- Take a holistic view to valorising grassland biomass, covering environmental, climatic, social-economic, and technological perspectives. Potential support of government incentives and regulatory-push effect need to be coordinated.
- Support conversion of arable land into grassland to preserve the environment, build up soil carbon, and facilitate the delivery of resources for biorefineries that can produce feed, food, materials, and bioenergy.
- Develop specific actions supporting the maintenance of grasslands threatened by abandonment and provide targeted policy support to maintain the ecosystem services related to grasslands (fire control, tourism, biodiversity, high soil carbon content).
- Align fertiliser regulations at EU and national levels and provide policy support and advisory services for small- to medium- scale circular biochar business at national or regional level.

Support Measures

- Increase awareness of the benefits of grasslands through training, workshops, and outreach to consumers via non-specialised media.
- Develop ready to use business solutions sold or made available through licensing.
- Organise engaging and open policy dialogues to discuss best practices.
- Establish adequate knowledge transfer actions that allow farmers to understand the new products delivered from grasslands.
- Promote the establishment of farmers cooperatives.

1. INTRODUCTION AND MOTIVATION

1.1 Motivation and methodology of the White Paper

This White Paper aims to demonstrate the wide range of opportunities for valorising grasslands based on the findings from GO-GRASS cases, and relevant best practices at local, national, and European levels. It will demonstrate innovative and diverse ways of considering grass and grasslands as new resources for the benefits of society, environment, and businesses. The focus is on value chains, enabling business environments, main policy gaps and best practices for policies that promote valorisation of grasslands and grasses. It ends with recommendations for European, national, and regional policy makers.

Around 17% of the EU's total surface area was covered by grassland in 2018[1] but this abundant resource is often left unused, creating costs for society and for rural areas. By valorising grass and grasslands, Europe can generate new opportunities for farmers and rural businesses, who are the backbone of European bioeconomy[2]. In this context, innovative approaches for processing, using, and marketing grass-based products and grasslands ecosystem services could become central to the revitalisation of rural areas.

The Common Agricultural Policy (CAP) 2014-2020 included the definition of permanent and temporary grassland in EC Regulation 1307/2013, where agricultural area is defined for receipt of direct payments under Pillar I of the CAP. Temporary grasslands are part of the arable lands meaning those cultivated for crop production, or areas available for crop production but lying fallow, including areas set-aside. Permanent grassland or permanent pasture is "land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more."[3]

Permanent grasslands cover 34% of the European Union's agricultural area and are vital for human well-being as they contribute to a wide variety of essential ecosystem services[4]. However, the potential for economic, environmental, and social valorisation goes beyond current practices.

Our policy recommendations are developed from an extensive review of the CAP and experts' interviews. The recommendations seek to support **European decision makers and regulators, planning and rural development agencies, and local authorities** to develop targeted policies for a circular and sustainable use of grassland in collaboration with researchers, networks, and farmers.

The findings and conclusions are based on a collaborative and open approach using qualitative analysis, and interviews with relevant stakeholders. Lessons learned from the GO-GRASS demo sites and desk research are also included.

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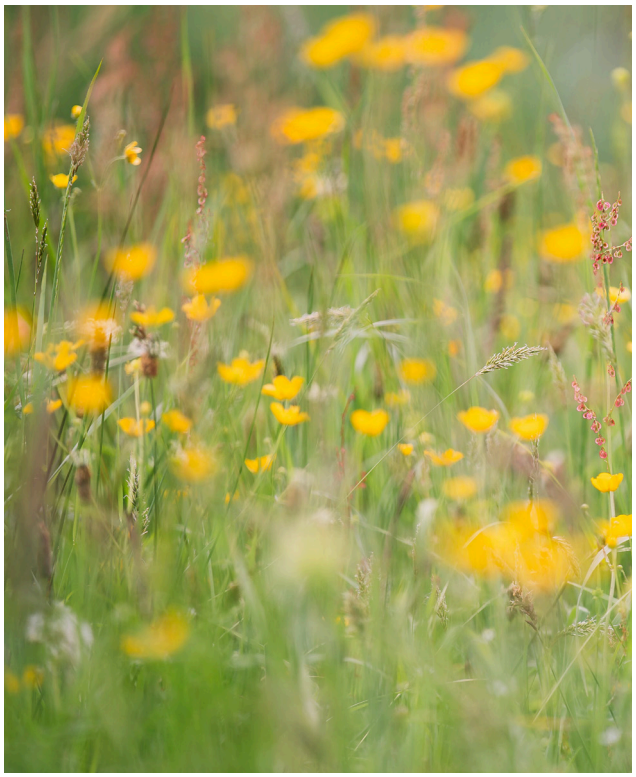
[1] For more on EU Land Cover Statistics, see EUROSTAT, 2021.
[2] For more on European Bioeconomy Strategies, see Park and Grundmann, 2022.
[3] For more on EU Regulation for Direct Payments for Farmers, see Official Journal of the European Union - Regulation 1307/2013.
[4] For more on Permanent Grassland Cover, see Schils et al., 2022.

The White Paper is structured in the following way:

- The needs and current challenges for grassland valorisation in Europe;
- Support conversion of arable land into - Grasslands as a key resource to revitalise rural areas, explaining the opportunities for their valorisation, and drawing on the findings from the four GO-GRASS demo sites;
- Innovative technologies and value chains that can contribute to the development of new circular grass-based business models;
- How innovative grass-based business models are supported by suitable business environments;
- The main policy gaps that need to be addressed to improve value creation of grasslands extrapolated from the GO-GRASS demo sites and related projects.



1.2 Needs and current challenges for grassland valorisation

In 2016, the trend in agricultural land cover in the EU was towards a decrease in arable land and an increase in permanent grassland. Arable land, including temporary grasslands, made up 60% of the utilised agricultural area in the EU in 2016, with 103 million hectares. Permanent grassland and meadow covered 59 million hectares (34%) and permanent crops 11 million hectares (6%).[5]

Grassland habitat is ideal for vast **diversity of species** and is vital as breeding grounds for birds and invertebrates. They are among the most species rich habitats on Earth.[6] High plant diversity gives rise to high microbiota and arthropod diversity and can support grassland-adapted birds and other species such as rodents. Grasslands boast large numbers of insect species such as grasshoppers, beetles and solitary bees, which need plant biomass as a resource, or that use the often-warm habitats and partly open soils for breeding. Vertebrate herbivores are another major group that benefit from the large biomass production in grasslands. These include small and inconspicuous mammals as well as granivorous birds. Many bird species use the short grass of steppes or grazed meadows for breeding, and they are particularly vulnerable to changes in nutrient status and management.

Grasslands provide important **ecosystem services**, including erosion control, high water infiltration capacity, water purification linked to nitrate uptake, and support of wildfire control. They provide a wide range of public goods and services, ranging from direct recreational and tourism opportunities to indirect benefits such as fodder supply to produce meat and

[5] For more on Grassland and Cropping Patterns, see Eurostat 2016.
[6] For more on Grassland Biodiversity, see Petermann and Buzhdygan, 2021.

dairy products. They also act as carbon 'sinks': grasslands store about 34% of the global terrestrial carbon, from this, about 89% of this grassland carbon is stored in the soil.[7] However, only the carbon associated with the forest above and below-ground biomass is considered as part of the carbon accounting in the national carbon off-setting projects considered by the IPCC, while neither the forest nor grasslands soil carbon storage are considered.[8]

Protecting soil organic matter is essential for climate change mitigation purpose, and for preserving ecosystem functionality and health. **Soil organic matter plays a vital part in enhancing soil fertility and quality** by significantly improving: (i) soils' capacity to store and supply essential nutrients (such as nitrogen, phosphorus, potassium, calcium and magnesium) and to retain toxic elements, (ii) soil structure that ultimately helps to control erosion and improves water infiltration and water holding capacity, giving plant roots and organisms better living conditions. Soil organic matter is a primary source of carbon which gives energy and nutrients to soil organisms.[9] To increase soil carbon, practices that favour a slow decomposition rate of soil organic matter are the most effective. However, a slow or reduced decomposition rate may restrict the supply of nutrients to crops, and then the best solution may be to ensure a stable level of soil organic matter, with yield-related and financial benefits in the long run, and advantages for soil health and disease prevention as well.

Grasslands are currently essential for feeding livestock, which then supply milk and meat to human populations. They are the cheapest source of feed to supply grazing livestock and can thus contribute to reducing livestock production costs.

Unfortunately, **permanent grasslands are decreasing** in the last decades in Europe.[10] According to the European Environmental Agency (2021),[11] in the last period measured (2012-2018), more than 2,600 km2 of land was converted into urban area in the EU27+UK. Though small in relative terms, this loss is large in absolute terms, particularly for grassland ecosystems (-1,887 km²).

Valorisation of grassland is important because otherwise grassland can be taken over for „higher yielding" alternatives use such as intensive croplands. Ploughing permanent grasslands or converting them to intensive croplands, favours soil aeration and microbiological activity that mineralizes the organic matter and **releases carbon and nitrous oxide to the atmosphere**. In addition, nitrates risk leaching into surrounding waters may cause eutrophication and extra greenhouse gas emissions to the atmosphere.

The **decrease in permanent grasslands has important ecological threats** such as an **increased nutrient leaching** due to the intense fertilisation (Denmark) or the **increase in fire intensity** by the uncontrolled biomass growth in abandoned areas (as it happens in Galicia, one of the regions that has the most wildfires in Europe).[12] Those are very flammable masses in dry summers that act as catalysts in case of fires, in opposite to the potential firewall that grasslands can exert on the same situations.[13]

[7] For more on Soil organic carbon stock in grasslands, see Eze et al., 2018.
[8] For more on Ecosystems Carbon Storage, see Liu et al., 2018.
[9] For more on Soil Organic Matter, see EIP-AGRI, 2016.
[10] For more on permanent grasslands, see GO-GRASS, 2019.
[11] For more on Changes in the Coverage of Ecosystem Types, see EEA, 2021.
[12] For more on Wildfires in Europe, see Jaime de Diego et al. 2021
[13] For more on Fire-Prone Shrublands, see Celaya et al. 2022

The lack of management is linked to a **loss of biodiversity** and biomass accumulation that are more prone to wildfires, releasing large amount of greenhouse gasses into the atmosphere.[14] Fire prevention through grazing is the most efficient way to avoid greenhouse gases emissions, and biodiversity destruction as shown by the Open2Preserve EU project.

Climate change and its effects on grassland productivity vary across Europe, with increasingly warmer and wetter winters in the North of Europe and increasingly warmer and drier summers in Southern Europe. According to a scientific literature review carried out by Ergon et al 2018, warming and elevated concentration of atmospheric CO2 may boost forage production in the Nordic region.[15]

On the contrary, production in Mediterranean areas is likely to become even more challenged by drought in the future. In both regions, climate change will affect forage quality and lead to modifications of annual productivity cycles, with an extended growing season in the Nordic region and a shift towards winter in the Mediterranean region. Under these unpredictable conditions, plant biodiversity at all levels is a good strategy to increase grassland buffer capacity. Currently most of the technologies for using the grassland biomass are developing at lab scale. Developing and optimising these technologies is vital to integrate them into the industry.

The decrease in grasslands surface in the EU leads to a reduction of their associated ecosystem services such as biodiversity and soil quality. Valorisation of grasslands through the development of new grass-based products could help to valorise these systems helping restore their environmental associated benefits.

[14] For more on Land Management and Biodiversity, see Damianidis et al. (2020)
[15] For more on Forage Production under Climate Adaption, see Ergon et al. (2018)

2. GRASSLAND VALORISATION THROUGH INNOVATIVE TECHNOLOGIES AND VALUE CHAINS

2.1 New technologies, value chains and optimal scenarios: creating opportunities and markets for grass-based products

The farming sector is currently the biggest user of grass from a valorisation perspective: in its various natural (e.g. pastures or fallow land) or processed (pellets, hay, or silage) formats. The uses of grass in an agricultural context evolve around a crop, pointing to value chains that link suppliers of inputs to crop production with the agricultural sector. This perspective includes value chains related to the provision of seeds, machinery, and utilities to the farm sector.

In contexts related to roadside management or maintenance of fallow land, grasses are of little value as a resource for agriculture for feed or bedding material. This can motivate the use of grasses for bioenergy purposes (biogas systems). There are on-farm systems for biogas production in for example Germany, the Netherlands and Denmark, and many examples of how local biogas production can be connected to larger biogas or natural gas grids.

GO-GRASS has explored how selected grass types could be processed into novel products. It is indeed a key learning from GO-GRASS that **the success of new grass-based products depends on their commercial potential.**[16] This implies that the new grass-based product should target a market experiencing a pull-effect, meaning that market demand criteria include other conditions besides competitive pricing. Below some GO-GRASS products-based examples:

- Demands of the organic farming sector in Denmark for local organic feed production stimulated a market for local feed protein. By developing a value chain and optimised process, it has been proven that fresh-cut grass can be processed into a feed protein for use by organic farmers. The commercial success of this example relates to the higher prices in the organic market compared to conventional feed protein concentrate and to continuous improvements in the efficiency of the process and value chain cooperation.

- Reed canary grass is common on farmlands in Northern Sweden and farmers have traditionally used it for feedstuff to their animals, but different projects and initiatives have tested and used it as biofuel during 1980-2011. By developing a process to be installed in farms, farmers are granted an opportunity to process the senesced and dry grass – which is cut in spring anyway – into animal bedding material. In this example, commercial success relates to the market accessibility of the new grass-based bedding and its easy use

- In the Lower Oder Valley National Park in Germany, grasslands are being monitored and areas where ground nesting birds are found may only be harvested after mid-August. This late harvested grass has low feed quality and is not well suited for biogas production but has a high primary energy content and is suited for the combined production of biochar and heat. The produced biochar is a soil amendment with many benefits, such as increased water and nutrient retention and can be used to ameliorate deteriorated agricultural land, along with sequestration of biogenic carbon in the soil. The produced heat may be used to substitute current heat production with fossil fuels. Thus, overall farmers may be encouraged to attain nature conservation practices with minimal management effort to produce a high-quality soil amendment and carbon positive heat, based on local otherwise wasted feedstock.

- Roadside grass and nature areas are usually harvested once or twice a year in the Netherlands. In the case of roadside grass, it is normally composted or left on the side of the road due to its low feed quality and possible presence of contaminants and rubbish. Yearly harvested grass holds a limited amount of protein, but is rich in cellulose, as opposed to young green grass. Cellulose is the building block for carton and paper, currently obtained from softwood trees. The valorisation of nature and roadside grass into paper and carton is a suitable option for a local fibre supply, which does not compete with feed or land. In the production process, biogas is produced. Locally grown fibres have a lower carbon footprint due to lower transportation costs and a different processing, when compared to wood, which is not commercially grown in the Netherlands for paper production. In this example, commercial success relies on the improved environmental impact of locally produced grass-based fibres, from a low value stream.

[16] For more on Success Factors of New Grass-Based Production, see Orozco and Grundmann, 2022.

The above examples demonstrate that the commercial success of new grass-based products depends mainly on market demand and value chain coherence. The new products, as illustrated by GO-GRASS examples, are introduced in market segments where well-known products drive market development.

It is therefore recommended to look deeper into the mechanisms that facilitate the shaping of markets for grass-based products and, to investigate the demand patterns for them. It is essential that these new products demonstrate attributes that distinguish them from existing solutions, for example by emphasizing sustainability, local production, and organic and circular qualities. Grass-based products are still niche products demanding only a few per cent of the market in their respective segments (existing products include e.g., cutlery and cups, paper, energy, packaging), and a deeper examination of customer preferences, supply chain characteristics and market conditions is needed.

In addition, lock-ins relate to investments in farm machinery, facilities and labour for handling grass as a feed source or, the procedures, machines and public resources and actions deployed for managing roadsides verges. However, with the abundance of grasslands and great variation in grass typologies across Europe and a strategic focus at European level on bioeconomy, Green Deal, rural revitalisation and innovation make it clear that market development is central to enhancing innovative grass valorisation.
Current policies do support land use to ensure the agroecosystem sustainability within the Pillar I of the Common Agricultural Policy. However, neither the direct payments nor the eco-schemes are thought to support the value chains in the post-2020 CAP. In the 2014-2020 CAP, support to the value chains is associated with some Pillar II measures, which in the case of the livestock derived products is poorly implemented.[17]

The importance of developing new and alternative grass-based products for the valorisation of grasslands systems seems unquestionable. However, it is also important to optimise the new value chains to reduce the number of generated by-products together with the development of new technologies aimed at the recovery of potential high-value products from the residues. Carbon efficiency of value chains could be considered as a new evaluation parameter alongside carbon footprint and circular aspects.

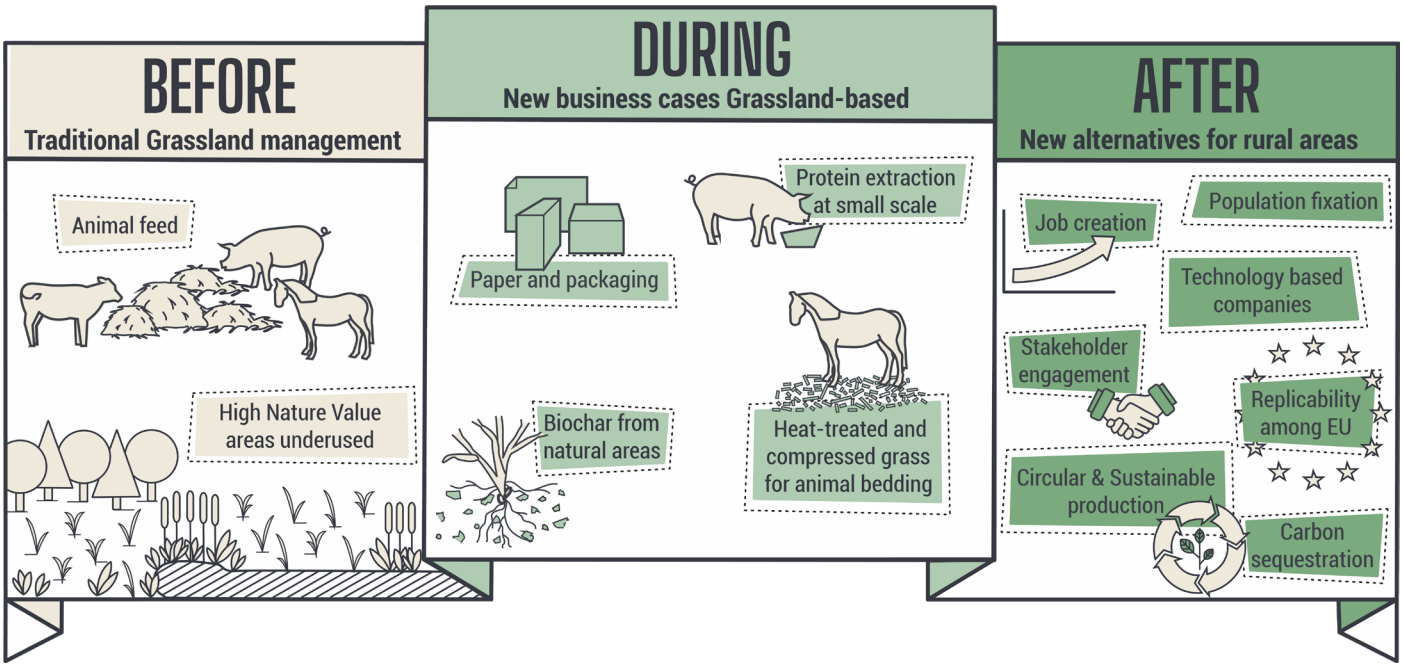
Development of markets and value chains for grass-based products are inter-related with the demand and supply for conventional and currently used non-grass-based products, thus pointing at highly diverse markets functioning across several sectors (e.g. agriculture, ener-gy, materials, etc.). Due to the abundant volume of grasses and great variation in properties of grass types, the potential for shaping new value chains is important and covers different scales.

[17] For more on Silvopasture Policy Promotion, see Rodriguez-Rigueiro 2021; and Mosquera-Losada et al., 2022.

2.2 Four demo sites developed within GO-GRASS

GO-GRASS is a Horizon 2020 project which is developing circular and sustainable business models with high replication potential that can be used by entrepreneurs, local authorities and other stakeholders.

The project is demonstrating innovative cost-effective technologies, processes, and tools applicable within four diverse demonstration sites. This is enabling effective use of grassland, being left to decay after mowing, causing costs and lost benefits for individuals and society.



DENMARK

The demo site in Denmark aims to develop a small, farm-scale bio-refining technology to extract protein concentrates for monogastric animals from grassland situated in nitrate sensitive areas. Danish agriculture is intensive, and 87% of agricultural area is in crop rotation.

Main characteristics:

A green biorefinery is used for extracting protein from grass. The extracted organic protein concentrate can be fed to pigs and poultry to enrich their diet and substitute soy meal. Other product streams are a fibrous pulp, that can be used for ruminant feed, biogas or biomaterials as well as brown juice that can be used for biogas and subsequently as fertiliser. The facility is working on the **optimisation of biorefining processes to provide high yields and high purity of the protein product as well as quality co-products in the form of renewable bioenergy and recycled nutrients.**

Innovative technology:

The demo is testing and optimizing new integrated technology and demonstrating it in an industrially scalable facility. The main innovation of the process revolves around using different grasses and legume mixes, harvest and logistics, mechanical wet fractionation to increase yields of protein at scale. The increasing quality of protein concentrate is tested in feed trials with pigs and the fibre pulp is tested in large farm-scaled feeding trials with dairy cows. The demo-site is cooperating with new commercial biorefineries in Denmark to develop and implement the technology for processing grass and legumes. These biorefineries will produce first a commercial protein concentrate to substitute soy, a fibre fraction for cattle feeding and a brown juice that can be used for biogas production. This will open a new market and contribute to the required reductions in nitrate leaching due to the Water Framework Directive by converting annual cropland into more or less permanent grassland.[18] The establishment of grass-derived protein for organic farming in Denmark would contribute to the **reduction of soy imports and derived emissions from the long transport and destruction of ecosystems in the local area exploited for soy production.**

[18] For more on Feedstock Production to Future Biorefineries, see Manevski et al., 2018.

GERMANY

The demo site in Germany targets to produce biochar via carbonisation of **grassland-cuttings from wetlands** as a supplement for soil improvement.

Main characteristics:

The German demo site at Nationalpark Unteres Odertal converts low nutritional quality grass from the wetlands into biochar. By implementing a first complete processing line, the grass is converted into biochar via pyrolysis (thermal decomposition in an inert atmosphere). The final product can be used on agricultural farmland, where it may provide a multitude of benefits, such as **increasing water holding capacity and nutrient retention of the soil.** During the conversion process, large amounts of energy are being released which can be used for heat generation. A large fraction of carbon from the grass remains in the biochar and is returned to the soil. Therefore, the overall process may be viewed as a **decentralised carbon sequestering technology that releases energy and produces biochar, which contributes negative emissions.**

Innovative technology:

The demo-site valorises the late-harvested grass into biochar through the process of pyrolysis. For this, the heterogeneous grass biomass from conservation areas must be conditioned for pyrolysis in an innovative process step. The biochar can be applied site-specifically as a soil amendment to agricultural fields outside the National Park. This process increases the fertility and water holding capacity of the soil. The biochar can be mixed with compost, biogas digestate or manure to enrich the char particles with nutrients before it is applied. This conversion of the grass to a stabilised char can contribute to capturing and storing carbon in the soil, therefore increasing its fertility. Once implemented, this innovation can also be used to valorise other types of lignified biomasses e.g., from urban parks, nutrient-poor grasslands and even roadsides.

THE NERHERLANDS

The demo site in the Netherlands is using digester and fermentation technology to produce paper and carton products from **road-side grass and nature or fauna grass.**

Main characteristics:

The demo site develops a process to extract fibres from roadside and nature grass to produce high-quality packaging and paper, besides biogas. Partners of the Dutch demo site optimise the technology of reducing sugars by digestion and separating and cleaning fibres from the grass. Also, they develop a cleaning system, which will separate unwanted components from the harvested grass. The final grass-fibre used to fabricate the end products reduces transport costs and less chemical usage for preparation than fibre produced out of wood.

Innovative technology:

The grass-fibres are separated and isolated through a digestion process and washing process and then used to produce paper and cartons. The process of turning a low value resource into paper generates value and revenues for farmers, other landowners and (regional) governments. The solution reduces the costs previously needed for disposing roadside grass. The environmental benefits are also clear, as less trees have to be cut for the production of paper. The small-scale production of paper, where a small portion of grass (8%) is added, is a process that already exists. However, **liberating the cellulose from the grass and almost completely substituting all the wood-based cellulose is a breakthrough innovation in the paper industry.** Some preliminary results on the environmental assessment of the grass-based paper obtained from the Dutch demo implies a lower carbon footprint when the whole value chain is considered (from the cultivation until the product fabrication) even when considering that the energy needs for grass dewatering are higher than for wood dewatering. However, there are some other components of the value chain, such as less heating or chemicals for the extraction of vegetal fibres from grass than from wood, that reduce the environmental impact of grass-based paper.

SWEDEN

The demo site in Sweden aims to establish briquetting and shredding technology at local and small-scale to produce heat-treated animal bedding using **reed canary grass**. There are big areas in Sweden that are abandoned and earlier drained peatlands which are often a source of carbon emission. Swedish authorities have so far only suggested to rewet these areas to stop the CO2 emissions, but research shows that a crop like reed canary grass with its deep root system and viable growth can establish several benefits on these organic fields, as a carbon sink, production of biomass to replace fossil and/or other alternatives and providing biodiversity particularly in forest regions.

Main characteristics:

In the demo site, Reed Canary Grass is shredded, pressed into briquettes with screw presses and then shredded to flakes – an innovative material for animal bedding, which afterwards can easily be used as fertiliser, as well as for biogas and energy production. **The screw press with temperature enough to reach the hygiene quality and the shredding of briquettes are key components in process.** Reed Canary Grass is a much more suitable source for animal bedding than the materials used so far – sawdust and wood shavings – which hold more potential for the use in biorefinery processes or material development. Furthermore, Reed Canary Grass bedding with manure will result in higher efficiency of the biogas process and contribute to increase circularity.

Innovative technology:

The main technology applied in the demo is the briquetting of reed canary grass and shredding of the briquettes at local and small scale. These two main components are the process of converting an agricultural crop into uniform shapes, facilitating its handling and storage. To provide this supply, the briquetting technology needs to be optimized with the other technologies such as grass shredding, briquette shredding and packaging to create a new affordable production chain that meets the customers' needs.

3. INNOVATIVE GRASS-BASED BUSINESS MODELS SUPPORTED BY SUITABLE BUSINESS ENVIRONMENTS

3.1 Grass-based business models

The four GO-GRASS demo cases prove the potential of grass-based business models. One of the strengths of the 'new' business models is the availability of unused grass as the key resource to produce local-based products and services. The end-users of most of the primary products are farmers or local manufacturers, and this enables the creation of backward and forward linkages with other economic and social activities at the local or regional levels; resulting on further opportunities for diversifying business models such as biogas or fertilizer production to close the circular loop process. The Swedish business model combines better use of the product, it reduces transport needs, and the straw and manure can be reused in agricultural farms and in gardens.

In the Dutch demo, the main value proposition is its high value products made from the low quality and waste grass. This has enabled a more sustainable production of paper and cartons and new revenue stream and circular valorisation of the liquid fraction for farmers and landowners. The customer segments indicate the multi-faceted local benefits and beneficiaries of the business model for grass delivery by the landowners, local/regional governments, or natural park management organizations. Paper and carton manufacturers buy the grass fibre while farmers can draw additional benefits from the liquid fraction.

The unique value proposition of the Danish demo is the co-production of high value products from grass biorefining and reduced nitrate leaching to support farmers continued license to produce. The biorefining products include organic protein concentrates, high quality roughage for ruminant feed, biochemicals and specific high value compounds and biogas recycled fertiliser from treated biomass. The production of organic protein enables the opportunity to substitute part of the large import of soya bean products, which are used for feed. Denmark's leading position in developing technologies within biorefining of green biomass has provided the opportunity for the development of the business model. The main customers are cooperatives, farmers and other local community actors.

In the German demo, an important area of grassland is underutilised due to low quality of the grass either for feed or as inputs for biogas production. The value proposition of the German demo business models for biochar production will increase the water holding capacity, retain nutrients, and store carbon.

Grass based business models can create backward and forward linkages with different sectors and local actors. These have provided a big potential to close the circular loop, contribute to sustainability and create different revenue systems in the business

models. New sources of revenues such as payments for storing carbon and for the liquid fraction as fertilizer are yet to be exploited to establish new revenue streams to achieve the large potential, and there is a need to create awareness with potential customers about the products and services.

3.2 Supportive business environments and enabling institutions

Grass-based technological and business innovations require supportive business environments and enabling institutional settings to materialize.[19] Some biogeographical regions in Europe researched in GO-GRASS have designed policies set in place to support the development of a circular and bio-based economy. For example, innovative grass-based businesses could benefit from regularly adjusted policy regulations and administrative procedures to develop more sustainable products.[20] This is in line with bioeconomy policies at EU and global level that aim to promote alternative grass-based products.

Scaling up innovative grass-based innovations and businesses requires investment and access to financial resources. The availability of sufficient direct funds to be one of the important necessary factors promoting alternative grass-based products. Funding mechanisms designed to incorporate and promote the specific benefits generated by grass producing and processing companies are major enablers from the enterprise's perspective. Practitioners welcome clear and dedicated regulations that specifically support the developing of a grass-based industry.
Consumers play a decisive role in the development of innovative grass-based business models. GO-GRASS findings suggest that building a high level of confidence and trust regarding the quality of the grass-based products have a positive impact on consumers' willingness to choose grass-based products. Product certification and clear information on the verified quality, usability, production methods and raw materials used in the production of grass-based goods contribute to the consumers choice of grass-based products. Consumers can also stimulate companies to innovate and to supply more resource efficient goods and services. Appropriate price signals and adequate labelling with clear information on the sustainability of grass-based products are supportive instruments for the development of a grassland-based bioeconomy.
Creating an enabling environment for innovative, emerging grass-based business models through raising consumer perception and opening market opportunities is a long-term endeavour. Complementary activities should be added to this to be achieved in a short-medium term, e.g. in the areas of technology, knowledge, resource and infrastructure, and funding.
The GO-GRASS experience shows that the implementation of successful business models requires not only technical innovations but also institutional and organizational or social innovations that contribute to

[19] For more on Developing a Sustainable and Circular Bio-Based Economy in EU, see Lange et al., 2021.
[20] For more on Success Factors for Grass-Based Businesses, see Orozco and Grundmann, 2022.

more cooperation, jointly strategy setting, shared governance structures and learning at business and other levels. A thorough and comprehensive understanding of the local interdependencies between grass-based business models and their business environment can significantly help to adequately address any misalignments that may hinder the development of business activities.

GO-GRASS recommendations for the grass-based sector emphasise regulations and the creation of market structures for a secure supply of raw materials at stable prices, sufficient and fair market competition, secure and transparent sustainability profiles of bio-based inputs, due diligence of all actors along the value chain, sufficient capacities for regulation and innovation at all levels, and rewarding multifunctional uses of grassland resources.

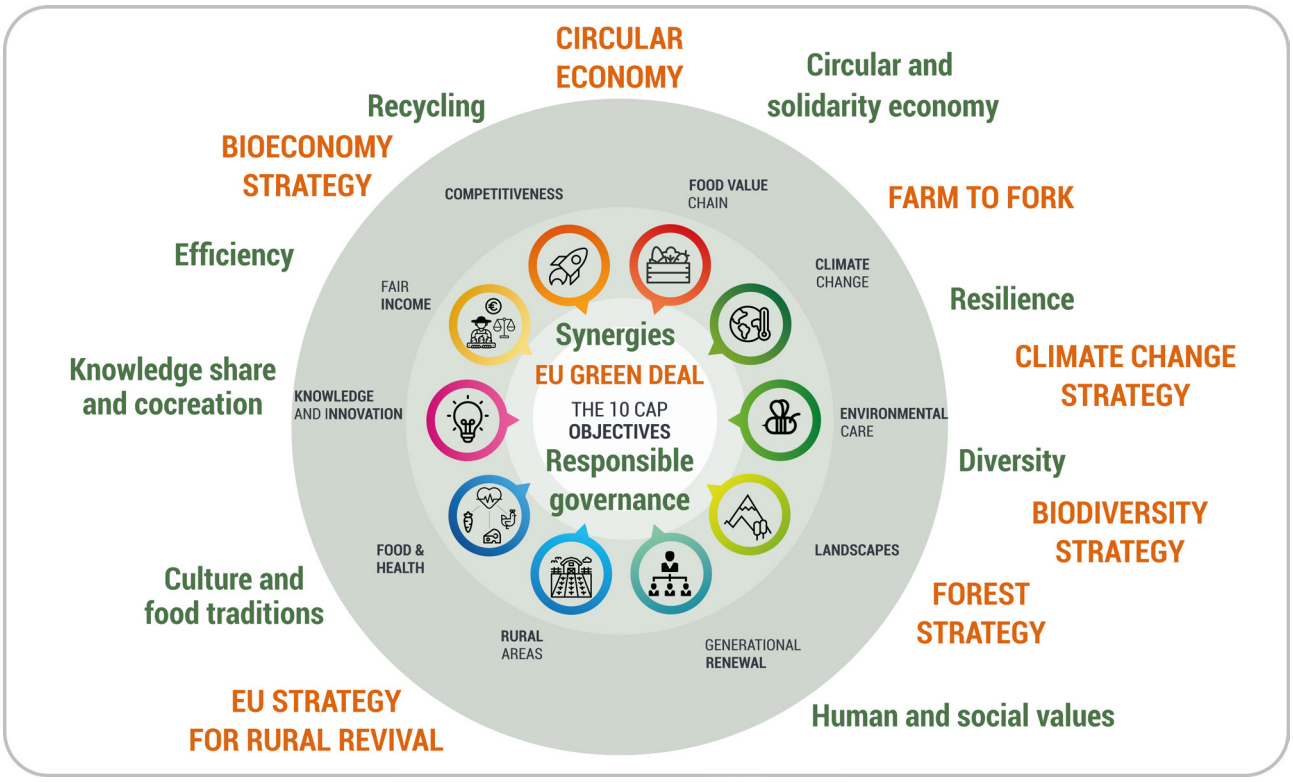
Supportive conditions for creating enabling business environments for grass business models are the results of coordinated efforts from stakeholders, such as public agencies, research institutes, cooperatives, networks, or associations interacting with the enterprises. Future policies need to consider social and organisational innovations as part of the overall strategies to promote grass-based business models across rural areas in the EU.

4. GAPS IN EUROPEAN POLICIES AND REGULATIONS

4.1 European policies for the bioeconomy and grasslands

The post-2020 Common Agricultural Policy (CAP) is based on national strategic plans, which are linked to the use of land to fulfil the EU's social, environmental, and economic objectives. The CAP represents around 33% of the total European Union´s budget. Therefore, the CAP is the main driver of agricultural land use across Europe.

Since 2007, CAP product based-direct-payments were replaced by land-based direct-payments tAfter 2007, CAP product-based direct-payments have been replaced by land-based direct-payments, to increase land use sustainability, without considering the value chains. The CAP strategic plans do not include payments to products, these only being residually considered in the coupled payments (e.g. milk) which tend to disappear. CAP pays grassland land use (both temporary and permanent grasslands). Therefore, these CAP grassland payments may increase grass valorisation, as proposed by GO-GRASS, only when abandoned land is transformed into grasslands. This is especially relevant in those areas with a large amount of abandoned land, usually associated to poor production and infrastructure limitations.



EU objectives (in green) in relation to the EU strategies (in orange) and the agroecology principles as a sustainable form of land management.

Pillar II measures that promote value chains, are allocated to the development of products coming from sustainable systems associated with origin denomination.[21] This could be associated with farm alternative uses, through the promotion of landscape preservation. Pillar I lacks a clear approach regarding the value chain of agro-food systems, and thus, hinders the development of current national protocols to increase CAP payments for grass valorised products.

EU member states need to fulfil other commitments, such as carbon balance estimation, which requires stablishing a carbon accountability linked to the soil carbon stored in permanent grasslands. However, the value chain carbon footprint is not considered per se as part of the accounting.

The European Commission´s **Green Deal strategy** defines new agricultural approaches linked to the agri-food systems. The Green Deal has a holistic approach of farming systems, considering not only the carbon balance in the agroecosystem, but also, the carbon linked to the value chain. Policy makers and end-users need new protocols that allow measuring this carbon balance to get carbon credits. GO-GRASS evaluated alternative grass-based products, including products to be directly sold or used by farmers (animal bedding, biochar, biogas, protein, fibres). Some of these, especially farms´ biogas export, need public infrastructure and control, while others remain under the farmer´s control.

The **EU Bioeconomy Strategy**, published in 2012 and updated in 2018, includes the concept of the bio-based product development to increase the use of resources. This strategy does not allocate specific funds for this, but it supports the development of some European Projects, and high-diversity landscape features, as the EU aims to increase them up to 10% of agricultural areas. The Bioeconomy Strategy does not explicitly include extensive grasslands.

The valorisation of grassland biomass also faces the challenges of land use in Europe, specifically the **competition in land use, exploitation of marginal land and soil degradation.**[22] Policy gaps regarding the use of land should be tackled, so that the bioeconomy objectives for ensuring food and nutrition security, and for the sustainable management of the natural resources, are guaranteed. Development of the bioeconomy depends critically on preventing conflicts with land usage and other agricultural operations. New biotechnologies that process potentially underutilized biomass in combination with novel value chains may be useful in filling the gap caused by an unsustainable biomass supply.[23] In addition, the lack of EU specific regulatory instruments to monitor the soil quality and to reduce soil threats, as the absence of integration of sectoral policies regulating soil emission limits, result on clear challenges for the bioeconomy development. New channels that foster knowledge exchange between local stakeholders on **sustainable land use management** should be set to align bioeconomy objectives with the current policy frameworks. The EU regulations that **monitor the soil quality** for the food and agricultural sectors should be better harmonised.

The European Commission's proposal on **certification of carbon removals**[24] highlights several ways to remove and store carbon, among which closely related to GO-GRASS project are the carbon farming and carbon storage in long-lasting products and materials

[21] For more on European Agroforestry Policy, see Mosquera-Losada et al. 2022.
[22] For more on Value Chains in the European Bioeconomy, see Singh et al., 2021.
[23] For more on Development of Biorefineries in the Bioeconomy, see Ding and Grundmann 2022.
[24] For more on Development of Biorefineries in the Bioeconomy, see EC, 2022.

(e.g. biochar). Even though there is no specific mention of "grassland carbon removal" in this initiative, 80% of European grasslands are below saturation of carbon storage, indicating unmet potential in carbon sequestration.[25] The proposal focuses largely on the forestry and wood-based carbon storages. However, from a carbon-offset perspective, conserving grasslands and promoting rangeland practices that promote reliable rates of carbon sequestration could help meet the emission-reduction goals more readily than conserving the forestry.[26]

Therefore, both the grassland and forestry ecosystems should be considered as critical to reach net zero emissions. Besides, the fluctuation of grassland soil organic carbon stocks stems from complex interactions between grazing, soil carbon inputs and decomposition processes.[27] Intensive grassland management such as continuous livestock grazing reduces plant cover, diversity and productivity, but seasonal or rotational grazing show the least negative effects and can even promote soil carbon storage.[28] The perennial grasses that dominate grasslands are characterized by extensive fibrous root systems that often make up 60-80% of the biomass carbon in these ecosystems. To optimize grassland utilization as carbon sink, the restoration of grassland particularly in the regions where grasslands are most degraded, to prevent their further degradation due to global changes and overgrazing seems crucial. Secondly, though aboveground vegetation of grassland is a small proportion of the total ecosystem carbon pool,[29] the excess biomass generated from grassland management can be valorised to produce innovative bio-based products, which could further contribute positively to the carbon removals.

All GO-GRASS Demo cases show strengths, weaknesses, opportunities and threats with regards to implementing **carbon removal as revenue and business models**. The strengths revolve around the important potential, as well as the additional long-term benefits provided. The weaknesses are related mainly to lack of knowledge, barriers for standardisation and governance or coordination. The opportunities are existent as well as the threats, which are mainly related to uncertainties and policy inconsistencies especially for local actors. A preliminary assessment shows that business models for carbon removals at farm level are particularly relevant for the grass-based Demos of GO-GRASS. Farm level models are suitable, in particular for the demos of **biochar production, animal bedding and organic protein from grass.** Models outside the agri-food chain require a certain scale of production, which could be the case for the demo producing paper and packing material from roadside grass.

The analysis of the main challenges and policy innovations in EU countries that are part of GO-GRASS, can be examined considering the main end-products and their potentials to address most of the EU CAP 2008-2020 goals from a policy point of view:

[25] For more on Grassland Soil Carbon Sequestration, see Bai et al., 2022.
[26] For more on Grasslands as Carbon Sinks, see Dass et al., 2018
[27] For more on Climate Effects from Managed Grasslands, see Chang et al., 2021.
[28] For more on Grassland Soil Carbon Sequestration, see Bai et al., 2022.
[29] For more on Grassland Carbon, see Ontl and Janowiaw., 2017.

BIOGAS

Business expectations: With the growing price increase of non-renewable fuels due to shortages and the need for reduction of CO2-equivalent emissions, it is expected that the biogas business model will run on its own as part of the solution of the fuel shortage, once adequate business environment is provided. Besides, the use of digestates as fertilizer may contribute to solve the growing prices of the fertilizers in the European Union.

Policy recommendations: The policy formulation should consider (i) the level of readiness of the business models in the starting phase when the farmers and rural entrepreneurs are more dependent on economic support to have adequate infrastructures, access to the grid network and training to produce biogas, and (ii) the creation of a business environment that supports the use of the biogas by end-users. From a CAP point of view, both the agri-food system and the farm scale should be incorporated to account for the benefits of using the grass as part of fuel production, ensuring direct CAP payments for the grasslands delivering the grass within the climate neutrality goal of the EU Green Deal. The EU aims to be climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions.

BIOCHAR

The current geopolitical situation in Europe has strongly affected European prices of raw materials and energy. According to the Biannual Report on Global Food Markets (FAO 2022)[30] and based on the available data from the World Bank,[31] global fertilisers prices have been duplicated in the last year: average of 685 US dollar mt-1 (including urea, diammonium phosphate and muriate of potash) from January to September 2022 compared to 379 US dollar mt-1 in the same period of 2021).

Nitrogen fertilisers represent most utilised mineral fertilisers in the EU (approx. 89%), while phosphorous fertilisers, though less important in terms of quantity, remains a key input for plant growth and considered as strategic material, as its main source is phosphate rock which is a non-renewable resource. This prompted the EU to list phosphate rock as a Critical Raw Material (CRM) in its second list of CRMs from 2014.[32] Moreover, nitrogenous fertilisers (ammonia, urea, ammonium nitrate) are produced with energy input from natural gas; while phosphates are mined outside of the EU, resulting in high production and transportation costs, also linked to oil prices.[33]

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[30] For more on Global Prices, see Food Outlook – Biannual Report on Global Food Markets (fao.org)
[31] For more on Commodity Market Prices, see Commodity Markets (worldbank.org)
[32] For more on CRM, see "The fertiliser transition - Institute for European Environmental Policy" (2022)
[33] For more on Mineral Fertilizers, see https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220628-1

Within this context, the European Commission considers that, "a global mineral fertiliser crisis, of a severity unseen since the 1970s, is currently unfolding. The COVID-19 pandemic with its supply chain disruptions, followed by the energy crisis, have resulted in record high fertiliser prices", resulting on the release on November 9th, 2022, of a **Communication on ensuring availability and affordability of fertilisers**[34] including measures aimed (among others) a better access to organic fertilisers and nutrients from recycled waste-streams, especially in regions with a low usage of organic fertilisers.

The current European policies and strategic plans are aiming to strengthen the resilience of the EU's agricultural sector; to reduce their dependence on synthetic fertilisers and scale up the production of renewable energy without undermining food production; and to transform their production capacity in line with more sustainable production methods (Member States' CAP Strategic Plans)

Business expectations: The expected shortage of phosphorous fertilisers is due to shortage of raw materials (in this specific case phosphate rock). Also, the increasing price of mineral fertilizers, triggered by supply chain interruptions and the energy crisis (European Commission, 2022) highlights the role of biochar as nutrient retainer. The success of the grass-based biochar business model requires an adequate and supportive business environment.

Policy recommendations: The production of biochar should be directly fostered by policy makers in the different regions of Europe. The biochar production should consider social aspects linked to the farming context where farm size, number of cooperatives linked to environment uncertainties associated with the grass production (i.e. climate transitional areas) should be carefully considered. Improvement of access to organic fertilizer from residues and waste, emphasized in the Commission's communication on ensuring availability and affordability of fertilisers, should provide opportunities for the producers of grass biochar. Member States should include this mitigation activity as part of the IPCC accounting and the certification scheme of carbon removals to help reach net zero emissions.[35] This will help create an appropriate market for the carbon credits associated with the biochar, as it has already been developed (GRA 2020).[36] From a CAP point of view, both the agri-food system and the farm scale should be incorporated to account for the benefits of using the grass within the climate neutrality perspective.

[34] For more on Fertilizers Availability and Affordability, see https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0590(01)
[35] For more on Certification Scheme for Carmon Removals, see EC, 2022.
[36] For more on Carbon Sequestration thought Biochar, see GRA, 2020.

PAPER DERIVED PRODUCTS

Business expectations: The growing need of paper derived products for packaging to replace plastics, the need of using grass wastes and replacing non-native species makes the business of grass-produced paper attractive. Moreover, grass-revenue is higher than eucalyptus if we consider that grass is produced annually with annual carbon cycles and short economic return compared with fast-growing tree species production that takes at least 12-15 years until biomass raw material can be introduced into the paper production business.

Policy recommendations: The innovative use of grass to deliver grass-based paper products, means that this business model is in a very early stage of development. Once it is developed in GO-GRASS, Member States should support either the development of new companies with this business model or help in the transformation of already existing tree-based paper production companies. This could be carried out through direct payments or tax reduction incentives. Moreover, forest tree species are not currently suitable to receive CAP direct payments, while grass production associated with EU farming systems usually receives CAP direct payments, which is an extraordinary support for this business model. Payments in the future should be governed by the actual benefits and negative effects of producing and harvesting grasslands and forests respectively.

GRASS DERIVED PRODUCTS

Business expectations: The growing human population requires sufficient protein to feed animals and human beings. This is currently causing a very high import of especially soya from other continents to Europe. The development of mechanisms and processes linked to the production of protein products coming from grass is essential for improving EU self-sufficiency in protein. Exploring the use of these processes with locally adapted grass species across Europe, and in different periods of protein production (summer in the north, autumn in the south), could make Europe more balanced from a protein perspective and reduce the need for import and the protein dependency. This has been shown to be especially relevant in the context of recent crises (e.g., Covid-19) that added value to the self-sufficiency and resilience. The reduction of carbon emissions associated with transport will also benefit to the reduction of carbon footprint of protein products, when analysed as part of a global perspective.

Policy recommendations: Considering that grasslands are part of the CAP direct payments, the promotion of this activity should come from Pillar II, through the value chain valorisation, measure, which is poorly adopted across Europe. The technique to produce protein products is based on specific types of grasses and legumes, and it should be adapted and expanded to

other countries considering the different composition they have in their grasslands. This may be reached through the implementation of operational groups in those countries. The value of new permanent grassland areas to increase soil carbon content and of old grasslands to keep a high stock of soil carbon should be included in the EU carbon removal tools.

ANIMAL BEDDING

Business expectation: Animal production is likely to increase at the global level due to the growing global human population. The scarcity of grassland in extensive agriculture, as well as the intensification of livestock farming, could mean that animals increasingly have to be kept in stables where bedding material is needed. The possibility of adopting the circular business model will depend on the availability of the grass but also on the availability of other bedding materials. In Northern Sweden the availability of grain straw is low, and therefore there is a market for grass-based bedding material. Businesses that include cultivation of a perennial energy efficient grass such as reed canary grass with deep root system and good capacity of carbon capture should be included in the carbon removal policy for carbon sequestration.

Policy recommendations: Considering that grasslands are part of the CAP direct payments, the promotion of this activity should come from Pillar II, through value chain valorisation, a measure which is poorly adopted across Europe. The technique to develop products is based on specific types of grasses, which could be expanded to other countries where animal bedding products are in shortage. An analysis of the potential use of different types of grass as raw material for animal bedding and a comparison with the competitor's end-products should be carried out at demos sites level. The funding from operational groups could be key to develop the business models in other areas of Europe.

4.2 Policies applied to bio-based products from grass in specific European countries

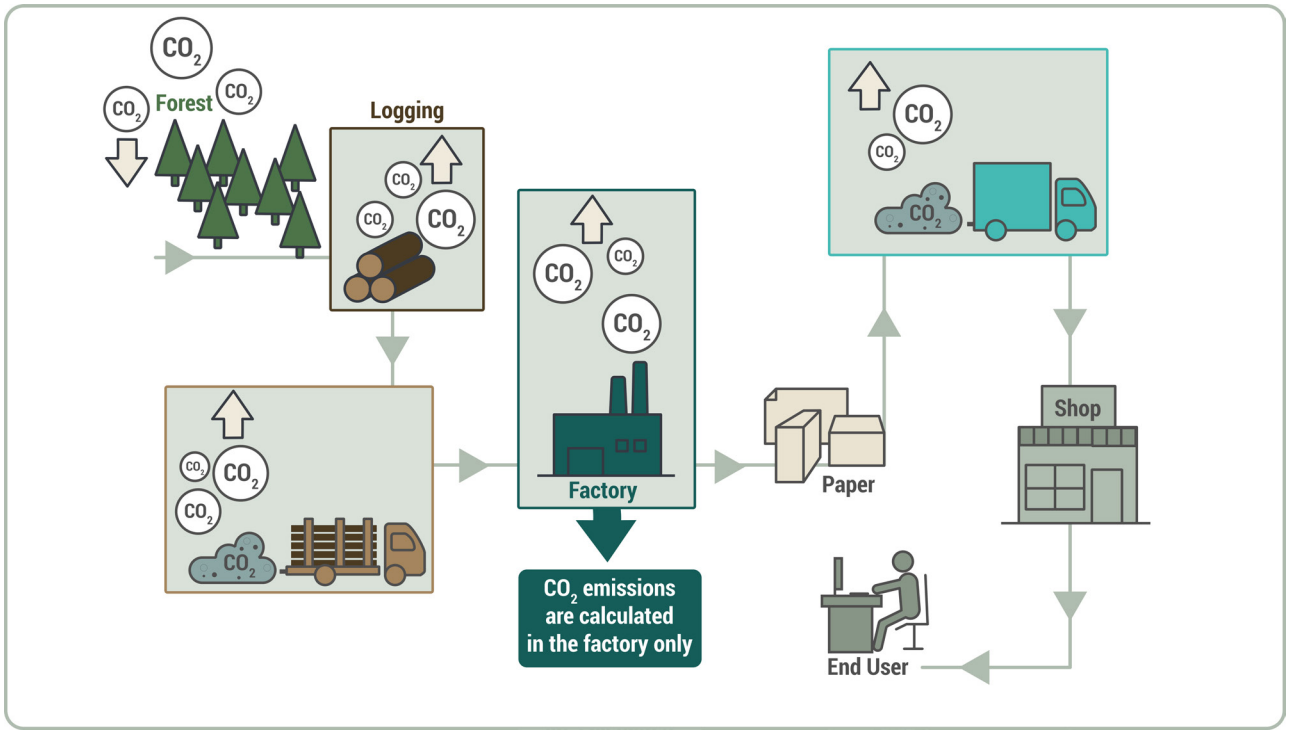
In Germany, Sweden, Denmark and the Netherlands, the GO-GRASS partners have identified different policy gaps and good practices that may be relevant for potential replicators and policy makers.

Policies applied to paper factories in the Netherlands

A drawback for paper factories to switch to alternative, more locally based fibre sources are their own climate targets. The climate targets are usually calculated from the company's direct GHG emissions (Scope 1), indirect GHG emissions from electricity, heating and cooling (Scope 2) or other indirect GHG emissions (Scope 3). Scope 3 emissions can be both upstream and downstream, and include procurement, transport, production of fabricates or waste management.[37] They make up the biggest part of a company's emissions. However, in corporate reporting, companies often only look at CO2 emissions from the factory itself, and do not take the value chain into account, which falls under scope 3.

The diagram below is showing an example of the supply chain of wood cellulose, from tree to end consumer and the CO2 emissions in the chain. However, from the product perspective, framework for life cycle assessment and communication (e.g. the European Product Environmental Footprint methodology and International EPD System) require the entire value chain to be included in the scope of analysis.

The Dutch government only considers the CO2 emissions in the red square around the factory; therefore, it is beneficial for the factory to reduce emissions there. Reduction of CO2 emissions in the complete chain is not of interest for big companies in the Dutch context, since they are not monitored and credited for the processes outside the factory.



[37] For more on Scope 3 Emissions, see Manevski et al., 2018.

This is an issue for the use of grass fibre or other alternative natural fibres, considering that the process of papermaking takes longer for alternative fibre when compared to wood fibre. In the same amount of time, less alternative fibre paper is produced, which results in a higher carbon footprint within the factory.

The outcome of the LCA study performed by ACRESS and Wageningen University suggests that grass fibre is more sustainable than wood fibre. The CO2 emission obstacle would be very interesting for further research and regulations, and this could be a major issue holding back the use of alternative fibre within the paper industry.

Policies applied to grass biochar in Germany

While grass meets the feedstock requirement for biochar marketed as an EU fertilizing product, specified in the amendment to the EU regulation on fertilizing products (EU) 2009/1009 in 2021, the current German fertilizer ordinance does not allow the marketing of grass biochar as a soil amendment as it limits the origin of charcoal to chemically untreated wood). Therefore, producers who wish to market the grass biochar must obtain an individual approval to the product or go through with a conformity assessment by a designated assessment body outside Germany, so that they can market the product as an EU fertilizing product.

According to REACH (Registration, Evaluation, Authorization and Restriction of CHemicals) regulation, biochar producers are required to gather data on the chemical substances of the char and submit a dossier to European Chemicals Agency, if their production is over 1 ton per year. Biochar can be registered under the charcoal dossier. The registration incurs cost, and reduced fee is applied to micro-, small- and medium-sized enterprises.[38]

The above-mentioned approval procedures as well as the registration under REACH that applies can be costly and time consuming. Especially, this may place significant financial and bureaucratic burdens on grass biochar producers of small scale.

The European Commission submitted a proposal on carbon removal certification in 2022, which offers opportunities for biochar. Nonetheless, it is yet uncertain to what extent biochar will be included in the certification scheme. In the pre-legislative synthesis of European Parliament for the carbon removal certification, use of biochar was introduced as one of promising carbon removal strategies. At the same time, it points out that effect on carbon sequestration remains to be unclear and its potential may be limited as much of the feedstock is already utilised.

Policies applied to grass-based protein concentrate production in Denmark

The change of annual cropland into perennial grassland is associated with several ecosystem services, which can be of high value in an intensively farmed country like Denmark. Especially, the significant reduction in nitrate leaching can help fulfil the EU Water Framework Directive, which is otherwise difficult to implement for Denmark.

In addition, soil carbon storage can help deliver the emission reduction required by the Danish Climate Law, and reduced pesticide use can help protect drinking water resources. However, as there are no direct economic incentives for farmers to deliver these ecosystem services, there was a lack of pull for their development.

Therefore, the Danish Parliament decided

[38] For more on Biochar Registration Regulation, see (EC) No 340/2008.

to support the establishment of green biorefineries to produce protein concentrate and other products, which can create a market pull for more grassland. The development was initiated by a report on "Proteins for the future" produced by the National Bioeconomy Panel in 2018[39] followed by a government "action plan for sustainable proteins for the future"[40] which included the first 3.4 M Euro to support the establishment of green biorefineries.

Finally, the broad agreement on "Green transition of agriculture" in 2021 allocated 35 M € to support the new business development.[41] These actions, along with a general goodwill within farming organisations, agricultural industries, NGOs and the general public to support the transition, have created the foundations for the first two commercial green biorefineries to be established. Additional green biorefineries are expected from 2023, when the support for green transition in agriculture will be implemented.

As a successful example for potential replication, the Danish case on producing protein concentrate, fibre silage, and biogas, has been very successful, and the first two commercial plants have been established during the project period.[42] The success has been facilitated by the documentation of a "triple bottom line" of economic, environmental, and social benefits that allowed to get support from all sides: political, farm industry, farmers, and NGOs, in strong interaction with research.

The benefits and triple bottom lines were essential for a new innovative business case to be viable within the agricultural business environment, which is now under great pressure to deliver on climate and environment, rural jobs, and rural development. Involving all stakeholders in the discussion and further development of a new business case is key for a successful outcome.

Regulations and policy context for animal bedding in Sweden

Regulations from the Swedish Board of Agriculture include provisions on animal husbandry. Stables for cattle must be cleaned and emptied from manure every day, unless the system for animal husbandry is constructed for other procedures that ensure good hygiene. Lying areas shall be kept clean, dry, and adapted to animal species and thermic climate in the stable. In calving pens, for calves younger than one month, bedding material shall be provided, and it should also be provided for cattle older than one month. During the cold season, bedding material should be provided in lying areas in stables with outdoor-like climate. The bedding material shall be suitable for the animals and of good hygienic quality. The air in the stable may only occasionally exceed threshold values for ammonia, carbon dioxide, hydrogen sulphide and organic dust. There are also limits for relative humidity. Outwintering cattle that spend more than half the day outdoors must have access to an open shed with clean and dry bedding material during the cold period, i.e., for cattle when there is no growth in pasture land. Similar prescriptions are applicable to horses and pigs. Live animals must have access to bedding material during transportation. These regulations and this policy context do not seem to hamper the development of animal bedding material from reed canary grass (RCG) in Sweden.

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[39] For more on Proteins for the Future, see The Danish National Bioeconomy Panel, 2018.
[40] For more on Danish Action Plan for Sustainable Proteins, see https://fvm.dk/nyheder/nyhed/nyhed/miljoe-og-foedevareministeren-fremtidens-baeredygtige-proteiner-kan-komme-fra-danmark/
[41] For more on Danish Green Transition of Agriculture, see https://fm.dk/media/25215/aftale-om-groen-omstilling-af-dansk-landbrug.pdf
[42] For more on benefits of grassland crops and green biorefining, see Jørgensen et al., 2022.

The competition from other bedding materials (e.g. straw and wood shavings) depends on prices per bedding function, on the price for nutrients and soil improvers that can compensate for removed straw, and on the price for solid biomass fuels in heat and power production. In 2018, after a very dry summer, prices on straw increased dramatically which made many animal farmers look for alternatives such as wood shavings and peat. Production of animal bedding based on Reed Canary grass could contribute to more flexible and resilient supply, more stable prices of bedding materials and of biofuels for heat and power. From the cattle farmer perspective, the higher biogas potential from manure containing Reed Canary grass compared to straw or wood shavings is also a bonus.

In Sweden, several investment programmes have facilitated the development of biogas production. In recent years, a large part of new production and investment is run by private companies mainly focusing on industrial organic waste such as manure, waste and residues from agriculture, food industry and slaughterhouses. To increase the production of biogas and increase the competitiveness of the producers, support will be granted to biogas producers that upgrade the gas to biomethane (at the most 30 € per MWh) or to liquefied biomethane (at the most about 45 € per MWh) (Swedish Energy Agency - Energimyndigheten 2022).The new common agricultural policy (CAP) that will come into force in 2023 on the Swedish Board of Agriculture (Jordbruksverket 2022) does not seem to indicate any financial support (except Single farm payment) for the type of Reed Canary grass production that is included in the Swedish demo.

5. POLICY RECOMMENDATIONS

Using the main findings from GO-GRASS described in this White Paper, the project partners are developing recommendations on how the new results can be incorporated into the European policy framework for grasslands and the bioeconomy. The specific policy actions proposed will contribute to a conducive business environment for grass-based enterprises, addressing the environmental, technological, economic, and social challenges.

The policy actions are based on the learnings, the innovations and business models that are being developed in the four GO-GRASS demos. We formulate policies and support actions, which are designed to promote businesses and value chain development that will help integrate soil carbon storage into grass-based business models in general.

5.1 Policy measures

The following list of recommendations can be deployed from a bioeconomy and grassland point of view.

Measures at EU level

- Design policies that promote opportunities for diversification in the sense of new grass-based value chains, diverse demand patterns and business models and markets.
- Maintain the area of grasslands at Member State level as part of the greening measures of the CAP.
- Remove contradictory and restrictive legislation which currently limits the potential of carbon removal through grasslands.
- Recognise the importance of carbon content in grassland soils and show willingness to increase this in agricultural soils.
- Create the possibility for farmers to work on increasing the carbon content of their soils at a feasible and understandable administrative level.
- Create financial incentives to encourage land manager engagement in carbon farm-ing. A formalised carbon credits system as proposed by the EU Carbon Removal Certi-fication can help to increase the market for grass as a resource for the bioeconomy. Carbon credits can reduce the selling price for grass and, hence, increase demand.
- Develop monitoring systems to identify trade-offs in ecosystem services and reduce the environmental footprint of new business activities.

Measures at national and regional level

- Take a holistic view to valorising grassland biomass, covering environmental, climatic, social-economic, and technological perspectives. Potential support of government incentives and regulatory-push effect need to be coordinated.
- Support conversion of arable land into grassland to preserve the environment, build up soil carbon, and facilitate the delivery of resources for biorefineries that can produce feed, food, materials and bioenergy.
- Develop specific actions supporting the maintenance of grasslands threatened by abandonment and provide targeted policy support to maintain the ecosystem services related to grasslands (fire control, tourism, biodiversity, high soil carbon content).
- Align fertiliser regulations at EU and national levels and provide policy support and advisory services for small- to medium- scale circular biochar business at national or regional level.

5.2 Support Actions

GO-GRASS partners also recommend the implementation of the following support actions:

- Increase awareness of the benefits of grasslands through training, workshops, and outreach to consumers via non-specialised media.
- Develop ready to use solutions sold or made available through licensing. To facilitate the adoption of the grass-based alternatives by the farmers or other end-users, it would be advisable to create solutions or business models that can be implemented in an easy way. Technological companies can implement the solutions for the grass-lands through a licensing model to obtain revenues.
- Organise engaging and open policy dialogues to discuss best practices and show the conclusions to the policy stakeholders in cooperation with related projects (Nefertiti, Super-G, BRANCHES, BE-Rural).
- Establish adequate knowledge transfer actions including demonstration fields, biore-fineries and extension services that allow farmers to understand the new products delivered from grasslands.
- Promote the establishment of farmers cooperatives, and adequate management through the development of operational groups linked to the EIP-Agri, to foster innovation in grasslands bioeconomy.