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Hemp Club

Competent and Connected
Clusters Unfold the Hemp
Industry Potential for the
European Bioeconomy

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bioeconomy value chains with focus on hemp
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The HempClub project

The Competent and Connected Clusters Unfold the Hemp Industry Potential for the European Bioeconomy (HempClub) project is an EU COSME project coordinated by the Lombardy Green Chemistry Association bringing together 7 clusters and associations from Italy, Czech Republic, Romania, Austria and Portugal.

Acknowledging the fact that, with its unique chemical properties, environmental benefits, high yield and wide range of applications, hemp is a valuable crop for the bioeconomy, contributing to achieving climate neutrality, the HempClub project works to unlock the potential of hemp by creating EU value chains for biobased applications and new business opportunities for primary producers and chemical companies. As a European Strategic Cluster Partnership, HempClub promotes collaboration, synchronised strategies, and encourages innovative interregional investments to enhance cluster excellence. Through mutual learning, and SMEs and other stakeholders' mobility, HempClub aims to unlock the biomass exploitation potential supporting the ClusterXchange scheme's implementation.

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Abbreviations

CZECHEMP	Czech Hemp Cluster
FEDERCANAPA	Federazione Italiana Canapa
IND-AGRO-POL	IND-AGRO-POL association
LGCA	Lombardy Green Chemistry Association
SAT	Standortagentur Tirol GmbH
SPRING	Sustainable Processes and Resources for Innovation and National Growth
PRODUTECH	Portuguese Production Technologies Cluster

Executive summary

The European bioeconomy, valued at EUR 1,740 billion in 2022, confronts uncertainties in policy and industrial support, hindering progress. Meanwhile, the global significance of the bioeconomy, led by China and the USA in bio-based production, underscores the need for dedicated codes, compensation mechanisms, and political will for successful implementation. While progress is evident in aligning with EU Bioeconomy Strategy objectives, environmental challenges persist. Reduced consumption and increased innovation in biomass recovery and reuse are crucial. The strategy prioritizes sustainable food and resource management, reduced reliance on non-renewables, climate change mitigation, and competitiveness and job creation.

Hemp, or *Cannabis sativa*, distinguishes itself with negligible THC levels, making it a versatile plant for textiles, ropes, building materials, and bioplastics, thus, to be an important player in the bioeconomy revolution. Its ecological benefits, including phytoremediation, contribute to sustainability in various sectors, aligning with the United Nations' 17 Sustainable Development Goals (SDGs) and supporting the European Green Deal. Despite hemp's potential, challenges such as stigma, regulatory complexity, and the absence of global standards hinder its growth. Addressing these issues requires policy reform, standardization, education, and collaboration across sectors.

The exploration of promising value chains for industrial hemp focuses on establishing sustainable and collaborative supply chains. Building trust among key stakeholders is identified as crucial for successful collaboration. This document outlines a strategic process for building localized value chains, involving farmers, refining factories, local markets, and scaling up to industrial levels. Governmental support, particularly through legislation encouraging collaboration, is deemed essential. Identified key value chains for hemp across sectors, such as textiles, construction, automotive, nutraceuticals, bio-composites are detailed. Examples of innovative hemp-based products within these sectors are highlighted, alongside opportunities for overcoming regulatory hurdles, addressing THC limits, and strengthening networking and collaboration.

This policy paper addresses key challenges and opportunities in the hemp industry, emphasizing the necessity of integrating bioeconomy principles into a circular framework. The current regulatory landscape, marked by challenges in EFSA's Novel Food applications and stringent THC limits proposed by the European Commission, hinders industry growth and innovation. The paper suggests a multi-faceted approach involving scientific research, policy advocacy, public education, innovation, collaboration, and sustainable practices.

The recommendations include:

- investing in scientific research,
- advocating for balanced regulations,
- educating the public and policymakers,
- encouraging innovation within regulatory constraints,
- building platforms for knowledge exchange,
- providing consultancy for sustainable practices,
- lobbying for reasonable THC limits,
- emphasizing circular bioeconomy integration,
- promoting political will for a sustainable transition,
- exploring EU funding and support programs.

The paper stresses the importance of strong political will to enact legislation recognizing the dynamic nature of innovation and the benefits of transitioning from a fossil-based economy to a sustainable, resource-efficient model. Implementing these recommendations is crucial for overcoming challenges and unlocking the hemp industry's full potential in a sustainable and innovative manner.

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1. Introduction

The main objective of the HempClub project was to create an interconnected and interregional supply chain between operators in primary production, agri-food processing, and green chemistry by strengthening industrial symbiosis and sustainable and renewable business models. Within the framework of the project, *WP 2 - Portfolio of bioeconomy-added-value services for cluster members* is certainly of particular interest for this policy paper.

WP2 aims to develop a multi-perspective mapping of knowledge and resources related to the current and potential hemp value chain within the broader circular bioeconomy, according to regional priorities and strategies of the countries involved in the HempClub project (Italy, Czech Republic, Portugal, Romania, Austria).

During the two years of the project many activities have been performed which helped to the creation of the following final public document *D2.9 - Position paper on the development of bioeconomy value chains with focus on hemp*. A structured strategy to reach the final objectives of WP2 have been followed. The process started with:

1. Assessment of HempClub partners bioeconomy strategies and their involvement in the regional, national and EU trajectories.
2. Mapping of existing hemp-related value chains and initiatives at EU level, with the focus in the regions involved in the consortium.
3. Mapping of the technological and innovation opportunities and needs of the cluster's members to the development and implementation of circular bioeconomy solutions.
4. Creation of a set of specific services for cluster members correlated to an implementation plan.

The procedure helped to deploy collaboration between clusters and cluster members, allowing the exchange of practices and knowledge at national and EU level. Besides fostering the innovation sector, it was recognized the need to stimulate and raise awareness at policy level. This final deliverable highlights a strategic position on bioeconomy and hemp-related value chains, targeting policy makers and public authorities (at regional, national, and EU level) as the main audience, offering an overview of the main gaps in regulatory frameworks related to hemp and suggesting possible recommendations.

2. Overview of the Bioeconomy

2.1. Definition and Scope

The circular bioeconomy is a pillar of the ecological transition, because of its ability to contribute to the implementation of the European Green Deal, decarbonising the economy, decreasing the use of non-renewable resources, and maximising the efficiency and sustainability of renewable ones¹. In other words, the bioeconomy represents a critical shift towards a more sustainable and environmentally friendly economic system. It offers a holistic approach to managing natural resources, driving innovation, and promoting sustainable development. The common element of the various bio-economic activities is, therefore, the use of biological and renewable raw materials. The reuse of biomass within production cycles represents an important building block that can reduce the use of unsustainable inputs from a circular economy perspective. Waste from a production process or household and business waste management can be transformed into valuable bio-sustainable inputs for other transformation processes, if collected and treated appropriately. The transition to a bioeconomy is complex and multifaceted, requiring coordinated efforts across various sectors and disciplines:

- *Renewable Biological Resources.* The bioeconomy is founded on the use of biological resources such as plants, trees, algae, marine organisms, and microorganisms. These resources are renewable and provide the raw materials for various industries.
- *Sustainable Production and Consumption.* The bioeconomy emphasizes sustainable, eco-friendly practices that reduce environmental impact. This involves responsible management of natural resources to ensure long-term viability.
- *Innovation in Biotechnology.* Advanced biotechnologies play a crucial role in the bioeconomy. They enable the development of new products and processes that are more efficient and less harmful to the environment.
- *Integration Across Sectors.* The bioeconomy is interdisciplinary, integrating knowledge and techniques from biology, chemistry, physics, and engineering. This approach fosters collaboration across various sectors, from agriculture to energy production.
- *Economic and Social Impact.* The transition to a bioeconomy has significant economic implications, with the potential to create jobs, stimulate economic growth, and reduce dependency on fossil fuels. It also has social implications, including the potential for rural development and the promotion of sustainable practices.
- *Policy and Regulatory Frameworks.* Effective policy and regulatory frameworks are essential to support the growth of the bioeconomy. This includes policies that encourage sustainable practices, support research and development, and facilitate market access for bio-based products.
- *Global and Regional Perspectives.* The bioeconomy is not just a national concern but a global one, with different regions adopting unique approaches based on their resources, economic structures, and environmental challenges.
- *Challenges and Future Directions.* The bioeconomy faces challenges such as competition for land and resources, the need for technological advancement, and the balancing of economic growth with environmental sustainability. Addressing these challenges requires ongoing research, innovation, and collaboration.

It is a complex aggregate that transcends typical sectoral boundaries, encompassing agriculture and the related agro-food chains, the fashion system, bio-based products, wood, paper, and even organic waste, bioenergy and bio-based chemistry. The European bioeconomy generated an output of around EUR 1,740

1

https://rea.ec.europa.eu/news/more-robust-bioeconomy-could-help-eu-accelerate-its-progress-towards-circular-and-low-carbon-economy-2023-11-27_en

billion in 2022, employing over 7.6 million people². Germany and France generated a turnover of EUR 583.3 billion and EUR 452 billion, respectively.

Within the HempClub consortium, the turnover and the employment rate in the overall bioeconomy sectors is reported in Table 1:

Table 1 - HempClub consortium national turnover and employment in the overall bioeconomy sectors (2019)³.

HempClub nation	Turnover (billion EUR)	Employing (million people)
Italy ⁴	415.3	1.996
Portugal	42.7	0.6488
Czech Republic	38.2	0.3875
Romania	42.8	2.308
Austria	68.1	0.3286

The United States launched the National Biotechnology and Biomanufacturing Initiative⁵ to protect and incentivise domestic industry in this sector. This important act adds to the list of 'BiopREFERRED' products and the Inflation Reduction Act of 2022, the most significant climate legislation in US history, which provides funding, programmes and incentives to accelerate the transition to a clean energy economy.

European policy has boosted bio-based research to the point of launching flagship projects to support the scaling-up of technologies but has failed to support an industrial policy capable of strengthening our leadership and keeping our continent attractive and competitive.

Now, while China and the USA are vying for the lead in bio-based production, Europe is proving uncertain, amidst directives and regulations that often contradict each other and which, due to a silo approach do not fully grasp the opportunities of some strongly interdisciplinary and holistic sectors such as the Bioeconomy in which bio-based products, bioenergy, waste and by-products from the agro-food and wood supply chains, bioprocesses, and system redesign are strongly connected and can really contribute to the decarbonisation of the economy. It is not easy to prefigure an adaptation of the European system in an international scenario that is very different from the one we had when the Green Deal was launched, but certainly, the circular Bioeconomy becomes even more important in this context.

Therefore, if we do not want to burn the investments made and underway, we need dedicated NACE and EER codes for a full implementation of the Bioeconomy in a circular logic, and to activate compensation mechanisms to support the most advanced sectors for which there are not yet mature regulations, favouring the interconnection with the more traditional sectors in an effort of field experimentation.

²<https://group.intesasanpaolo.com/it/research/research-in-primo-piano/ricerche-tematiche/2023/9--rapporto-la-bioeconomia-in-europa>

³ https://knowledge4policy.ec.europa.eu/visualisation/bioeconomy-different-countries_en#bioeconomics

⁴ The data is from 2022.

⁵

<https://www.hhs.gov/about/news/2022/09/14/fact-sheet-hhs-takes-action-executive-order-launching-national-biotechnology-biomanufacturing-initiative.html>

In this sense, a strong political will is indispensable, beyond slogans, to correct legislation so that it is able to recognise the relevant spin-offs of aggregated systems and take into account the dynamic evolutionary process of innovation. This concept represents a significant paradigm shift from a fossil-based economy to one that is more sustainable and resource-efficient.

2.2. Current Trends and Opportunities

The bioeconomy is a complex and dynamic system and thus decision-makers need new strategies and tools to steer and govern this complex system towards the desired outcomes. Thus, a common denominator - also with the EU-level bioeconomy - is the necessity to monitor progress towards the respective bioeconomy objectives. The key messages are that Europe is generally moving towards the objectives of the EU Bioeconomy Strategy but environmental challenges persist. This points to a need for policy coordination as a consequence of multiple pressures on land from biomass demand. This indicates both a reduction in consumption and a further push to innovate and re-skill the workforce are necessary for more efficient production and especially recovery and re-use of biomass. The EU Bioeconomy Strategy defines five objectives that a sustainable and circular EU bioeconomy should achieve: i) Ensuring food and nutrition security; ii) Managing natural resources sustainably; iii) Reducing dependence on nonrenewable, unsustainable resources, whether sourced domestically or from abroad; iv) Mitigating and adapting to climate change; v) Strengthening European competitiveness and creating jobs. In detail⁶:

- **Ensuring food and nutrition security.** Food availability indicators are seen to be generally stable, which is in line with other recent assessments on food security made by the European Commission. The indicators contributing to the understanding of accessibility to food are showing that while there is more overall food security in the EU, the food purchasing power has slightly declined in the past 5 years (it is stable on a 10-year average).
- **Managing natural resources sustainably.** Provisioning ecosystem services show a clear positive trend. The indicators focused on pressures on forests and agroecosystems show a decline in sustainable management. On the other hand, indicators focused on pressures from fisheries show positive trends for the areas monitored (North-East Atlantic and the Mediterranean & Black Sea areas), although it should be noted that the level of fishing pressure started from a high level and although it is declining, it is still not at a sustainable level. The biodiversity indicators show stable conditions for farmland birds and grassland butterflies, but they are stable at a much-degraded state compared to the past. On the contrary, the index for common forest birds shows a promising positive trend that continues for several years. The surface areas of both marine and terrestrial protected areas continue to increase significantly.
- **Reducing dependence on non-renewable, unsustainable resources.** Trends for resource and energy efficiency are largely positive. For instance, the mass of biomass consumed to generate GDP has decreased. Similarly, energy efficiency and renewable energy use across the whole economy have increased, although the values specific to bioeconomy industries are not isolated here. Biowaste generation has been increasing in the last 5 years, although so has the fraction of biowaste recovered, amounting to more than 90% in 2018. Isolating food waste generation from biowaste, we do not see any significant change in time at any step of the supply chain. Assessing food waste by food category, we do see that there has been, in the past five years, a significant decline in food waste generation for cereals, fish and oil crops. The total consumption of biomass for energy and materials has been increasing steadily over the past years.
- **Mitigating and adapting to climate change.** The monitoring of progress towards this objective still presents several indicator gaps, in particular on the full set of climate change adaptation indicators. Nevertheless, the existing indicators in two major bioeconomy-related sectors, agriculture and LULUCF (Land use, land use change, and forestry), do not show promising trends. There is a slight worsening in the emissions from agriculture, as the sector is still reporting a large amount of GHG

⁶ https://publications.jrc.ec.europa.eu/repository/bitstream/JRC132639/JRC132639_01.pdf

emissions, with an increase from 2012 levels. LULUCF includes cropland and grassland, and these are relatively stable throughout time, but the fluctuations in the indicator are due to the forests (and to a certain extent, to the harvested wood products). The forest carbon sink is mainly driven by the difference between increments and harvests, and natural disturbances. The Water Exploitation Index is another critical indicator showing the balance between water demand and abstractions vs. water availability. This indicator is particularly critical for water-stressed regions such as the Mediterranean.

- **Strengthening European competitiveness and creating jobs.** The dynamics regarding the share of value added over the GDP of the bioeconomy sector are heterogeneous. In general, biomass-producing activities (agriculture, forestry and fishing) are either stable, or negative trends are shown in their share of GDP. This reflects the long-term development of a lower dynamism of these activities compared to the total economy. The share of manufacture of food and beverages activities registered a stable to positive trend in the analyzed periods. More traditional non-food biomass-processing activities show a stable evolution (e.g. wood products and paper) or, in the case of textiles, a structural decline. The most positive and dynamic trends can be observed for more recent bio-based industrial activities related to chemicals, pharmaceuticals, plastics, and the energy-oriented bio-based sectors. Despite the heterogeneous trends among bio-based activities, the gross value added per person employed in the bioeconomy showed a strong increasing trend in the periods considered. This indicates an improvement in labor productivity within the overall bioeconomy. The above finding relates to the increasing trends in both turnover and value added in the total bioeconomy, but also to a slightly decreasing trend in the number of people employed in the bioeconomy sectors. This decline can be explained by the reduction in the agricultural labor force in the analyzed period, which was only partially offset by an increase in the number of employed persons in other bio-based sectors.

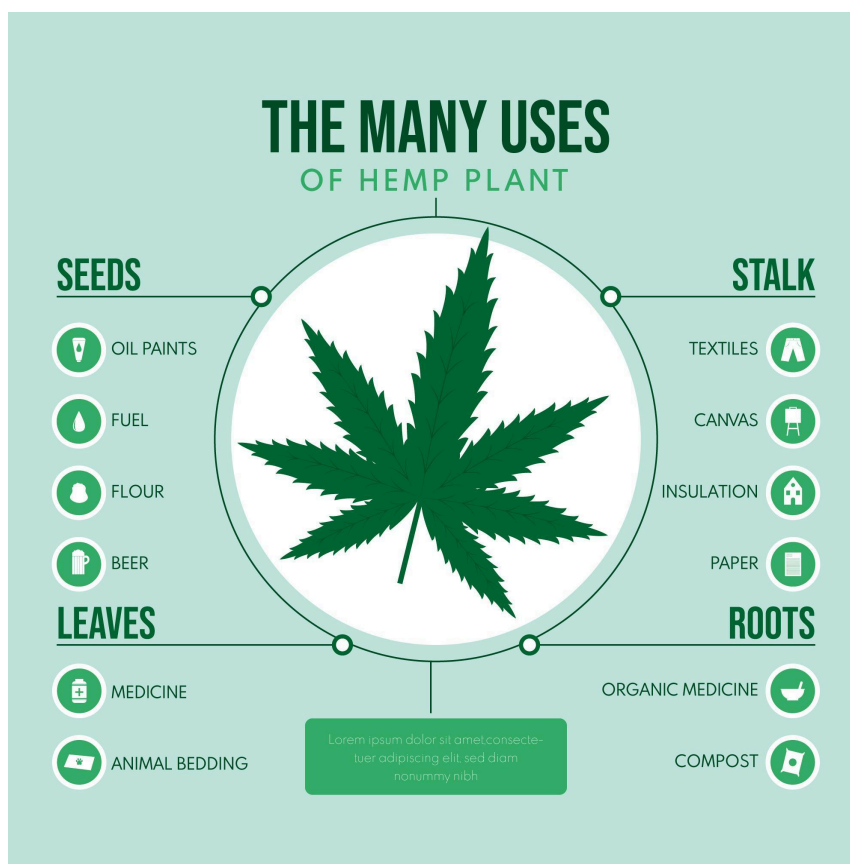
In conclusion, the bioeconomy presents a dynamic landscape where sustainable resource management, technological innovation, and circular economy principles are key. Despite progress towards EU Bioeconomy Strategy objectives, environmental challenges and policy coordination issues persist, necessitating a reduction in consumption and innovation in biomass recovery and reuse. The strategy's objectives highlight the need for sustainable food and resource management, reduced reliance on non-renewables, climate change mitigation, and boosting competitiveness and job creation. The trends across various sectors are mixed, with some showing positive developments while others require further attention to align with the bioeconomy's overarching goals.

3. Focus on Hemp

3.1. Introduction of Hemp

Hemp, scientifically termed *Cannabis sativa*, is a remarkably versatile plant that has been cultivated as an agricultural crop for millennia. Industrial Hemp is characterized by negligible levels of THC (tetrahydrocannabinol), the compound responsible for the psychoactive effects. This distinction is crucial, making hemp an industrially and agriculturally significant crop rather than a narcotic substance. In regulatory papers and policies, the word ‘hemp’ generally identifies cannabis plants or strains where the low content of THC was achieved by selective breeding. On the contrary, the term “cannabis” is usually employed when referring to higher THC strains, used as drugs or in the pharmaceutical sectors as medicinal cannabis. Generally, according to forensic toxicology and scientific literature, plant varieties with a THC content lower than 1% are not associated with psychotropic effects. In North America, the USA, and Canada, the legal limit for cultivation is 0.3%; in some countries such as Switzerland and recently Czech Republic (since the 1st of January 2022) it is even 1%. In the EU, the limit was increased by January 1st 2023 from 0.2% to 0.3%⁷.

The industrial relevance of hemp lies in its varied applications. The hemp stem contains fibers that are extraordinarily strong and durable, making them ideal for textiles, ropes, and even insulation materials in the building sector or additive to biocomposites. Also, the wooden part of the stem - shives - is used in building for making boards, bricks, or prefabricated panels. Furthermore, the seeds and oil derived from hemp are highly nutritious and rich in essential fatty acids, proteins, and minerals, making them valuable in food and or animal feed additives. The following Figure 1 shows the main uses of the various parts of the hemp plant.



⁷ <https://eiha.org/wp-content/uploads/2021/12/PR-CAP-VOTE-COUNCIL.pdf>

Figure 1 - The main uses of hemp plant⁸

In the context of a bio-based economy, hemp's significance cannot be overstated. The bioeconomy focuses on reducing reliance on fossil fuels and promoting sustainable, biological resources for industrial purposes ideally locally sourced to create local supply chains⁹. Hemp aligns perfectly with this ethos. Hemp does indeed provide many positive attributes such as:

- building healthy soils which can reduce soil erosion thanks to cultivation in narrow rows and a spherical root,
- expanding biodiversity (e.g. for bees) ensuring a low input of herbicides,
- providing weed suppression with the potential of increased yields in subsequent crops,
- needing no-to-low pest management inputs and being effective for phytoremediation,
- representing an industrial plant with side production of high nutrition food that enables farmers to grow multiple co-products from a single hemp crop,
- benefiting farmers, increasing employment, and strengthening local communities.

Below we discuss some of its benefits as well as challenges regarding its production. Before going into detail, however, it is useful to highlight how data on hemp production is still limited, possibly due to the decades during which it was illegal, the lack of missing standardization in the production, and equal Harmonized System (HS) codes for international trading. Moreover, researchers warn that the hemp industry is plagued by large information gaps that have developed regarding production, environmental and economic impact¹⁰.

Despite this timely clarification, however, all the evidence gathered so far tells us that hemp production has numerous ecologically beneficial attributes. Table 2 outlines the benefits of hemp and its fiber “cousin” flax (“linseed”) and demonstrates how it performs better compared to most other major crops.

⁸ https://www.freepik.com/free-vector/uses-hemp-plant-infographic_11521193.htm

⁹ https://www.researchgate.net/publication/332290182_BioEconomy_Hemp_chain

¹⁰ <https://www.mdpi.com/2071-1050/15/8/6457>

Table 2 - Ecological benefits of hemp and other crops in Europe¹¹.

	Nutrient depletion	Pesticides	Erosion	Soil compaction	Water consumption	Biodiversity	Agro-biodiversity
Hemp	A	A	A/B	A	B	B	A
Permanent pasture	A	A	A	A	A	A	A
Short rotation coppice (poplar, willow)	A	A	A	A	B	A/B	A
Winter grains	A	A	A	A	A	B	B
Linseed	A	B	A/B	A	A	A/B	A
Alfalfa	B	A	A	A/B	A/B	A/B	A
Grass	B	B	B	A/B	A	B/C	A
Switchgrass	?	?	A	A	A	B	A
Mustard	A/B	B	A/B	A	B	B	A
Sorghum	A	B/C	A	A	A/C	B	B
Wheat	A	B	A	A	B	B/C	C
Sunflower	A/B	B	B/C	A	B	A/B	B
Rapeseed	B/C	C	B	A	n/a	B/C	A/B
Sugarbeet	B/C	B	C	C	A/C	B	B
Maize	C	C	C	B	A/B	C	B/C
Potato	B/C	B	C	C	C	B/C	C

Environmental impact:
A = Lowest
B = Medium
C = Worst

Moreover, hemp has low input requirements to properly grow and achieve high yields. It is considered a low-maintenance crop and due to its vigorous growth, shading capacity, and disease resistance, hemp can be, and is being, grown without the use of pesticides and herbicides – particularly synthetic ones – in many countries. Given the limited need for chemical inputs, hemp is an ideal crop for organic agriculture as it works well with manure or other organic fertilizers as well for regenerative farming. Again, hemp can be a beneficial rotational crop, providing weed suppression and increasing yields. Crops grown in rotation with hemp have been shown to have both less weed pressure and up to 10-20% increased yields in subsequent crops such as corn, soybeans, tobacco, and wheat. This makes it an important rotational crop and could also reduce the energy needed to manage weeds.

The impact of hemp in the bioeconomy does not end there but numerous other elements that can be highlighted:

- Hemp can be beneficial to biodiversity. Hemp is considered superior to numerous other annual row crops in terms of limiting damage to biodiversity, though it does not compare well to perennial or winter annual forage sod crops that are often composed of multiple species, including nitrogen-fixing legumes. In addition, as hemp is widely grown with limited or no synthetic pesticides, the use of such inputs during production does not pose an extensive risk to biodiversity.
- Being wind-pollinated, hemp plants produce large amounts of pollen that are attractive to bees. Hemp flowering during a period of limited pollen availability can make hemp flowers a valuable source of pollen for many species of foraging bees. This can also help to sustain agroecosystem-wide pollination services for other crops in the landscape.

¹¹ <https://textileexchange.org/app/uploads/2023/04/Growing-Hemp-for-the-Future-1.pdf>

- Hemp's roots improve soil health and prevent erosion. Hemp's extensive and deep root penetrates deep into the soil providing aeration, while simultaneously building soil aggregate and preventing soil erosion. In addition, the roots decay before the next planting season, providing aeration and fertilization to the soil.
- Hemp is effective for phytoremediation of heavy metals, chemicals, and radiation in soil. Hemp has been used to extract heavy metals, dioxin, pesticides, radioactive materials, and more from polluted soil after the cultivation of these plants on degraded land. In some cases, the fiber could be reused in other products, pollutants can be extracted, or it may need to be disposed of as hazardous waste, depending on the contaminant.
- As a multi-purpose plant, farmers can grow multiple co-products from a single hemp crop. As an example, a farmer can yield both grain (oilseed) and straw (from which fiber could be obtained by the decortication process). Further, hemp straw produces multiple types of products – both fiber and hurd – have very different material applications. Benefits of multi-purpose hemp production include greater economic sustainability, with farmers able to use the same land to produce more than one product at the same time (farmers can potentially earn more from the same crop with the same input costs), and greater environmental sustainability as farmers are using the same amount of water as well as the same amount of soil fertility inputs.
- Hemp production can bring several potential benefits to farmers, workers, and local communities. As a beneficial rotational crop for farmers, diversifying agricultural activities can help mitigate risks associated with market fluctuations, pests, and weather conditions.
- Hemp cultivation has the potential to provide fair employment opportunities for workers when labor risks are appropriately managed. Local communities may benefit from the growth of this relatively less impactful crop and the effects on local water supply, biodiversity, and soil health. Benefits can vary depending on local regulations, market demand, stage of developed infrastructure, quality of management, and community engagement.

The legal and regulatory landscape for hemp has seen significant changes in recent years, with many countries recognizing its economic and environmental potential and relaxing restrictions on its cultivation and use. This shift presents a growing opportunity for the hemp industry, particularly in sectors such as bioplastics, where hemp-based products offer an eco-friendly alternative to petroleum-based plastics. However, challenges remain. The overlapping classification of hemp with other forms of Cannabis often leads to regulatory complexities. There is a need for clearer policies and more research to maximize hemp's potential in the bioeconomy and boost the trade. Hemp's multifaceted applications, coupled with its environmental benefits, make it an invaluable resource in the transition towards a more sustainable and bio-based economy. Its role extends beyond mere industrial use, offering solutions to some of the most pressing environmental challenges of our time. The continued growth and integration of hemp into various sectors will be pivotal in shaping a greener, more sustainable future.

3.1.1. Biobased sectors competitors/competition with hemp

Biobased sectors encompass a wide range of industries using biological materials for production, such as textiles, construction, and bioplastics, where hemp faces opportunities from both traditional and other biobased materials^{12 13 14}.

Textile

The textile and fashion application leads the hemp market. Hemp for 'textile' applications means not only fashion and furniture fabrics, but also technical fabrics and non-woven for building, furniture, and

¹² <https://www.mdpi.com/2073-4395/13/3/931>

¹³ https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/hemp_en

¹⁴

<https://www.semanticscholar.org/paper/Applications-of-hemp-in-textiles%2C-paper-industry%2C-a-Crini-Lichtfouse/df4a64a043c88e34a62a5d42f1509af77daf06f5>

horticulture applications. Hemp textiles are created using bast fibers once they have been separated from hemp hurd through the process of decortication, resulting in durable, breathable, and antibacterial fabrics, while being also resistant to mold and ultraviolet light, features that make the hemp fibers very appreciated in the hemp market. Furthermore, hemp cultivation is associated with a reduction of inputs and GHG emissions, thus making its derived fibers and fabrics more sustainable. This could represent a solution to the “environmental and social emergency” of the fashion industry. Indeed, the industry is responsible for almost 20% of global wastewater and 10% of global greenhouse gas emissions, as well as using more than 25% of all chemicals produced globally. Moreover, it has significant social costs such as dangerous working conditions and the use of hazardous chemicals during production. In recent years, leading brands such as Levi’s, IKEA, H&M, and Patagonia have included hemp in their collections. Swedish fast fashion company H&M includes hemp as part of various eco-friendly clothing lines; IKEA has included hemp as a material for various pillow covers, table runners, and other furniture. Moreover, the suppliers of hemp fiber textiles in the European market are mainly based in China. Indeed, China is not only the biggest producer of hemp fiber but is notably improving in the automation of hemp scutching. The Heilongjiang province, in the far northeast of the country, produces alone almost half of the hemp fiber world volume and the R&D in the automation processes, including spinning and weaving, is supported by the Central Government with the cooperation of the National Hemp Industry Technology System and the Qinggang Agricultural Center.

Construction

The green building sector is one of the biobased sectors in constant growth with new sustainable-by-design polymers driving the green transition of the sector. In this context, hemp is a versatile material that in the form of hempcrete bricks/blocks, prefabricated panels, and hempcrete spray can be used for construction and insulation. Hemp, indeed, has insulation and transpiration properties that allow a huge energy saving in buildings, thus reducing the GHG emissions of buildings that are responsible for 38% of all greenhouse gas emissions worldwide. Three-quarters of these emissions are, indeed, related to their ongoing energy use and the remaining quarter are embodied emissions during their construction. Hemp panels can be obtained mainly from hurd or whole stems, such as hemp wood material. Traditionally seen as a less valuable by-product of bast fiber, hurd’s potential as a building material has enlarged the biorefinery concept for this plant. Hurd can be turned into a range of construction products such as roofing tiles, insulation, fiberboard, and more recently hempcrete blocks. First developed in France in the 1990s, hempcrete is the popular name for construction blocks made by mixing hemp hurds with a lime-based binder and water, which is then used for walling and insulation. Another leader in the EU is the Dutch HempFlax, which produces a range of insulating materials and other biocomposites used for the automotive industry but also for construction, as well as precast hemp blocks made with water and lime binding. Hempcrete can be, in some projects, applied also by spraying which could speed up the process of applications.

Biocomposites and Bioplastics

Bioplastics and biocomposites are expected to be areas of significant innovation and growth in the coming years. Asia is the main producer, accounting for 50% of the global, followed by Europe (25%). Hemp biocomposites offer some mechanical advantages and a 25% weight reduction over glass fiber composites. Weight is important because, according to the Euro 6 standard, the fiscal drag will be heavier for vehicles generating more than 98 g/km of CO₂ emissions. It is easier for lighter vehicles to ensure CO₂ emissions below that limit. Demand for biocomposites is rapidly growing, particularly in the automotive industry. German car manufacturers – BMW, Volkswagen, and Audi – were the first to use natural fiber composites, incorporating hemp in vehicle interiors, such as door panels. Another example of the potential of hemp-based composites is the French Automotive Performance Materials, a joint venture between the automotive components manufacturer, Faurecia - part of the FORVIA Group, a global automotive supplier - and a major French agricultural cooperative, Interval. One of its flagship products, NAFILean, is a 20% hemp fiber reinforced polypropylene compound designed for automotive structural parts by injection process: panels, door panels, and center consoles. Faurecia was recognized in 2022 for the German Innovation

Award and received the “Winner” award in the Automotive Technologies category. With their use of natural fibers, these materials set standards in recycling and contribute to weight reduction in vehicle interiors and thus to a reduced carbon footprint in automotive construction. The carbon footprint of different natural fibres for biocomposites and insulation material is well described in a study conducted by the Nova Institute, providing data for the automotive and insulation industry. Hemp biocomposites are also being used in consumer products, like suitcases, cosmetics packaging, and mobile phones produced by a Swedish company, Triflon. Cellulose from hemp fibers can also be used to produce a non-toxic bioplastic 2.5 times stronger than polypropylene, recyclable and 100% biodegradable, although it is still difficult to produce 100% hemp-based bioplastic. It is also lighter and requires less energy to produce, according to some studies. Packaging is the biggest segment of the bioplastics market (1,2 million tons, 48% of the global volume). An interesting example of hemp-based packaging is US Sana Packaging, Colorado, a sustainable packaging brand that designs and develops packaging made from 100% plant-based hemp plastic, 100% reclaimed ocean plastic or other innovative recycled materials. The Italian thermoplastics producer, LATI Industria Termoplastici (Lombardy region), has made a recent agreement with another innovative Colorado company, the Hemp Plastic Company, for the distribution in Europe of their hemp blended plastics. However, hemp plastic still struggles to compete with traditional plastic in terms of price and, for this reason, its usage is still limited. Paul Benhaim describes the role of hemp plastic in the fight against climate change and its potential is well described in the study.

Paper

The use of hemp in papermaking dates to the first paper made by the Chinese over two thousand years ago. Hemp paper can be made from both hurd or bast fiber. Paper production using offcuts from textile fiber processing was widespread until the industrialisation of paper production, when commercial paper production was optimized for wood pulp. As a result, hemp paper became economically not competitive and, after the Second World War, it was dedicated only to small niche uses, such as cigarette paper and banknotes, particularly in France. However, hemp paper offers some advantages compared to wood pulp. Dried hemp is rich in cellulose, the main ingredient of paper, averaging around 57% as compared to 40-50% in wood, and it has a lower lignin concentration, which needs to be removed chemically in the paper process. Furthermore, hemp as a raw material can be produced faster than wood (a few months versus 20 years). Additionally, hemp fiber paper can be recycled up to eight times, compared to just three times for wood pulp paper. As climate change and environmental concerns increasingly demand paper recycling, papermakers need to dispose of resistant fibers and are showing renewed interest in hemp. However, at the moment, fiber extraction from hemp from the stalk has a yield of only 20-25% and the process is costly. The price and the amount of fiber obtained are, thus, still an obstacle to the development of the hemp paper industry. An interesting example of hemp-paper industrial production is China's **Shenzhen Datong**, which recently made headlines with an innovative hemp paper-based product line also including baby diapers and feminine hygiene products. In Europe, hemp paper is still confined to special paper production, more often at the artisanal level, with excellent examples such as the “*Hempathy*” line of papers, hand-made creations of **Sandro Tiberi** from Fabriano, a paper district since the Middle Ages. There are also bigger companies specialized in quality papers, such as **Büttenpapierfabrik Gmund** (Gmund am Tegernsee - D) with its *Gmund Hanf* line, made from 100% European hemp. Another big German paper industry, **Hahnemuehle**, prepared a special custom-made paper for a new edition of an encyclopedic book on industrial hemp in 2022.

Food and Beverages

Food and Beverages include hemp seed-derived products but also, more recently, flowers and leaves extracts. Hemp food is a relatively new market, although its use in the kitchen is testified from the Middle Ages. In Europe, the hemp food sector was unlocked in the second half of the 1990s, becoming more and more relevant in the food sector, being classified today as a “superfood”. Today Canadian companies were the first to unlock the potential market of hemp food. Since 2000, they have been the unique suppliers of the huge US market, taking advantage of the fact that until 2018 hemp food could be sold but not produced

inside the USA. The food and beverages market holds great potential for hemp-based products looking to benefit from recent trends toward health and sustainable eating. The largest European grower of hemp, France, produces over 11,500 tons of hemp grain per year. In 2016, 44% of the French hemp seed production was employed for animal feed, 43% for human consumption, and 13% for oil production. The largest French producer of hemp seed, *La Chanvrière de l'Aube*, claims to supply 30-50% of Europe's hemp seed demand each year. The second European hemp seed producer is the Lithuanian company *Allive* contracting organic farmers all around Europe for their BRC quality production of hemp food ingredients on more than 8000 ha.

Novel Food

Flowers and leaves of industrial hemp strains, rich in CBD and terpenes with a negligible amount of THC, can be used as flavorings for many beverages, like teas, beers, and non alcoholic drinks, or as food supplements, in the form of CBD extracts or isolates or pure CBD. The global market is full of such products, also with the involvement of big companies like *Constellation Brands* (*Tweed Fizz™*, *Tweed Iced Tea™*) or *Anheuser-Busch InBev* which made an agreement with the biggest pharmaceutical cannabis company, *Tilray*, to study cannabis-infused beverages for the Canadian market. Unlike many national legislations, the European Union from 1997 until 2019 hasn't forbidden hemp flowers and leaves extracts as food ingredients. According to the new Novel Food regulation, only the products authorized and enumerated in a Union List can be placed on the market. In 2021, European companies submitted about 50 novel food applications for CBD products, but none of these has been authorized, also because of the remarks of EFSA in June 2022. To get around this obstacle, the Danish company *Royal Unibrew*, with its brand Ceres, announced in April 2022 *Hempiness*, a beer derived from hemp seed and terpenes. The great world epicenter for CBD food and drinks authorizations is the UK, where in February 2020 a policy for implementing the authorization process was announced and in April 2022 the UK's *Food and Standard Agency (FSA)* published a register of products linked to active novel food applications. Since then FSA received **almost 12,000 cannabinoid (CBD) product applications**, none of which are yet fully authorized as novel foods. FSA allowed the products on the list to stay on the market under liberal rules pending safety checks.

Cosmetics

Hemp-based products are already popular in Cosmetics, especially hemp seed oil and CBD oil ingredients, mainly used topically in skincare products. Hemp seed oil has been used for a long time as a nourishing and moisturizing ingredient. The British company *The Body Shop*, for example, has been using hemp since 1992, and nowadays other famous brands such as *Garnier (L'Oréal)* or *Estée Lauder* offer hemp-based product lines. The European Cosmetic Ingredients database, *CosIng*, nowadays authorizes about twelve hemp-based ingredients, mostly derived from seed oil but also leaves, roots, sprouts and CBD and CBG (Cannabigerol), another non-psychoactive cannabinoid. CBD oil is a powerful anti-inflammatory, which helps treat acne, sensitive skin, eczema, psoriasis, and rashes. Also if *CosIng* is not binding for member countries, its list of authorized ingredients has contributed to the rapid growth of the hemp-based cosmetics market. The CBD market is driven mainly by numerous indie brands. The major barrier to the further development of the industry, in its current state, is the lack of supply chain consistency.

Feed

Hemp seeds have long been used as supplemental animal feed (poultry and fish in particular). After hemp seeds have been cold-pressed to extract oil, the residue (hemp seed cake), which has a high protein content and an amino acid profile similar to that of soybean meal, can be used to produce flour for bakery, in small amounts, but mostly for animal feed. Scientific studies show the benefits of hemp seed cake as feed, from increasing the nutritional value of cow milk to enriching the omega-3 content in egg yolks when fed to hens, without detectable cannabinoid residue in the eggs. The hemp press cake is also well recognised as a feed supplement for horses. Other hemp by-products, such as sediment, hulls, and pulp may also have the

potential to be used as animal feed. The European feed market is dominated by soybean meal as a source of protein, mostly imported from Latin America and mostly GM (Genetically Modified). In this context, hemp seed cake, derived from domestic crops, can be a valuable and safer alternative and an efficient way of maximising the value of using the whole plant. Already in Europe, hemp seed, hemp seed cake, hemp seed oil, hemp flour and hemp fiber are allowed as animal feed for livestock, with maximum diet incorporation rates for each species.

3.1.2. Circular deployment of hemp at local level

In the heart of local communities, hemp cultivation is emerging as more than just an agricultural activity; it's becoming a catalyst for local economic and environmental transformation. This versatile plant, known for its environmental benefits, is intricately woven into the fabric of local economies and ecosystems. The cultivation and processing of industrial hemp offer significant employment opportunities across various sectors. From farmers and agricultural workers to researchers, manufacturers, and retailers, the hemp industry has the potential to create a vast number of jobs. As the demand for hemp-derived products such as construction materials, textiles, paper, biofuels, and CBD-infused goods continues to rise, a thriving hemp industry can drive local and regional economic development. Industrial hemp provides a valuable opportunity for farmers to diversify their agricultural activities. By incorporating hemp cultivation into their crop rotation, farmers can reduce reliance on traditional crops and tap into a lucrative market. Hemp is a resilient plant that requires little water, and minimal pesticide and has a short growth cycle, allowing farmers to optimize land utilization and generate additional revenue streams. This diversification can strengthen rural economies and provide stability to agricultural communities. Economically, the rise of hemp has opened doors to new job opportunities, invigorating local markets. Small towns and rural areas, often hit hardest by economic downturns, are finding a lifeline in hemp farming and processing.

Environmentally, hemp is a game changer at the local level. Its cultivation is a lesson in sustainability, requiring less water and pesticides than traditional crops, making it a friendlier choice for local ecosystems. Hemp's deep roots prevent soil erosion, its fast growth cycle allows for efficient land use, and its remarkable carbon absorption ability is a local weapon against climate change. By adopting hemp, communities are not just participating in agriculture; they're making a positive environmental statement. Hemp requires fewer pesticides, herbicides, and water compared to many traditional crops, making it a more sustainable option for agriculture. Moreover, hemp has a remarkable ability to absorb carbon dioxide, making it an effective tool in combating climate change. Its deep root system helps prevent soil erosion and improves soil health.

By promoting hemp cultivation, we can foster environmentally friendly practices and contribute to a greener and more sustainable future. Industrial hemp presents a unique opportunity for rural communities to revitalize their economies. However, the benefits of hemp are tempered by challenges that directly affect local communities. Local engagement and action are crucial in harnessing the full potential of hemp. Communities must advocate for and adopt sustainable practices in hemp cultivation and processing. Educational efforts can raise awareness about both the benefits and the responsibilities that come with hemp production. Local initiatives, such as cooperative farming and community-led hemp processing facilities, can ensure that the benefits of hemp are enjoyed sustainably and equitably. The cultivation of hemp presents a unique opportunity for local communities to drive economic growth, enhance environmental sustainability, and foster a sense of community resilience. By embracing both the opportunities and challenges of hemp, local communities can play a pivotal role in shaping a sustainable and prosperous future, rooted in the fields of this remarkable plant.

3.1.3. Ecological boundaries solutions for hemp

Hemp, known for its environmental friendliness, still faces ecological boundaries that need addressing to optimize its sustainability. One major aspect is water usage. Although hemp generally requires less water than crops like cotton, in arid regions, efficient water management techniques such as drip irrigation are

crucial to minimize consumption and ensure sustainability. Another important consideration is land use. Hemp can grow in varied soil types, allowing for the use of marginal lands and reducing pressure on prime agricultural land. This adaptability also aids in crop rotation, improving soil health and reducing the risk of soil erosion. Pesticide use, while typically lower in hemp cultivation compared to other crops, still poses ecological risks. Employing organic farming practices and integrated pest management can further reduce chemical use, protecting local ecosystems. The processing phase of hemp production also has ecological implications. Traditional processing methods can be energy and water-intensive. The key sustainability issues with hemp production lie in retting and processing¹⁵.

- *Retting*. To soften the harvested stems and remove the natural binding agent called pectin, water, bacteria or chemicals are used. These chemicals may be harmful and contaminate groundwater, during improper disposal of wastewater and both chemical and biological pollution (due to natural impurities) can occur. Water retting may also consume large amounts of water and energy, used to heat water. This contamination can then affect the health of farmers, workers and local communities. However, sustainable retting without the use of chemicals and heat is also possible through dew, field and snow retting;
- *Processing*. Though most processes involved are largely mechanical and non-polluting, certain areas can have a large impact on the environmental footprint of hemp. Wet-spinning, where the yarn slivers are wetted in troughs of water to produce finer yarn, as well a range of chemical dyes and finishes such as wrinkle-resistants and softeners may be applied to change the feel of the end-fabric, that use large amounts of water, energy and harmful chemicals. If wastewater is not treated and is not recycled along with chemicals, this can be leaked into surrounding ecosystems, acutely affecting local communities.

Therefore, developing eco-friendly processing techniques is vital. Innovating in the decortication process, which separates hemp fibers, can lead to reduced energy use and waste. Additionally, the use of hemp by-products is an essential component of its ecological sustainability. By-products like hemp shives, typically used in construction, and hemp seeds, used in health foods, ensure comprehensive utilization of the plant, aligning with zero-waste principles. Addressing these ecological boundaries requires a combination of efficient resource management, sustainable farming practices, and innovative processing methods.

3.2. Significance of Hemp in the Bioeconomy

The United Nations (UN) 17 Sustainable Development Goals (SDGs) are 17 interconnected goals to end poverty, advance health and education, reduce inequities, protect the environment, and accelerate economic growth through 2030. Agreed upon by all 193 member states, the SDGs include 169 associated targets and a set of global indicators designed to shape national, state, and local government priorities and partnerships¹⁶. The significance of hemp in the bioeconomy, particularly in the context of the SDGs, is multifaceted. The UN Sustainable Development Goals illustrate hemp's versatility and help demystify negative perceptions about the plant. Through the SDGs, improved education, regulation, research and partnerships can be tailored to catalyze hemp as a critical crop with numerous societal benefits¹⁷. Using the United Nations' 17 Sustainable Development Goals (SDGs) as the analytical framework, UW-Madison's Global Health Institute (GHI)¹⁸ evaluated industrial hemp's innumerable benefits and identified 54 hemp-related SDG targets to improve multi-sectoral collaboration, research, education. Hemp cultivation and usage align closely with several SDGs, as reported in the following Figure 2.

¹⁵ <https://refashion.fr/eco-design/sites/default/files/fichiers/SC-ebook-hemp%20%281%29.pdf>

¹⁶ <https://sdgs.un.org/goals>

¹⁷ <https://cannabis2030.org/>

¹⁸ https://issuu.com/uwghi/docs/industrialhemp_and_the_sdgs "Industrializing Hemp to Advance the United Nations' 17 Sustainable Development Goals"

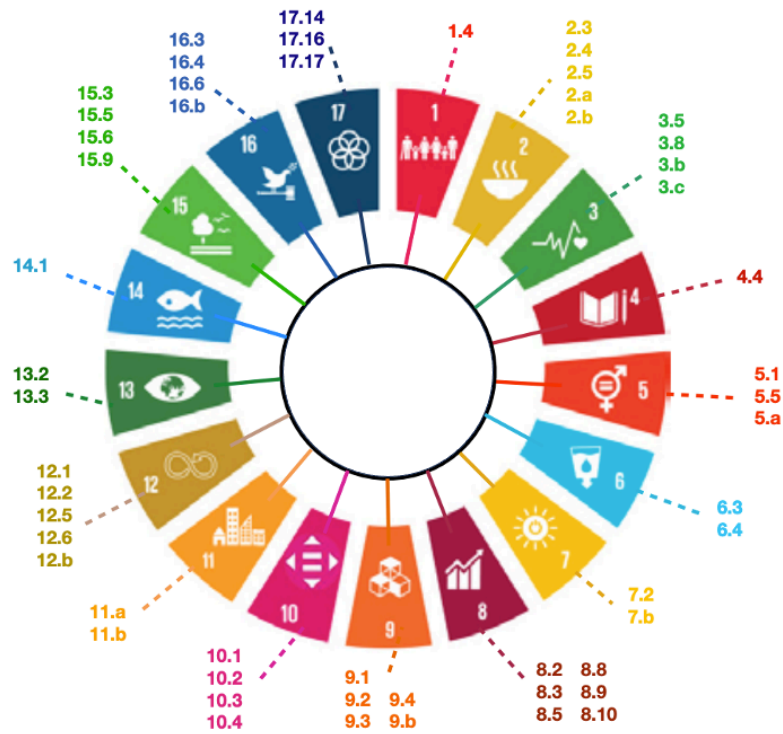


Figure 2 - A visual illustration of the sub-targets related to the SDGs goals and industrial hemp¹⁹.

A full evaluation of all 17 goals and 169 targets has been conducted to 54 unique entry points for unlocking hemp's full potential in advancing local to global sustainable development, as reported in the following Figure 3.

¹⁹ https://issuu.com/uwghi/docs/industrialhemp_and_the_sdgs

<p>No Poverty 1.4 Equal rights to economic resources</p> <p>Zero Hunger 2.3 Double agriculture and land access for women, family farmers, indigenous people 2.4 Sustainable food production and agricultural practices 2.5 Maintain genetic diversity of seeds and equitable sharing of genetic resources 2.a Invest in rural infrastructure, agricultural research and extension services 2.b Correct and prevent trade restrictions</p> <p>Good Health and Well-Being 3.5 Prevent and treat substance abuse 3.8 Access to safe and affordable essential medicine 3.b Research and development of medicines 3.c Increase financing and recruitment of the the health workforce</p> <p>Quality Education 4.4 Relevant skills for employment, decent jobs and entrepreneurship</p> <p>Gender Equality 5.1 Gender equity 5.5 Political, economic, and public life 5.a Land ownership</p> <p>Clean Water and Sanitation 6.3 Reduce Pollution 6.4 Water-use efficiency across sectors</p> <p>Affordable and Clean Energy 7.2 Increase renewable energy 7.b Upgrade technology</p> <p>Decent Work and Economic Growth 8.2 Productivity through diversification 8.3 Job creation and entrepreneurship 8.5 Decent work 8.8 Safe working environments 8.9 Sustainable tourism 8.10 Strengthen domestic financial institutions</p> <p>Industry Innovation and Infrastructure 9.1 Sustainable infrastructure 9.2 Sustainable industrialization 9.3 Increase access to financial services 9.4 Upgrade infrastructure and retrofit industries 9.b Support technology R&D</p>	<p>Reduced Inequalities 10.1 Income growth 10.2 Social, economic and political inclusion 10.3 Eliminate discriminatory laws 10.4 Fiscal, wage and social protection policies</p> <p>Sustainable Cities and Communities 11.a Strengthen national and regional development planning 11.b Mitigation and climate change adaption</p> <p>Responsible Consumption and Production 12.1 Sustainable consumption and production 12.2 Efficient use of natural resource 12.5 Reduce waste through prevention, reduction, recycling and reuse 12.6 Companies adopt sustainable practices and integrate into reporting cycle 12.b Sustainable tourism</p> <p>Climate Action 13.2 Climate change adaptation in all policies and plans 13.3 Human and institutional capacity to mitigate climate change</p> <p>Life Below Water 14.1 Reduce marine pollution from land-based activities</p> <p>Life on Land 15.3 Restore degraded land and soil 15.5 Protect and prevent extinction of threatened species 15.6 Share benefits of genetic resources 15.9 Integrate biodiversity values into national and local planning</p> <p>Peace, Justice and Strong Institutions 16.3 Justice for all 16.4 Reduce illicit financial and arms flows 16.6 Develop accountable and transparent institutions at all levels 16.b Non-discriminatory laws and policies</p> <p>Partnerships for the Goals 17.14 Enhance policy coherence 17.16 Multi-stakeholder partnerships 17.17 Effective public, public-private and civil society partnerships</p>
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Figure 3 - Hemp industrialization aligned with SDGs sub targets²⁰.

For example, under **SDG 2 (Zero Hunger)**, hemp seeds, rich in proteins and fatty acids, contribute to food security. Again:

- **SDG 12 (Responsible Consumption and Production):** Hemp's sustainability in production and versatility in usage exemplify responsible consumption.
- **SDG 13 (Climate Action):** Hemp's carbon sequestration abilities make it vital for climate action efforts.
- **SDG 15 (Life on Land):** Hemp farming supports soil health and biodiversity.

Hemp also contributes to sustainable agriculture, aligns with climate action goals, and supports a transition to a circular economy. Within the EU Green Deal framework, hemp is positioned as a sustainable crop that can drive ecological restoration and economic growth, harmonizing with the EU's ambition for a greener, more sustainable future. The role of hemp in EU policies reflects its potential in fostering a sustainable and bio-based economy. Europe's future depends on a healthy planet. With the Green Deal, the EU is determined to use its position to lead on global climate action. The aim is to be the first continent to achieve a net-zero emissions balance through climate neutrality by 2050 and thus also to become a role model for others. A net-zero emissions balance is achieved as soon as the amount of greenhouse gasses released into the atmosphere is neutralized. The EU aims to spend 30% of its overall budget for 2021-2027 on tackling climate change and its effects. Hemp's role in the EU Green Deal is significant in several aspects:

²⁰ https://issuu.com/uwghi/docs/industrialhemp_and_the_sdgs

the following Table 3²¹ reports a list of policy initiatives under the European Green Deal, where hemp can make the difference.

Table 3 - List of policy initiatives encompassed by the European Green Deal with relation with hemp²².

EU Policy initiative	Where hemp can have a positive impact
Climate ambition	
New EU Strategy on Adaptation to Climate Change	Hemp growing is environmentally friendly and has many positive externalities on soil and biodiversity that helps mitigate the effects of climate change. Being a source of bio-based raw material for a different range of sectors, hemp can dramatically help cut the emissions in the textile, plastics and construction sectors. It can also be used as a valuable crop for carbon farming.
Industrial strategy for a clean and circular economy	
EU Industrial strategy	Hemp value chains can provide growth in rural areas, manufacturing and food processing industries. Processing requires highly skilled workers ideally in proximity to the cultivation facilities.
Circular Economy Action Plan and initiatives to stimulate lead markets for climate neutral and circular products in energy intensive industrial sectors	Hemp-based materials are reusable, biodegradable, and/or compostable. Hemp-based construction materials have an exceptional thermal performance which reduces energy consumption, while sequestering carbon. Hempcrete is nonflammable, resistant to mould and bacteria, naturally regulates humidity and has exceptional acoustic performance. Insulation panels are exceptionally performative and used for many years. Hemp can be molded in different plastic materials, that can be used for packaging, technical purposes and are particularly indicated for the automotive industry, because of its strength and lightweight. Hemp textile is particularly interesting from an environmental point of view as it uses significantly less water and chemicals than cotton. Hemp fabric is breathable, naturally antibacterial, resistant to UV light, mold and mildew, and durable. Waste fibres from hemp can be transformed into carbon nanosheets and built into supercapacitors that out-perform the standard equivalent.
Greening the Common Agricultural Policy / 'Farm to Fork' Strategy	
Proposal for a revision of the Sustainable Use of Pesticides Directive to significantly reduce use and risk and dependency on pesticides and enhance Integrated Pest Management	Hemp already requires a low level of phytosanitary products and is a perfect crop for organic agriculture. It has a positive impact on the yield of subsequent crops when used in rotation and can be utilized as a pioneer crop.

²¹ https://eiha.org/wp-content/uploads/2020/09/Hemp-a-real-green-deal_EN.pdf?ref=blog.signature-products.com

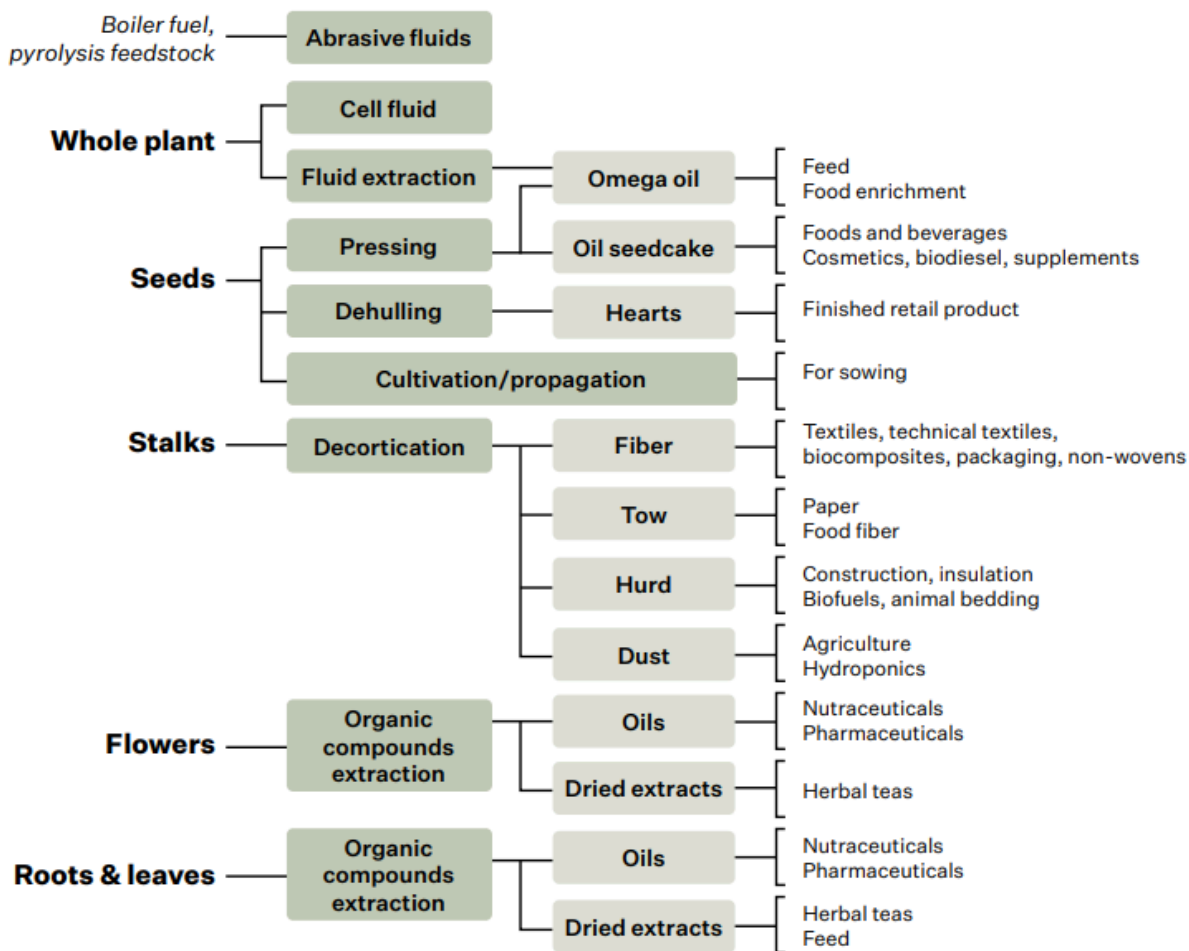
²² https://eiha.org/wp-content/uploads/2020/09/Hemp-a-real-green-deal_EN.pdf?ref=blog.signature-products.com

Proposal for a legislative framework for sustainable food systems	Hemp is a sustainable multipurpose crop. Nothing goes to waste and everything is upcycled. Local supply chains will need to be established to fully harness the potential of the hemp economy.
Determine the best modalities for setting minimum mandatory criteria for sustainable food procurement to promote healthy and sustainable diets, including organic products, in schools and public institutions	Hemp seeds are particularly rich in high-quality proteins and have a unique essential fatty acid spectrum. Hemp feed can also serve as an enhancer for the nutritional profile of animal products, particularly meat and eggs.
Review of the EU promotion programme for agricultural and food products with a view to enhancing its contribution to sustainable production and consumption	Funding should be granted to products respecting particularly high sustainable standards. Promotion programs could greatly benefit hemp fibres and encourage the reconstitution of textile value chains in Europe.
Review of the EU school scheme legal framework with a view to refocus the scheme on healthy and sustainable food	EU school scheme should encompass a wider range of products, including hemp seed and hemp seed oil, rich in fatty acids and other nutrients, particularly adapted for a healthy diet
EU carbon farming initiative	Hemp could represent a great crop for carbon farming purposes. Its use should be encouraged with the aim of capturing carbon in the soils or in manufactured goods.
Examination of the draft national strategic plans, with reference to the ambitions of the European Green Deal and the Farm to Fork Strategy	Hemp being a rotation crop, it can bring additional revenues to farmers and give impetus to EU rural areas. Sectoral interventions coupled by rural development interventions will be key in enabling a fully-fledged circular bio economy based on hemp.
Preserving and protecting biodiversity	
EU Biodiversity Strategy for 2030	Hemp produces pollen for bees and other pollinators in a period of floral scarcity and nutritious seeds for wild birds. Hemp has a positive effect on soil health because it stabilises erosion, adds nutrients to the soil, naturally removes heavy metals and increases the yield of subsequent crops.
Measures to support deforestation-free value chains	Hemp is a good and sustainable source of cellulose for paper making that could help reduce deforestation.
Zero pollution action plan for water, air and soil	Hemp is an optimal pioneer crop, notably because of its phytoremediation capacity. It is a cadmium-tolerant plant and is resistant to long term exposure to other heavy metals.
Mainstreaming sustainability in all EU policies	

<p>Proposal for a Just Transition Mechanism, including a Just Transition Fund, and a Sustainable Europe Investment Plan Renewed sustainable finance strategy Review of the relevant State aid guidelines, including the environment and energy State aid guidelines</p>	<p>Hemp sector has a sustainable approach to business that encompasses economic, social, environmental and public health considerations. Investments in the hemp sector should be encouraged as they would automatically generate positive environmental externalities and reduce dependence on fossil fuels and extraction activities.</p>
<p>Stakeholders to identify and remedy incoherent legislation that reduces the effectiveness of delivering the European Green Deal</p>	<p>EIHA is working at identifying bottlenecks and barriers to growth and has already started flagging them to the competent authorities.</p>
<p>Working together – a European Climate Pact</p>	
<p>Launch of the European Climate Pact / Proposal for an 8th Environmental Action Programme</p>	<p>EIHA is available for supporting the EU institutions with science-based and transparent information and to contribute to the shaping of the future of a more sustainable Europe.</p>

3.3. Specific Challenges and Barriers in Hemp sector

Hemp is grown for its seed, fiber, and flower, or as a multi-purpose crop (oilseed and fiber, for example). A unique plant, it has spawned markets for a wide variety of products, ranging from textiles, clothing, rope, home furnishings, industrial oils, cosmetics, to food and pharmaceuticals. The uses and derivative products of hemp - see Figure 4 below - are so diverse that hemp globally may well intersect more markets and industries than any other crop.



Agricultural benefits:



Figure 4 - The many uses and agricultural benefits of industrial hemp²³.

Hemp is defined as “a *Cannabis sativa L.* plant — or any part of the plant — in which the concentration of tetrahydrocannabinol (THC) in the flowers and leaves of the inflorescence is not more than the regulated maximum level established by authorities having jurisdiction.”. Industrial hemp should not be confused with marijuana, which is a variety of *Cannabis sativa L.* with elevated levels of THC (up to 20%). Despite its growing importance in the bioeconomy, the hemp sector faces this misunderstanding that impacts its development and widespread acceptance. One of the most significant challenges is the stigma due to its botanical relationship to psychoactive strains of cannabis. This stigma affects consumer perception, regulatory policies, and even banking and insurance services for businesses involved in hemp. Misconceptions about hemp's psychoactive properties persist, leading to hesitance in both market adoption and policy reform. Production of hemp is not yet legal worldwide, but countries worldwide are increasingly authorizing their farmers to grow the crop. Prohibitions and restrictions served to halt much of the research

²³ <https://textileexchange.org/app/uploads/2023/04/Growing-Hemp-for-the-Future-1.pdf>

into appropriate varieties and production practices for different regions, as well as the development – or even basic maintenance – of machinery, from decortication to the finer processing stages. As a result, much of the research and development is only being undertaken now, although brands expect it to already have been addressed.

As hemp re-enters the market after decades of prohibition, industries centered around it are still in their infancy. These emerging industries face challenges in establishing stable supply chains, consistent product quality, and market predictability. The lack of historical data and proven business models adds to the uncertainty and risk, impacting investor confidence and the pace of industry growth. Moreover, the absence of global standards for hemp cultivation, processing, and product specifications poses significant challenges. This lack of standardization affects everything from crop quality to the safety and efficacy of hemp-derived products, creating barriers to international trade and consumer trust. Establishing clear, consistent standards is crucial for the industry's development and integration into global markets.

The hemp industry requires a skilled workforce familiar with its unique characteristics and applications. However, there's a notable gap in specialized education and training programs. This lack of knowledge extends not only to cultivation and processing techniques but also to the legal and business aspects of the hemp industry. Investing in education and training programs is essential to equip the workforce with the necessary skills to drive the industry forward. Lastly, while there has been progress in legalizing hemp, the regulatory landscape remains complex and fragmented, especially regarding the allowable levels of THC and the legal distinction between hemp and other forms of cannabis. This complexity hampers business planning, cross-border trade, and research into hemp's potential applications.

Addressing these challenges requires a multifaceted approach involving policy reform, standardization, education, and market development. Overcoming these barriers is essential for the hemp sector to realize its full potential in the bioeconomy. This will involve collaboration between governments, industry stakeholders, researchers, and educators.

4. Promising Value Chains

4.1. Identification of Key Value Chains and best practices

The establishment of a well-functioning chain of hemp production, processing, and marketing by inducing collaboration between a wide range of stakeholders, will create an economically profitable, socially just, and environmentally friendly hemp supply chain. The development of a localized value chain of industrial hemp, by building collaboration across educational institutions, suppliers, machine suppliers and other industries will create new synergies and interactions, which may lead to a more well-functioning supply chain. It is necessary to build trust between key stakeholders to succeed with establishing a network, where all stakeholders feel that their work is appreciated and that they can profit from the collaboration.

Once the farmer network has been established, ensuring a reliant supply, the material can be efficiently used within the hemp refining factory. Following the establishment of a local market and the construction of the hemp refining facility, there is the potential for scaling up these innovations to an industrial level. This would include reaching out to various stakeholders across the value chain, particularly those with an interest in incorporating hemp into their product formulations. The objective is to establish a collaborative vision on how industrial hemp can assume a more prominent role in their product development strategies. Materials such as insulation panels, garden mats and other construction materials hold promising market potential, as these applications do not require soft fibers and certified hygienic properties, which are prerequisites for products like wet wipes or sanitary pads. The farmers can be involved as shareholders, although their involvement in key production or establishment processes should be limited, allowing them to concentrate on their core farming activities. The development of harvest equipment and further research on the spring harvest method, can facilitate the on-farm refinement of hemp, empowering farmers with a more streamlined and efficient process.

Governmental support in the form of legislation that induces industries to collaborate can be essential for the development of the industrial line of hemp. Since the legislation was implemented, many different industries have profited from new collaborations and have made use of material that was otherwise wasted. This kind of incentive and support from regulating bodies can implore companies to make changes in their current ways of production to go towards more efficient use of their resources. However, the wood industry and the agricultural sector are different, and other initiatives are needed to stimulate the production line of industrial hemp. Hemp production can be supported through regional programs that support the building of industry in the hemp sector. This could be a new certification label that certifies biomass production in diversified farm systems. Furthermore, it is necessary to have a procedure for the traceability of biomass in order to trace it back to these farming systems living up to environmental and social just parameters. The European Innovation Council (EIC) supports game changing innovations throughout the lifecycle from early-stage research to proof of concept, technology transfer, and the financing and scale up of start-ups and Strategic Market Creation (SMC). This program holds the potential to support the innovations in the production line of hemp and can be distributed at a local level to the farmer network, for specific project proposals from entrepreneurs that build on the capacity that has been founded in the network.

In identifying key value chains of hemp about various sectors, we explore its diverse applications and relative value chains.

Textile Industry. Delving into the value chain of hemp in the textile industry reveals a complex and multifaceted process, showcasing how hemp fibers, known for their durability and sustainability, are increasingly adopted as an eco-friendly alternative to conventional materials like cotton and synthetic fibers.

1. **Cultivation and Harvesting:** the value chain begins in the fields where *Cannabis sativa*, the plant from which hemp fibers are derived, is cultivated. Hemp is an environmentally friendly crop,

requiring minimal water and pesticides compared to cotton. Its cultivation is beneficial for soil health and is often used in crop rotations to improve soil quality. The harvesting of hemp is a crucial step, typically involving the cutting of the stalks of the plant, which contain the valuable fibers;

2. **Processing the Fibers:** once harvested, the hemp stalks undergo processing to extract the fibers. This involves retting, a process that breaks down the pectin binding the hemp fibers together, followed by decortication, where the fibers are separated from the core. Retting can be done naturally on the field or after the harvesting by a microbial or enzymatic process. Hemp's processing is generally more environmentally friendly than that of cotton or synthetic fibers, as it requires fewer chemicals and less water.
3. **Spinning and Weaving:** the extracted hemp fibers are then cleaned and carded into strands. These strands are spun into yarns, which can be woven or knitted to produce fabrics. Hemp fibers are known for their strength and durability, making them ideal for a wide range of textile applications. The spinning and weaving processes are similar to those used for other fibers but can often be done using less energy and water due to the natural properties of hemp;
4. **Finishing and Dyeing:** in the finishing stage, hemp fabrics can be treated for different textures and properties, such as softening or making them water-resistant. Unlike synthetic fibers, hemp is biodegradable and does not release microplastics during washing. The dyeing process can also be more eco-friendly, as hemp fabrics work well with natural dyes, reducing the need for harmful chemical dyes.
5. **Manufacturing and Distribution:** the final fabrics are then used to manufacture a variety of textile products, from clothing to home furnishings. The manufacturing process benefits from the durability and versatility of hemp fibers. The distribution of hemp-based textiles follows typical retail channels but is increasingly marketed as a sustainable and eco-friendly option;
6. **Consumer Use and End-of-Life:** hemp textiles are appreciated for their durability, which means they have a longer lifespan compared to some other materials. At the end of their life, hemp products are biodegradable, adding to their environmental appeal. Consumers who choose hemp are often conscious of their environmental footprint, aligning with a growing demand for sustainable and ethically produced goods.

In the field of textile industries, there are new applications with hemp, such as:

- Leatherette by Napee (Italy) is an “eco-leather” textile containing hemp waste powder that does not use toxic solvents in the production process, is recyclable and has a negative carbon impact. The bonded fabric is made by adding dust produced during the fiber decortication process to biopolymers which are then spread on a textile base. The result is a mixture of plants and resins that can undergo the printing, drumming, and embossing processes into a final faux leather product that maintains breathability. The hemp is sourced from all over Italy, however Napee is developing a localized circular supply chain model that minimizes the need for transportation, reducing the impact on the carbon footprint. The most promising first uses for the fabric are as a substitute for leather and imitation leather in boating, bags and accessories, shoes, and upholstery.
- Hemp bedding, table sets, and decorative pillows for hotels by Stevahemp ²⁴(Merano, Italy). Not only the manufacturing and service sectors are playing a role in polluting the environment, but also the hotel industries with the usage of linen and cotton textiles are supporting this action. In fact, hotels have to change sheets, towels, napkins, bathrobes and other items for each new guest, which have a considerable impact on the environment. The use of hemp fibers helps to increase material durability, exhibiting greater robustness (3 times more than cotton), non-deformability and heat-insulating properties, finally reducing the environmental impact of the individual guest.

²⁴ <https://stevahemp.com/>

- Hemp barefoot shoes produced in Europe from European sources of hemp by BOHEMPIA²⁵ (Czech Republic).

Construction and Furniture: Hemp is utilized in construction through hempcrete - a lightweight, insulating material - and for the production of fiber insulation mats. In furniture, hemp fibers and oils are used for their strength and sustainability. The value chain of hemp in the fields of construction and furniture underscores its versatility and sustainability. Below a detailed look at each stage of this value chain:

1. **Cultivation of Hemp:** The process begins with the cultivation of hemp, which is an environmentally sustainable crop. Hemp grows quickly, requires minimal water, and doesn't need a high level of pesticides or fertilizers. This initial stage is crucial as it sets the foundation for a low-impact, sustainable product.
2. **Harvesting and Processing:** Upon reaching maturity, the hemp plant is harvested. For construction and furniture purposes, both the fibers and the woody core, or 'shives', of the hemp stalks are valuable. The fibers are known for their strength and durability, making them suitable for furniture manufacturing or insulation felt in the building sector. The shiv, being lightweight and porous, is ideal for construction uses, both as bricks or as coating.
3. **Production of Hempcrete:** In the construction industry, the hemp shiv is mixed with a lime-based binder and water to create hempcrete. Hempcrete is a lightweight, insulating material, valued for its thermal and acoustic properties. It is mold-resistant, pest-resistant, and fire-resistant, making it a safe and sustainable building material. The process of creating hempcrete is less energy-intensive compared to traditional concrete production, further emphasizing its environmental benefits.
4. **Manufacturing of Furniture:** In the furniture industry, hemp fibers are processed into a durable fabric or composite materials. These fibers can be woven or mixed with other materials to create upholstery, rugs, or even structural components. Hemp oils, extracted from the seeds of the hemp plant, are used in finishes and varnishes, offering a sustainable alternative to synthetic, petroleum-based products.
5. **Construction and Furniture Assembly:** Hempcrete is used in construction for walls, insulation, and flooring, providing a sustainable alternative to traditional building materials. In furniture manufacturing, hemp-based materials are used to create pieces that are not only durable and strong but also eco-friendly. This stage involves skilled labor and craftsmanship, contributing to local economies.
6. **Distribution and Marketing:** Hemp-based construction materials and furniture are distributed through traditional channels, but there is an increasing focus on marketing these as eco-friendly, sustainable alternatives to conventional materials. This appeals to environmentally conscious consumers and aligns with global trends towards sustainability.

Interesting examples in the field of construction and furniture are:

- Hemp fiber insulation mats by KOBÉ-CZ²⁶ (Czech Republic) are products made from natural hemp fibers which are mixed with two-component binder fibers in a specific ratio, being suitable to achieve the required quality. Synthetic fibers are thermally activated, securing their connectivity with other fiber products. The advantages of this material are mainly: health harmlessness, excellent accumulation abilities, easy handling and installation, and high diffusion openness.

²⁵ <https://www.bohempia.eu/>

²⁶ <https://www.kobe-cz.eu/en/>

- Hemp boards for furniture (Mendel University²⁷, Czech Republic) are an engineered wood product constructed from hemp shives. Hemp boards can be used in place of wood particleboard or medium density fiberboard. The board is very versatile and can be used for applications like cabinets, furniture, shelving, sub-flooring, molding, doors, or other simple wood structures.
- Hempcrete bricks and coating by Tecnocanapa, Pedone Working and Schoenthaler in Italy.²⁸

Automotive and Biocomposites: The automotive industry employs hemp in biocomposites for interior panels and other parts, leveraging its lightweight and strong nature to enhance fuel efficiency. The integration of hemp into the automotive and biocomposites sector marks a significant stride in sustainable manufacturing. Let's delve into the value chain of hemp in this context, emphasizing its utilization in the automotive industry for interior panels and other parts, which capitalizes on hemp's lightweight and strong characteristics to boost fuel efficiency.

1. **Cultivation and Harvesting:** The journey begins with the cultivation of hemp, which is an environmentally conscious process. Hemp grows rapidly, requires little water, and is typically free from the need for herbicides and pesticides. This phase is crucial, as the quality of hemp grown directly impacts the efficacy and quality of the biocomposites it will form;
2. **Processing and Fiber Extraction:** Post-harvest, the hemp stalks are processed to extract fibers. This involves retting (the process of naturally breaking down the pectins in the plant to release fibers) and decortication (separating the fiber from the core). These fibers are the primary raw material for automotive biocomposites. The processing is generally more eco-friendly compared to synthetic fiber production, involving minimal chemical use.
3. **Production of Biocomposites:** The extracted hemp fibers are then transformed into biocomposites. This involves combining hemp fibers with a polymer matrix to produce a composite material. The polymers can be either synthetic or bio-based, but the trend is moving towards using more sustainable, bio-based polymers. The hemp fibers provide strength and durability, while the polymers bind the fibers together and provide the shape and additional properties required for automotive parts.
4. **Manufacturing Automotive Parts:** These biocomposites are then used to manufacture various parts for the automotive industry, such as door panels, dashboards, and other interior components. Hemp biocomposites are favored for their lightweight nature, which is crucial for enhancing fuel efficiency in vehicles. They also offer good insulation properties and strength, essential for automotive parts.
5. **Integration into Vehicles:** The finished hemp-based components are then integrated into vehicles during the assembly process. Their integration is a testament to the industry's shift towards more sustainable and environmentally friendly practices. The use of hemp biocomposites reduces the overall weight of the vehicle, leading to improved fuel efficiency and lower carbon emissions.
6. **End-of-Life and Recycling:** At the end of their lifecycle, hemp-based automotive parts offer environmental advantages. Unlike purely synthetic materials, hemp components are more amenable to recycling and, depending on the polymers used, can be more biodegradable. This aspect is pivotal in reducing the automotive industry's environmental footprint and aligns with the global push towards more sustainable manufacturing practices.

Interesting examples in the field of automotive and biocomposites are:

- Linificio e Canapificio Nazionale²⁹ is active on several fronts in automotive innovation and biocomposites. As a B Corp certified has taken part in several European projects, the most relevant is:

²⁷ <https://mendelu.cz/en/>

²⁸ <https://tecnocanapa-bioedilizia.it>, <https://pedoneworking.it>, <https://www.schoenthaler.com/>

²⁹ <https://www.linificio.it/>

- SSUCHY project³⁰ is positioned on the development of composite constituents, based on a renewable resource (i.e. biopolymers and plant fiber reinforcements) for the development of multifunctional recyclable and/or biodegradable bio-based composites with advanced functionalities for application in different sectors: transportation (ground transportation and aerospace) and high value market niches such as the acoustic and electronics sectors. It is dedicated to the development of specific concepts, technologies and materials to achieve a complete value chain and prove the principle at the scale of product demonstrators. Moreover, it has already been presented under the Horizon Europe Programme the continuation of the SSUCHY project where hemp biocomposites for wind blades will be assessed.
- Skis with 100% hemp fiber composite by GROWN³¹(Austria). Grown skis are handmade, developed by computer aided engineering, and optimized with virtual development processes, where the environmental footprint is 40% lower than conventional skis.
- Hempstone by DRUMPARAM³²(Austria). It is made from pure hemp fiber (100%) with no additives, glue, or synthetic binders, created specifically for musical instruments and home design.
- In the Austrian landscape, two companies Hempstatic³³ and Silent Fiber³⁴ are producing acoustic insulation for interior design.

Nutraceuticals, food additives, and beverages: Hemp seeds are experiencing a resurgence as prominent ingredients in food products, beverages, and nutritional supplements. This resurgence can be attributed to several factors, including the distinctive composition of its fatty acids spectrum, a growing interest in the valorization of agro-food industry residues, and the exploration of new sources of protein. The utilization of hemp seeds is primarily observed in three forms: whole seeds, seeds for oil, and de-hulled seeds. Notably, a rapidly advancing market in the realm of plant-based foods and beverages is driving the demand for hemp-derived products. These encompass a variety of offerings derived directly from hemp seeds, including whole seeds, as well as processed forms such as meal, flour, protein powder, oil, and bioactive substances. The oil extracted from hemp seeds stands out as an exceptionally rich source of two essential fatty acids: linoleic acid (omega-6) and alpha-linolenic acid (omega-3). This nutritional profile positions hemp seed oil as a more concentrated source of nutrients and proteins compared to soybean, the nearest vegan alternative. Consequently, the nutritional value of hemp seeds and their oil makes them particularly appealing in the context of the nutraceutical domain.

Despite these promising attributes, the nutraceutical domain necessitates further advancements through a meticulous functional characterization of the component proteins within hemp seeds. Achieving a comprehensive understanding of these proteins is crucial for unlocking the full potential of hemp seeds in the nutraceutical industry.

Relevant examples applied to this sector are:

- Hempeat³⁵ (Poland) produces meat alternatives based on hemp seed protein.
- Good System (Slovakia) produces vegan plant-based protein shakes for EU markets with 50% hemp seed protein.
- Ansce Bio Generic (Italy)³⁶ produces a line called Hemy that includes i) nutraceuticals (hemp seed oil for multifunctional physiological support) and ii) aromaceuticals (hemp terpenes for food applications).

³⁰ <https://www.ssuchy.eu/>

³¹ <https://grownskis.com/new/>

³² <https://www.drumparam.at/>

³³ <https://hempstatic.at/>

³⁴ <https://www.silentfiber.net/en/?v=cd32106bcb6d>

³⁵ <https://www.linkedin.com/company/hempeat/about/>

³⁶ <https://anscebiogeneric.it/>

- Canah International SRL (Romania)³⁷ produces shelled seeds, natural hemp protein, hemp seed snacks/protein bars, protein shakes, Muesli/Granola, hemp chocolate, hemp oil, dietary supplements/capsules with hemp oil, Omega 3+, recipes for food preparations that include oil, flour or hemp seeds, cosmetics (anti-aging creams/serums; moisturizing serums in various forms) and and export in all EU Member States unless Denmark.

Besides the above mentioned, other key value chains of hemp could be described, but for the sake of brevity will only be listed³⁸: i) Hemp in medicine, ii) Paper production, iii) Composites and plastic alternatives, iii) Horticulture and market gardening, iv) Hemp as a source of feed additives, v) Hemp and beverages, vi) Hemp for cosmetics and hygiene.

4.2. Assessment of Opportunities for future development

A strategic blend of scientific research, policy engagement, public education, product innovation, and cross-sectoral collaboration is crucial for navigating the complexities and harnessing the opportunities in the hemp industry. Specifically, there are significant opportunities for future development if we consider the focus on socio-economic and policy:

1. Overcoming Regulatory Hurdles with EFSA (European Food Safety Authority) on Hemp Products:
 - Research and Evidence Gathering: collaborate with scientific entities to produce comprehensive research addressing EFSA's concerns about hemp safety for human consumption;
 - Policy Advocacy: actively engage with regulatory bodies through EIHA (European Industrial Hemp Association), presenting evidence-based arguments to reconsider the standstill on Novel Hemp Food applications.
 - Public and Stakeholder Education: initiate campaigns to inform stakeholders about hemp's benefits, safety, and potential uses, enhancing public and policy-maker perception.
2. Addressing European Commission's THC Limits in Hemp Products:
 - Lobbying for Reasonable Regulations: back EIHA in advocating for more practical THC limits in hemp products, using scientific data and industry impact studies;
 - Innovative Compliance Strategies: invest in product innovation to meet proposed THC limits, ensuring market readiness for regulatory changes.
 - Engaging with Regulators and Industry Players: facilitate discussions between the Commission, hemp industry, and scientific community to reach a balanced, safety-focused, yet industry-friendly regulatory framework.
3. Strengthening Networking and Collaboration in the Hemp Sector:
 - Building a Knowledge Exchange Platform: create an online hub for sharing insights on sustainable practices, renewable energy, and circular economy related to hemp.
 - Cross-Sectoral Collaborations: organize events uniting businesses, academia, and interest groups to foster innovation and sustainable practices in the hemp industry.
 - Supporting Sustainable Implementation: provide consultancy and support for companies and regions in adopting environmentally responsible and hemp-centric practices.

³⁷ <https://www.canah.ro/>

³⁸ https://www.researchgate.net/publication/342021371_Applications_of_hemp_in_textiles_paper_industry_insulation_and_building_materials_horticulture_animal_nutrition_food_and_beverages_nutraceuticals_cosmetics_and_hygiene_medicine_agrochemistry_energy_pr

5. Conclusions

This policy paper has highlighted key challenges and opportunities in the hemp industry, emphasizing the need for dedicated NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) to fully integrate bioeconomy principles in a circular framework. The current regulatory landscape, marked by a standstill in EFSA's Novel Food applications and stringent THC limits in hemp seed food and feed proposed by the European Commission, poses significant challenges to the industry's growth and innovation. The paper underscores the importance of scientific research to address safety concerns, policy advocacy to influence regulatory frameworks, and public education to shift perceptions positively, offering a multi-faceted approach:

1. **Strengthening Scientific and Regulatory Engagement:** ensuring the safety and efficacy of hemp products through rigorous scientific research and constructive engagement with regulatory bodies. Addressed in Section 3.3, emphasizing the need for comprehensive research and collaboration with regulatory bodies to support the development and acceptance of hemp products. In this perspective EIHA presented a CBD isolate dossier for Novel Food application which is under risk assessment in EFSA and obtained the validity check from the Commission.
2. **Policy Advocacy and Public Awareness:** Collaborating with industry bodies like EIHA to advocate for more balanced regulations and educating the public and policymakers about the benefits and safety of hemp products. Highlighted in Sections 2.2 and 3.1, focusing on engaging with policymakers to develop more favorable regulations for hemp and educating the public about its benefits.
3. **Fostering Research, Innovation and Compliance:** Encouraging research and innovation in data collection (e.g. on carbon sequestration results and LCA of various hemp product chains) and product development to meet regulatory standards and explore new market opportunities within the constraints of current regulations. As discussed in Section 4.1, this involves encouraging product innovation within regulatory confines and adapting to market changes.
4. **Enhancing Collaboration and Networking:** Building platforms for knowledge exchange and collaboration across sectors to promote sustainable practices and circular economy principles in the hemp industry. In Section 4.2, the paper recommends building platforms for knowledge sharing and collaboration across sectors, crucial for promoting sustainable practices in the hemp industry.
5. **Supporting Sustainable and Innovative Practices:** Offering consultancy and support for the implementation of environmentally responsible practices, aligning with the goals of climate, energy, and circular economy. As seen in Sections 2.1 and 3.2, providing support and consultancy for companies to implement environmentally responsible practices is vital for aligning with the goals of climate, energy, and circular economy.

The paper argues for the necessity of a strong political will, beyond mere slogans, to enact legislation recognizing the dynamic nature of innovation and the significant spin-offs of aggregated systems. This paradigm shift, moving away from a fossil-based economy towards a more sustainable and resource-efficient model, is essential for the future of the bioeconomy. These recommendations underscore the necessity of integrating the bioeconomy into a sustainable, circular logic. The paper advocates for compensation mechanisms to support sectors lacking mature regulations and stresses the importance of interconnection with traditional sectors. A strong political will is crucial to enact legislation recognizing the dynamic innovation process and the significant spin-offs of aggregated systems, marking a pivotal shift from a fossil-based economy to a sustainable, resource-efficient model.

6. Recommendations

1. **Invest in Scientific Research and Collaboration:**
 - Allocate resources for comprehensive scientific research addressing the safety concerns and efficacy of hemp products.
 - Foster collaboration with scientific entities and regulatory bodies to support the development and acceptance of hemp products.
2. **Advocate for Balanced Regulations:**
 - Collaborate with industry bodies like EIHA for policy advocacy, seeking more balanced regulations that foster innovation in the hemp industry.
 - Engage in constructive dialogues with regulatory bodies such as EFSA to influence regulations positively.
3. **Educate Public and Policymakers:**
 - Initiate public awareness campaigns to educate both the public and policymakers about the benefits and safety of hemp products.
 - Collaborate with industry associations to disseminate information and positively shift perceptions regarding hemp.
4. **Encourage Innovation within Regulatory Constraints:**
 - Encourage and incentivize innovation in product development to meet regulatory standards.
 - Explore new market opportunities within the existing regulatory framework to foster industry growth.
5. **Build Platforms for Knowledge Exchange:**
 - Establish online platforms for knowledge exchange and collaboration across sectors to promote sustainable practices and circular economy principles in the hemp industry.
 - Organize events that bring together businesses, academia, and interest groups to foster innovation and sustainable practices.
6. **Provide Consultancy for Sustainable Practices:**
 - Offer consultancy and support for companies to implement environmentally responsible practices aligned with climate, energy, and circular economy goals.
 - Develop programs to assist companies in adopting sustainable and hemp-centric practices.
7. **Lobby for Reasonable THC Limits:**
 - Lobby and collaborate with industry associations to advocate for practical THC limits in hemp products, backed by scientific data and industry impact studies.
 - Engage in discussions with regulators, industry players, and the scientific community to develop a balanced and industry-friendly regulatory framework.
8. **Emphasize Circular Bioeconomy Integration:**
 - Advocate for the integration of bioeconomy principles in a circular framework within NACE.
 - Stress the importance of compensation mechanisms for sectors lacking mature regulations and encourage interconnection with traditional sectors.
9. **Promote Political Will for Sustainable Transition:**
 - Urge political leaders to enact legislation recognizing the dynamic nature of innovation and the benefits of aggregated systems in the hemp industry.
 - Encourage a paradigm shift from a fossil-based economy to a sustainable, resource-efficient model with strong political will.
10. **Explore EU Funding and Support Programs:**

- Leverage EU funding programs, such as the European Innovation Council (EIC), to support game-changing innovations in the hemp industry.
- Seek support for localized initiatives and projects that align with the goals of building a sustainable hemp supply chain.

Implementing these recommendations will contribute to overcoming challenges and unlocking the full potential of the hemp industry in a sustainable and innovative manner.

7. Appendices - Consortium Partner Profiles

LGCA

Lombardy Green Chemistry Association³⁹ is the Regional Cluster for Bioeconomy and Green Chemistry in Lombardy, aiming at shaping the bio-based economy and promoting it as the most powerful tool for sustainable development. LGCA was officially recognized in 2015 by the Lombardy Region as part of the network of Technological Clusters wanted by the Lombardy Region, to strengthen the thematic areas considered to be a priority at the national and international level. The cluster has a regional scope. The cluster has 48 members (50% SMEs, 15% firms, 35% RTOs) operating in 4 value chains: Agrofood, Green Chemistry, Food/Pharma, and Wood.

The **mission of the cluster** is articulated in three different objectives:

- To create favorable conditions for the development of bioeconomy at the regional level;
- To become the reference point and the interlocutor of regional and national authorities for the definition and implementation of policies to support innovation in the bioeconomy field;
- To establish a meeting and planning place for all Lombard subjects interested in green chemistry and bioeconomy.

CZEHEMP

The **Czech Hemp Cluster**⁴⁰ (CzeHemp) is a non-governmental non-profit cluster organization of private companies, public sector, research and education to strengthen cooperation in the Czech hemp and medical cannabis industry. CZEHEMP has a national scope in relation to its members although it has an international outreach regarding its activity. The cluster has 30 members (50% SME, 3% large enterprise, 7% Research & Education, 40% others), all operating in the hemp value chain.

The **mission** of the cluster is to strengthen the cooperation within the hemp and medical cannabis industry, remove the barriers to its development and restore the national and international value chains, and the cluster supports the UN Sustainable Development Goals, EC innovative policy, national competitiveness policy and development of bioeconomy in the Czech Republic.

FEDERCANAPA

Federcanapa⁴¹ is an association promoting and supporting industrial hemp value chains in Italy, with a national scope. The association has 76 members, 25 of which are SMEs, 15 are start-ups (2021 data):

- Farms 25%
- SMEs processing seeds or biomass or fibers in food, pharmaceuticals, and cosmetics sectors 20%
- SMEs operating in trading or quality assurance sectors 5%
- Scientific researchers and university teachers 15%
- Technical and legal consultants 5%
- Other local or national associations 10%

³⁹ <https://www.chimicaverdelombardia.it/en/>

⁴⁰ <https://www.czechemp.cz/en/home/>

⁴¹ <https://www.federcanapa.it/>

- Individuals 20%.

Federcanapa's **mission** is to promote the development of industrial hemp value chains in Italy, the knowledge and the scientific research related to hemp production and transformation. The mission is strictly related to bioeconomy, where hemp products, safer and with better Life Cycle, are implemented in replacement of fossil-based products.

IND-AGRO-POL

The **IND-AGRO-POL**⁴² pole of competitiveness is an innovation cluster of the main actors in the agro-industry sector and in the related sectors. IND-AGRO-POL Association is the cluster organization of IND-AGRO-POL innovative cluster which is a national network with international vocation. It has its headquarters in Bucharest-Ilfov region and branches in other 6 regions of Romania. It has a national scope.

The cluster has 138 members of which 31 are members of the IND-AGRO-POL Association: 81 SMEs (58,7% SME), 4 large enterprises (2,9 % large enterprise), 9 universities (6,5 % universities), 22 research institutes (16% research institutes), 9 NGOs (6,5 % NGO), 3 regional authorities (2,2 % regional authorities), 1 bank (0,7 % bank), 16 others (6,5 % others).

The **mission of the cluster** is to stimulate innovation and collaboration in the agro-industrial sector (technologies and technical equipment construction for agriculture and food industry) and in related sectors (bioeconomy, renewable energy, environment and climate changes, eco-technologies and advanced materials, information technology and communications).

PRODUTECH

The **PRODUTECH**⁴³ – **Production Technologies Cluster**, is an articulated network of Production Technology stakeholders, deploying advanced manufacturing solutions and equipping the current factories for the future. PRODUTECH is officially recognized by the Portuguese Government, as the entity responsible for managing and promoting the development, innovation and competitiveness of the Production Technologies Cluster. It has a national scope. The cluster has 186 members: 121 SMEs (65%), 25 large enterprises (13,5%), 30 research institutions (26%), 10 others (5,5%).

The **mission** of the cluster is to strengthen collective efficiency and strategic intelligence at the service of the expansion, enlargement and qualification of the Portuguese Production Technology Sector in highly dynamic and innovative areas, as well as to develop and promote its offer and image at national and international level. Bioeconomy is not directly tackled by the cluster but is indirectly embedded in the developed activities as this is a major innovation area in all sectors. The same is valid for the cluster vision: although not formally stated both bioeconomy and circularity, with a bigger emphasis on the latter, are nowadays core in the innovative production processes.

SPRING

SPRING⁴⁴ - **Sustainable Processes and Resources for Innovation and National Growth** is the Italian national Cluster of Circular Bioeconomy, gathering stakeholders from the whole value chain. SPRING is officially

⁴² <http://www.inma.ro/indagropol/>

⁴³ <https://www.produtech.org/>

⁴⁴ <https://www.clusterspring.it/>

recognized by the Italian Ministry of Research and University (MUR) as the association responsible for promoting the development of a circular bioeconomy at regional and national levels. It has a **national and international** scope. The cluster has **154 members** (41% industrial innovation, 33% Research, 26% dissemination and territorial development), which includes large industry players, SMEs, associations, universities, research centers, foundations, regional innovation centers and many other stakeholders active in the circular and sustainable bioeconomy.

The **mission** of the cluster is to bring together innovative realities active in the development of the green chemistry sector in order to reach a circular and sustainable bioeconomy. From a strategic point of view, being a cluster dedicated to circular bioeconomy, SPRING in its **official strategic documents** (Triennial Action Plan, as well as position papers etc.) has a specific focus on supporting the development and deployment of bioeconomy value chains.

SAT

Standortagentur Tirol⁴⁵ has 7 Clusters to support local industries in key technology fields. The Cluster instrument is located in the regional government, and it is an economic tool to create future technology opportunities and new markets along with technology trends. The **Cluster Mechatronics Tyrol** is acting regionally as a support organization for key mechatronics applications around robotics, digitalization and I4.0, machinery and new materials composites, plastics, and textiles. All 7 clusters together have a number of around **450 industrial partners and cluster members**. With around 20% Start-Ups, 60% SMEs, 15% large companies and a small number of other organizations or associations.

The **mission** of the Mechatronics Cluster, together with all the seven clusters of the Standortagentur Tirol, is to support market development through networks of companies, research institutions, education providers and interest groups in economic and technological fields of strength. About bioeconomy, the link to the cluster mission is to allocate new or old technologies that empower local production and regional economy, including natural resources like fibres and plants to reduce dependence on foreign markets and suppliers. In the clusters, members contribute with their unique skills, focus areas and resources and benefit from those of others. The clusters provide the optimal framework for combining these potentials, multiplying and harnessing their effects, and thus developing innovative ideas, products, services and processes in an independent cooperative framework better than on their own.

⁴⁵ <https://www.standort-tirol.at/>