



Danube Transnational Programme

DanuBioValNet



The Phytopharma Value Chain **in the Danube Region**



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Glossary

Bioeconomy	The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. (Source: European Commission (2018). <i>A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment. Updated Bioeconomy Strategy</i> . p. 4)
Cluster	Clusters are geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate. (Source: M. Porter (1998). <i>On Competition, Updated and Expanded Edition. Harvard Business Review Book</i> , p. 213)
Cluster initiative	Cluster initiatives are organised effort to increase the growth and competitiveness of a cluster within a region, involving cluster firms, government and/or the research community. (Source: Ö. Sölvell, G. Lindqvist and Ch. Ketels (2003). <i>The Cluster Initiative Greenbook</i> , p. 9)
Cluster organisation	By a cluster organisation one should understand organised efforts to facilitate cluster development, which can take various forms, ranging from non-profit associations, through public agencies to companies. (Source: PricewaterhouseCoopers (2011). <i>Uncovering excellence in cluster management</i> , p. 6) Cluster management can be defined as the organisation and coordination of the activities of a cluster in accordance with certain strategy, in order to achieve clearly defined objectives. (Source: PricewaterhouseCoopers (2011). <i>Uncovering excellence in cluster management</i> , p. 3)
Eco-innovation	Eco-innovation aiming at significant and demonstrable progress towards the goal of sustainable development. Eco-innovation projects will therefore aim to produce quality products with less environmental impact, whilst innovation can also include moving towards more environmentally friendly production processes and services. Ultimately, they will contribute towards the reduction of greenhouse gases or the more efficient use of various resources. (Source: European Commission (2015). <i>Eco-innovation, When business meets the environment. FAQ: What is Eco-Innovation? Online</i>).
Value Chain	The value chain describes the full range of activities that firms and workers do to bring a product from its conception to its end use and beyond. A value chain refers to the full lifecycle of a product or process, including material sourcing, production, consumption and disposal/recycling processes. This also includes activities such as design, production, marketing, distribution and support to the final consumer. (Source: University of Cambridge (2017). <i>What is a value chain? Definitions and characteristics. Online</i>).

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1. The Bio-based Economy

Climate change and decreasing biodiversity are critical problems for modern society which must be tackled in order to protect our planet. Fossil resources are finite, and alternatives need to be developed. Another issue that should not be underestimated is sustainable consumption – currently a major focus of attention among academics as well as in many other fields. So how can we best tackle these issues, and where can we seek solutions?

This is where the bioeconomy (also known as the bio-based economy) comes into play. The bioeconomy is defined as “the production and utilization of biological resources (including knowledge) to provide products, processes and services in all sectors of trade and industry within the framework of a sustainable economy”. The aim of the bioeconomy is to make the carbon stored in renewable resources accessible for industrial value-added chains. This may mean using food and feed crops for the sustainable production of food and feed products. Alternatively, it may mean utilizing specific technologies (e.g. biogas plants, biorefineries, gasification and other conversion methods) to convert plants, residual biomass and biowaste into ethanol, methane, phenol, biopolymers, pharmaceuticals and many other products for use in industrial applications. Those involved in the bioeconomy are keenly aware that natural resources (such as arable land and water) are limited, so there is a concerted focus on sustainability, resource efficiency, and material/waste cycles. As a result, the burden on individual resources is considerably lower than in fossil-based economies. Furthermore, the technologies associated with the bioeconomy can open up additional development potential for rural areas. This applies to countries that have large areas available for agriculture and forestry. By unlocking such new opportunities, the technologies used in the bioeconomy can facilitate progress.

The concept of the bioeconomy is gaining traction and prominence worldwide. A number of countries have already launched their own bioeconomy strategies, and many more are working towards this. The European Union promotes the bioeconomy in a variety of ways; national and European governments have established many programmes in recent years aimed at fostering the bio-based economy.

The Danube Region too is seeking to build an innovative economic system that makes sustainable agriculture and the industrial use of renewable resources possible while also protecting the environment and safeguarding biological diversity. Furthermore, eco-innovations are likely to boost regional growth by diversifying local economies and creating new employment opportunities. New bio-based value chains (leading from primary production to consumer markets) need to be developed by bringing together enterprises from different regions and industries. However, no holistic transnational approach currently exists, so bio-based industry stakeholders in the Danube Region are not able to act in a connected way or properly benefit from existing potential.

This is where the DanuBioValNet project (“Cross-clustering partnership for boosting eco-innovation by developing a joint bio-based value-added network for the Danube Region”) comes into play. The project is financed by the EU under the Danube Transnational Programme. Its main aim is to develop new methods and tools to connect businesses (SMEs) from different regions and countries involved in bio-based industry. This can only be achieved through effective, coordinated interaction among relevant stakeholders – including policymakers and participants from industry, public institutions and academia. The stakeholders in the DanuBioValNet consortium come from ten countries in the Danube Region. Clusters representing a number of companies are sustainable partners which guarantee upgradeability across industry, science and government, and they have been selected to coordinate cooperation among the industrial partners and to spearhead the creation of new value chains. The project focuses on three bio-based value chains – phytopharma, bio-based packaging, and eco-construction – and it also forecasts their future development in the Danube Region. The vision is for the region to become a front-runner in the bioeconomy by supporting “bioeconomic distributed manufacturing environments” to achieve manufacturing scenarios that use locally available renewable raw and residual materials for conversion into locally required materials.

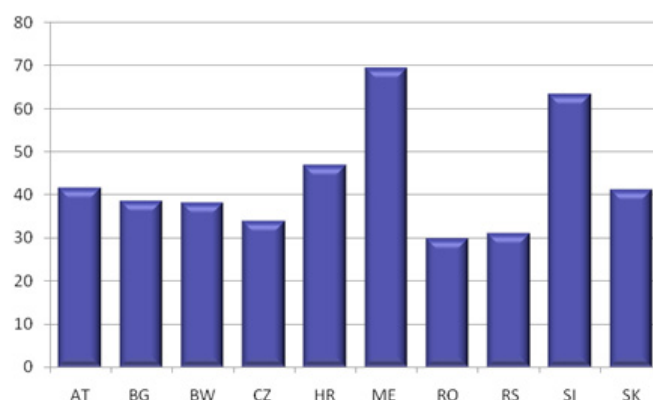


2. The Formation of Closed Bio-based Value Chains

2.1 Competitive Danube Region

The Danube Region possesses good potential for biomass production due to the large available area of forests and agricultural land in all project partner countries. Forests make up a significant proportion of the landscape in the Danube Region: in Montenegro they comprise 70% of the country's entire area, in Slovenia 63.3%, in Croatia 47%, and in both Austria and Slovakia 42%. In fact, Romania has the largest area of old-growth forests in Europe. Woodland and forests have traditionally been very important in the DanuBioValNet countries – ecologically, economically and socio-culturally. They contain a great diversity of species, ranging from broad-leaved trees (with oak and beech the most widespread species) to conifers (mostly spruce and pine).¹ According to the latest data provided by the project partners, almost half of the territory of the participating countries (49.4%) consists of agricultural land. This includes arable land, permanent crops, agricultural grasslands and horticultural land. The proportion of agricultural land is well above the EU-27 average (40% of the total land area in 2014). A wide variety of agricultural crops are cultivated in the Danube Region. Most of the land is used for cereal crop production (wheat, barley, rye, oats, maize, millet, sorghum – Romania and Serbia rank among the top 5 maize producers in Europe), oilseeds (particularly rape, soy and sunflowers), vineyards and orchards, wild and cultivated medicinal plants, grass, clover, and alfalfa.

Figure 1: Area of forested land



x axis = DanuBioValNet countries;
y axis = area of forested land as a percentage of total surface area

Figure 2: Area of agricultural land



x axis = DanuBioValNet countries;
y axis = area of agricultural land as a percentage of total surface area

1) Dermastia, M. & Maric, Z. (2017). The Bio-based Status in the Danube Region Report. DanuBioValNet.



Wood, agricultural biomass and bio-waste are the most important biomass sources in the Danube Region. However, their industrial use varies in different parts of the region. In most cases, the biomass that is not used for food and feed is used as a primary energy source for power and heating plants, for domestic use (combustion), and for the production of biofuels and biogas. Agriculturally produced bio-based feedstock is now used in the production of medicines, cosmetics, food, fine chemicals, construction materials, textiles, chemical building blocks, and fuels for electricity production or transport. A highly developed bioeconomy uses green resources firstly in the production of food and feed, and only afterwards (or simultaneously in the case of waste products) to produce chemicals, materials and energy. This is known as the cascading principle. The industrial structure of the DanuBioValNet participating countries includes all industries relat-

ed to the bioeconomy. An analysis of the strengths and opportunities of the bioeconomy in the DanuBioValNet countries shows that all ten Danube countries/regions possess good preconditions for conversion to a bio-based economy in terms of their natural geographic conditions and resources, traditional industries, R&D infrastructure, and high-quality human resources. This capacity also offers new opportunities to complement traditional products with new products and services in order to maintain and boost the region's competitiveness. In addition to the potential within the industrial sector (where agriculture and forestry have long played a key role), the development of the bioeconomy also offers inherent opportunities for the increased use of biomass raw materials within other commercial sectors. This applies to areas such as plastics and biopolymers, construction, phytopharmaceuticals and packaging.

2.2 The Phytopharmaceutical Value Chain

The DanuBioValNet project defines phytopharma as "health-related products derived from plant sources";² phytopharma comprises value-added activities associated with producing pharmaceutical and cosmeceutical agents of plant origin. These include bio-active ingredients for pharmaceutical-grade medicines, natural herbal medicines, cosmetics, cosmeceuticals, nutraceuticals, nutritional supplements and similar health-related natural products. Phytopharmaceutical products involve a wide variety of value chains, as they form part of at least three industries – pharmaceuticals (dietary supplements, drugs), cosmetics (natural cosmetics, perfumes) and the food industry (seeds, oils, herbal essences and extracts, etc.).

A wide variety of productive activities relating to the cultivation, harvesting and transformative processing of medicinal and aromatic plants (MAPs) can be found throughout the countries of the Danube Region. The Danube Region has an opportunity to further enhance its "branding" for phytopharma cluster excellence and products in line with the above-mentioned qualities by standardizing value-added activities and related systems. Forming strong alliances will help the entire value chain to attract investors and will facilitate cooperation-building to achieve common goals – ultimately strengthening the sector as a whole.

2) Memo Phytopharma Day, Stuttgart 4, December, 2017

Important producers of medicinal and aromatic plants and phytopharmaceutical companies from 6 countries/regions were interviewed in order to map the phytopharmaceutical industry's value chain. The figure below illustrates the structure of the phy-

topharmaceutical value chain for the purposes of the DanuBioValNet project.³ The entire value chain of the phytopharmaceutical sector (i.e. all the value-adding steps which make up the chain) is represented in the Danube Region.

Figure 3: DanuBioValNet phytopharma value chain



→ The first part of the value chain is represented by **cultivators**. These primarily include small-scale garden centres, nurseries and family farms with a long tradition of herb cultivation. Herb cultivation often forms part of a wider range of agricultural activities at these farms. There are also companies specializing in one specific plant species or seed production.

→ The final part of the value chain is represented by **producers**, who purchase the resource material from domestic and foreign cultivators. There are also companies which can cover the entire value chain in their own production process (by cultivating the resource material and conducting all subsequent processing activities). The largest such companies are located in Baden-Württemberg and the Czech Republic.

Commercial collecting of wild herbs is very important in Bulgaria, Romania and Serbia, but it also exists (albeit on a smaller scale) in all other countries of the Danube Region.

The above illustration of a simplified phytopharma value chain consists of several levels, including the activities of farmers (cultivation of medicinal plants in the region), producers of end products, and research institutes. The cured plant material is dried to create what is called the “plant drug” (or “vegetable drug”). Plant drug products include crushed or powdered plant drugs, tinctures, extracts, essential oils, extracted juices and derived secretions. They are obtained by extraction, distillation, compression, phase separation (fractionation), purification, concentration or fermentation. An active substance is thereby obtained, which is then incorporated into the final product.

Plant raw materials are sourced by cultivation and/or wild collection (according to the companies interviewed, wild collection plays only a minor role).

Some producers grow the resource material themselves. The other producers purchase the resource material as a semi-finished product from specialized cultivators of herbs. Established producers from Baden-Württemberg (BW) as well as from the Czech Republic have very well-established supply chains and are capable of sourcing materials at the global level (USA, China, South Africa, Russia, Nicaragua, South America, India, Canada). The main source countries in Europe are Latvia, Romania, Albania, Germany and Bulgaria; companies from other DanuBioValNet regions mainly source locally.

Stable high quality is the sine qua non of the supply chain, from raw materials to the final products. The Guideline on Good Agricultural and Collective Practice for Medicinal Plants (GACP) lays down the rules for the cultivation and harvesting of medicinal

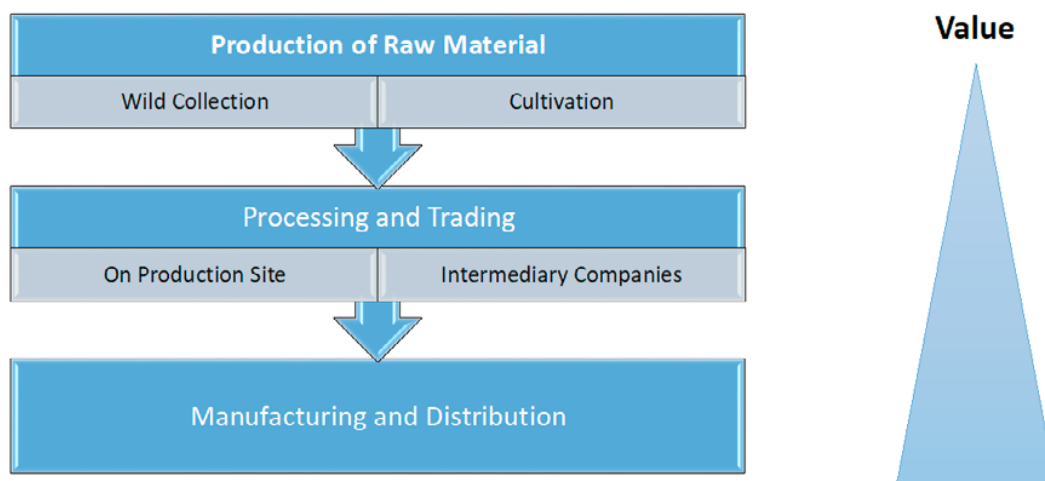
³ The value chain map was not designed to shed detailed insights on dynamics within and between nodes (e.g. separate nodes and channels for large commercial operators vs. SMEs and informal enterprises), but simply to identify the nodes themselves as clearly as possible.

plants, their drying and storage together with the appropriate hygiene standards and provisions on traceability. The majority of companies have long-term contracts with their suppliers. Most cultivators grow the resource material themselves; either they produce their own seeds (multiplication and cutting) or they purchase the seeds from certified seed production institutes or certified companies.

The current obstacles or constraints preventing producers from obtaining increased volumes of the necessary source material are climatic conditions

and the daily capacity of the production facilities. In the case of herb collectors and cultivators, there are several obstacles or constraints preventing them from obtaining more material: manual collection/cultivation techniques; ageing of the people involved in collecting/cultivating herbs and a lack of interest among the younger generation; specific mechanization; administrative procedures applicable to wild harvesting; lack of certified laboratories; outdated methods of physical and chemical analysis (reference values are not updated, required parameters are not in accordance with EU standards).

Figure 4: Value added from production towards manufacturing and distribution



The phytopharma value chain challenge is substantial. Regional strategies aiming to further develop the phytopharmaceutical industry and related value chains are not currently part of any regional strategies of the DanuBioValNet partners. Cluster programmes to support phytopharma cluster development do not currently exist.

Farmers, cultivators and pickers have not been considered as a part of any cluster initiatives or industrial strategies in phytopharma. In some regions these groups have been taken into consideration in agriculture-related policies and actions. Existing clusters face the challenge of adapting to very different modes of collaborative arrangements involving both vertical and horizontal relationships.

4) <http://www.coop4pam.com/web/wp-content/uploads/2017/10/O-setor-das-PAM-na-Europa-Johannes-Novak.pdf>

3. Innovation Ecosystems for Closing Phytopharma Value Chains

3.1 Sustainable Partners for Change: Clusters

A cluster can be understood as a geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies and trade associations).⁵ By definition, enterprises in clusters naturally tend to align themselves along the value chain of a particular industry, harnessing and exploiting the positive spill-over effects of the network. Cluster organizations can help companies to better engage with other local actors within their cluster and to organize collective actions to strengthen their competitiveness.

Cluster mapping is the process of measuring the presence of cluster actors (companies, R&D institutions, public sector bodies) in a given region across

defined sector-specific value chains. Cluster mapping, especially in “emerging industries” such as phytopharmaceuticals (phytopharma), is of substantial importance as it enables us to better understand the key competencies of the cluster actors as well as to evaluate the extent to which the relevant value chain is properly covered.

Despite the major industrial agglomerations in the pharmaceutical sector within the Danube Region, only a small number of phytopharma cluster initiatives exist there. They are relatively small in size and young in terms of cluster management experience. Selected cluster initiatives in the pharmaceutical sector within the Danube Region are listed in the table below:

Name	Country	Number of cluster actors	Establishment
Bulgarian National Association Essential oils, Parfumery and cosmetics (bnaeopc)	Bulgaria	27	1999
Hrvatski Cluster	Croatia	N. A.	N. A.
Orlicko Agrocltural Cluster	Czech Republic	15	2016
CzechBio	Czech Republic	31	2009
IND-AGRO-POL	Romania	10	2012
HERBAL PHARMANET	Serbia	16	2015
Bioeconomy Cluster	Slovakia	16	2015
Hemp Cluster	Slovakia	25	2015
Czech Hemp Cluster	Czech Republic	N. A.	2018

5) M. Porter (1998). On Competition, Updated and Expanded Edition. Harvard Business Review Book, p. 213



3.2 Engaging New Business Models

The bio-based industries, such as phytopharma, have been identified as cross-sectoral, highly innovative industries in which most parts of the Danube Region possess complementary competitiveness advantages and strong potential that can be harnessed by the development of eco-innovation, thus contributing to the prosperity of the region as a whole. From this perspective, bio-based value chains require companies to adopt new technologies and to act as part of interconnected value chains (VCs). These VCs must bring together producers, users, service providers, academics and buyers within the individual parts of the Danube Region and connect them along the axis of the Danube. A systematic multilevel approach to improving framework conditions for eco-innovation in bio-based industries demands new tools and business models on all levels.

Cluster services are the key tools enabling cluster organizations to support their cluster actors' efforts to innovate and become more competitive. The DanuBioValNet project has identified the most promising cluster services that cluster management organizations and other similar bodies may use when helping SMEs (including SMEs operating in bio-based industries such as phytopharma) to engage in cross-sectoral innovation along VCs or when matching up appropriate partners in order to bridge existing VC gaps.

One outcome of the project is the Cluster Tool Box, which provides a variety of ready-to-use best-practice services supplied by well-established and competitive cluster management and business support organizations. The tools can be used by any cluster management organization or similar body seeking to facilitate competitiveness and enhance cluster excellence.

The main types of cluster services usually provided by cluster management organizations are:

- Innovation-related activities reaching beyond mere information-sharing: collaborative technology development, technology transfer, R&D etc.;
- Matchmaking and general sharing of information and experience among cluster participants (internal networking);
- Matchmaking and networking with external partners/promotion of cluster locations etc. (external networking);
- Business and commercial activities: export promotion, sales promotion, offshoring/outsourcing etc.;
- Entrepreneurship support;
- Policy support.

Practical examples of these cluster services form a part of the Cluster Tool Box publication "New Cluster Services to Support SMEs in Bio-based Industries".⁶

6) http://www.interreg-danube.eu/uploads/media/approved_project_output/0001/32/92be3e66154430dbe1e68b16d5fe324bd9068316.pdf

3.3 A Supportive Environment

In order to successfully develop the phytopharma industry in the Danube Region, a supportive environment, especially on the policy level, is an essential requirement.

In general, the bioeconomy is still in the emerging phase – despite the fact that some bio-based industry value chains, such as phytopharma, have already achieved good levels of development in the Danube Region. Nevertheless, the more effective involvement of policymakers, as well as stronger international links among them, could facilitate, synchronize and catalyze financing schemes and programmes for clusters and other actors in bio-based industries.

The potential of the phytopharmaceutical sector in the Danube Region is huge. The region possesses excellent natural resources coupled with highly capable research facilities and producers – several of them global leaders in the production of herbal medicinal products. Given that the phytopharmaceutical industry possesses very high potential, it should be backed by systematic and serious policymaking including structural and programmatic interventions. The Danube Region therefore needs to make a joint effort in designing a suitable pathway and taking actions as well as influencing and engaging all relevant policymakers. It is important to develop appropriate policy measures that can de-risk investments in this industry and to apply synchronized measures/funding schemes at the macro-regional level along the entire phytopharma value chain in order to plug existing gaps and fill missing links. To achieve this, it is essential to use follow-up Calls in order to implement all conclusions on the level of local and national politics, as well as on the cluster level.

To support activities that push the boundaries of knowledge forward, it is critically important to remain well-informed about evolving market tendencies and opportunities as well as to gain a better understanding of socio-economic and environmental impacts. Where certain gaps in the phytopharma value chain have been detected or highlighted, specific policy directives or programmatic measures can be of value.

The main socio-economic constraints on the phytopharma industry in the Danube Region were identified as the lack of training/technical assistance to support quality improvements and the lack of a skilled workforce, support institutions/clusters and service provision for farmers, intermediaries and SMEs. There is also a lack of data and information for consumers. However, the educated consumer base is slowly growing.

Regarding policy, the business environment and legislation affecting the phytopharma industry, the Danube Region suffers from a lack of adequate knowledge of the industry's potential and a lack of stability in quality standards. To improve this situation, regulation of the use of phyto-based medicines should be improved at the EU level; a comprehensive regulatory framework should be introduced, and better prevention against pesticide pollution should be provided. It is also essential to raise the visibility of the phytopharma industry and to increase public awareness.

Policymakers should support the phytopharma industry by setting up programmes/grant schemes dedicated to phytopharma and the bio-based economy as a whole.

4. Phytopharmaceuticals – Particular Plants for a Bio-based Danube Region

4.1 Future Perspectives for Pharmaceutical Plants

In the next few years and decades, the phytopharmaceutical industry could flourish and make a significant contribution to medical treatments of human diseases. Historically, plant-based extracts have been the basis of medical treatments in nearly all cultures.⁷ Interest in research of medicinal plants has increased over the past decade. A growing and ageing global population will bring a greater need for medicinal treatments. This demographic change – and the burgeoning interest in more sustainable products – could potentially lead to an increased use of phytopharmaceuticals in upcoming years, as they have proven to be effective in medical treatment.⁸ For example, plants such as English ivy, peace lily, snake plant, jade plant, Chinese evergreen, valerian root, lavender oil, chamomile and Aloe Vera will be increasingly used in the production of medicines and cosmetics in the near future.⁹

To achieve a renaissance of phytopharmaceuticals, the sector needs to overcome various bottlenecks, such as the characterization of new natural drugs using better screening methods for plants and other natural sources.¹⁰ Future initiatives should focus on innovations and the development of new drugs based on botanicals for modern medicine;¹¹ this approach is critical in order to support the development of competitive solutions for the production of natural drugs – which in some cases are currently not an economically attractive proposition for companies. Therefore, investment in phytopharmaceuticals is necessary and is expected to increase, which will boost interest among researchers, academics and representatives of industry.

The most promising potential markets for phytopharma-based products are all countries from the European Union, as interest in growing, developing

and using natural products is high in these developed countries.¹² Outside the EU, important markets include the USA, Switzerland and the Far East. Large-scale production is expected to grow in the EU countries.¹³ For example, Baden-Württemberg already has a multitude of companies positioned towards the end of the value chain, including well-established global players. Several other regions cover the entire value chain, yet their market penetration and access to European markets (and global markets such as the USA and China) are limited;⁶ however, their access to these and other markets is likely to improve in the future.

Opportunities will also follow new business models (the sharing economy) and new technologies (weather forecasting, virtual technologies, analytics, logistics)¹³ The development of new collaborative efforts can greatly contribute to a thriving industry; public-private partnerships could be an effective measure here.¹⁴ Another option for large companies is to cultivate cooperation with small businesses – providing them with training support, granting them certificates, offering them the option of new growing methods, and helping them to become better acquainted with new trends.¹⁵ Efforts to achieve more sustainable agriculture will increase, forcing the large producers to collaborate more intensively with cultivators.¹⁴ In this context, forms of collaboration may involve training on optimum methods of growing and harvesting, knowledge-sharing, information about new trends and opportunities, assistance in the certification process, and other related services. Improvements in terms of legislation and bureaucracy are needed to support the development of new phytopharmaceuticals and open up access to new markets.¹³

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- 7) DECHEMA e.V. (2017). Phytoextracts – Proposal towards a new comprehensive Research Focus. ProcessNet-Subject Division Plant Based Extracts – Products and Processes
- 8) Wagner, H. (2011). Synergy research: approaching a new generation of phytopharmaceuticals. *Fitoterapia*, 82(1), 34-37.
- 9) Eshun, K., & He, Q. (2004). Aloe vera: a valuable ingredient for the food, pharmaceutical and cosmetic industries—a review. *Critical reviews in food science and nutrition*, 44(2), 91-96.
- 10) Abderrazak, A., El Hadri, K., Bosc, E., Blondeau, B., Slimane, M. N., Büchele, B., ... & Rouis, M. (2016). Inhibition of the inflammasome NLRP3 by arglabin attenuates inflammation, protects pancreatic- β cells from apoptosis, and prevents type 2 diabetes mellitus development in ApoE2K1 mice on a chronic high-fat diet. *Journal of Pharmacology and Experimental Therapeutics*, 357(3), 487-494.
- 11) European Commission (2018). A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment. Updated Bioeconomy Strategy.

4.2 Future Perspectives for Pharmaceutical Plants in the Danube Region

The visibility of bio-based industry in the Danube Region will potentially increase if ongoing initiatives continue and develop new strategies – such as media coverage, clusters, networking/communication tools, web platforms with useful information in national languages, as well as promotion and lobbying for the phytopharma industry.¹⁶ Bio-based industry experts are interested in open innovation networks that interconnect leading researchers in universities and industry.¹⁷ The establishment of Danube-wide phytopharmaceutical Contact Points would create valuable opportunities. Through such Contact Points, industry and academics would gain direct access to state-of-the-art information. Cooperation between academia and industry could produce databases for businesses, thematic workshops on relevant issues, support for project development and client education.¹⁷

Achieving sustainability will continue to be an objective in the short, mid and long term for all countries – including those in the Danube Region, which face specific social, environmental and economic issues.¹⁷ The need for sustainability will support the development of biotechnology and green technology. In this context, new skills should be developed in order to exploit new technologies. These skills can be developed via various training programmes focusing on new methods of collecting plant material and on the cultivation, cutting, drying and storage of plants.¹⁷

The future availability of plant material is dependent on various factors, including environmental issues, increasing competition with countries in other continents, and the future development of the organic market.¹⁸ More source material could potentially be obtained if the daily capacity of factories is

increased and if climatic conditions are favourable. In the case of herb collectors and cultivators, more material could be obtained by creating certified laboratories with specific mechanization.¹⁹

The Danube Region possesses vast natural resources coupled with an existing phytopharmaceutical infrastructure consisting of highly capable research capacities and companies – several of them global leaders in the production of herbal medicinal products. From a market perspective, Germany will continue to be the European market leader for botanical and plant-derived drugs.²⁰ Romania is also an important player; flowers of *Arnica montana* (as well as creams, oils and tinctures made from this plant) are exported to Germany and other European countries. Businesses involved with *Arnica montana* will continue to expand in Romania provided that the meadows are not fertilized.²¹ All Danube countries are likely to achieve progress on the market for phytopharma-based products. In the Danube Region, valerian root, lavender and camomile could be used more extensively to treat disorders of the nervous system. However, in the future the phytopharmaceutical industry will have to face the challenge of developing more complex drugs that are able to treat multiple diseases and conditions. For example, St. John's wort is not used solely for treating depression; its antiviral and antibacterial effects are also recognized. The plant is widely used in Germany to treat depression, though some countries (such as France) have banned it.²² In the context of the folk medicine revival, the quality of plant material and quality control should be improved via a process of standardization, better documentation, better traceability of herbal plants, and a suitable infrastructure for quality control of herbal material.¹⁷

12) Dermastia, M., & Meier zu Köcker (2017). Synthesis value chain mapping report Phytopharmaceutical industry. DanuBioValNet.

13) Wichtl, M. (2004). Herbal drugs and phytopharmaceuticals: a handbook for practice on a scientific basis (No. Ed. 3). Medpharm GmbH Scientific Publishers.

14) Bhatt, A. (2016). Phytopharmaceuticals: A new drug class regulated in India. Perspectives in clinical research, 7(2), 59-61.

15) Henderson, E., & Van En, R. (2007). Sharing the harvest: a citizen's guide to Community Supported Agriculture. Chelsea Green Publishing.

16) Maric, Z., Osvald, D., Miric, A., & Dermastia, M. (2018). Roadmap Report. Phytopharma Value Chain. DanuBioValNet.

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20) Inkwood Research (2017). Europe botanical & plant derivative drug market forecast 2018-2026.

21) <https://arnicamontana.ro/istoricul-sistemului/>

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Multi-resistant bacteria are a major current medical issue, for which solutions are still being sought. Experts are seeking combinations of substances with synergistic effects (combining different herbal compounds or herbal extracts with chemical ones).

With regard to legislation, the EU has introduced a directive making it easier to register traditional herbal medicinal products. However, the EU legislative framework should be improved in order to assist phytopharmaceutical producers in tackling patent protection issues by developing special extracts using production processes that can be patented.²³ Improvements in legislation and a reduction in bureaucratic burdens are also necessary. The comprehensive legislative framework could be communicated via an online platform. The regulatory framework should support the development of ethical businesses. Tax incentives and incentives for technology (biotechnology and green technology)

could be used to support sustainability in the phytopharmaceutical industry.¹⁷ New business models (such as the sharing economy) are expected to develop, and organic production will play an increasingly important role for businesses in the Danube Region. As a consequence, the role of phytopharmaceutical associations in legislative and regulatory issues will grow in the upcoming years.

Demographic challenges such as population ageing and the depopulation of villages and rural areas can be tackled by promoting increased health-awareness and supporting a reversal of rural depopulation. Policymakers, companies, NGOs and urban planners should collaborate to create an infrastructure that is able to support better living standards in rural areas, new employment opportunities, training programmes and VET for farmers and pickers, and better internet penetration.¹⁷

4.3 Next Steps

First and foremost, the phytopharma industry needs to become more visible, so that not only its products but also its highly diverse market segments along the entire value chain (e.g. plant cultivation) look attractive to the younger generation. Visibility and attractiveness could be increased via publicity and media promotion, including examples of best practice. Branding and selling phytopharmaceuticals on local and regional markets is also a potential way of generating direct consumer engagement. Branding via fair trade principles and regional marketing can increase regional visibility.

Education and training play a key role in creating a pool of future phytopharma industry professionals. Careers fairs could promote the phytopharma sector in order to attract young people to work in the industry; businesses also need to provide an acceptable environment for young people working in the least attractive segments of the phytopharma industry.

To this end, incubators could be set up in different segments of the phytopharma industry in order to

provide access to state-of-the-art technology. These incubators could support industry and science via programmes at regional, national and transnational levels (such as the LEADER program, a European Union initiative to support rural development projects initiated at the local level in order to revitalize rural areas and create jobs). These incubators should form part of wider regional development strategies; measures such as innovation support via funding, tax incentives for e.g. start-ups, networking and fabrication laboratories can boost prosperity not only within the phytopharma value chain, but also within regions as a whole.

On the EU level, a transnational cluster should map existing SMEs and thus develop a central database; this would create closer cooperation between the cluster and its SMEs in different countries.

Policymakers (including those at EU level) should become more involved in the certification, control and labelling of phytopharma products, so that customers can make better choices when purchasing a sustainable and effective product.²⁴

²³ European Commission (2018). A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment. Updated Bioeconomy Strategy.

²⁴ Boyarintseva, O., Ranguelov, S. & Vladimirova, M. (2019). Pilot actions for closing bio-based value chains: Phytopharma. DanuBioValNet.



5. Solutions for the Danube Region: Bioeconomic Distributed Manufacturing Environments

The bioeconomy is a modern way of dealing with renewable raw materials and associated biological resources in an ecologically prudent and economically viable manner.²⁵ The transition from a fossil-based to a bio-based economy reduces society's dependency on fossil fuels, increases sustainability and contributes to environmental and climate protection. However, even though excellent initiatives and bio-based products already exist, this complex transition will not happen suddenly and unexpectedly; it will most likely take up to several decades. In order to succeed, this process must be wanted and prepared for by governments, science, industry and society – especially in the Danube countries, with their great diversity of cultures and landscapes. Moreover, this process must be gradually integrated into the existing value systems of all economic sectors – including industry, services and agriculture. Consequently, large-scale national and international programmes, cooperative measures and initiatives are critically needed. Measures also need to be implemented on the regional level in order to achieve a successful transition. An important feature of the bioeconomy is its strongly regional character – meaning that it primarily targets local resources which move along short supply chains. Regional bioeconomy-centred strategies will help bring the strengths of a region

to the fore, making existing development potential more clearly visible and promoting the utilization of regional resources rather than relying on imports – thus making communities more self-sufficient. Furthermore, these regional strategies will integrate regional research and industry capacities, analyze material flows and establish interfaces with internal and external partners.²

Local bio-based product chain scenarios offer the potential for diversification in the local economy, creating employment opportunities in rural areas, yet many goods and services are still produced only in specific parts of the Danube Region. Consequently, due to the re-orientation of the global economy into distinct transnational and local solutions, regions can benefit from local or regional excellence and competencies via cross-sectoral and cross-border cooperation.

Many new business models and income opportunities are to be found in distributed bio-based concepts, which not only contribute to positive environmental impacts, but are at the same time a powerful engine for economic growth in rural areas. Educated and competent people are needed to operate distributed plants and to design products

25) Jonischkeit B., Bächtle C. (2013). Bioeconomy – Baden-Württemberg's path towards a sustainable future.

and services with higher added value. Primary production, cultivation, and harvesting will be closely linked to secondary production and the utilization and recycling of products. New opportunities will thus arise not only in agriculture, forestry and fish farming, but also in the food, chemical, pharmaceutical and energy industries. This will boost manufacturing of technologies and equipment, and it will generate a need for knowledge-intensive services such as consulting and legal services in planning, operation, optimization and maintenance.²⁶

If properly implemented and managed, the approach described above – which is also known as the Bioeconomic Distributed Manufacturing Environments (BDME) approach – offers strong potential to help build a highly sustainable way of life by providing opportunities to substitute scarce resources with renewable ones. The BDME approach focuses on distributed manufacturing in order to achieve local manufacturing scenarios that use locally available renewable raw and residual materials in conversion processes in order to deliver locally required materials. The current idea is to develop a bioeconomy focused on the introduction of renewable resources and their conversion products as intermediates in existing value-added chains. In some more complex scenarios, value-added chains are interconnected with wider value-added networks, so that more sophisticated products can be developed. In this manner, all components of a particular plant (or another regionally available renewable resource) can be synergistically used. Examples may include the following:

- 1) Fully integrated phytopharma production making use of the whole plant (e.g. leaves for tea, shoots for fibre-based packaging, roots for phytopharmaceutical active substances, seeds for food supplements;
- 2) Engine oil made from sunflowers.

Such condensed decentralized manufacturing environments need machinery infrastructure of a highly integrated, scaled-down modular type. As this machinery is potentially transportable in 40-ft container setups, it means that modern logistics scenarios (in which raw material streams converge at conversion plants) are replaced by scenarios in which manufacturing equipment is used for the conversion of locally available resources. This joint usage of highly advanced technologies is applied especially by agricultural cooperatives. The applicability and economic sense of the BDME approach needs to be investigated by using value chain models as well as applying technological and economical manufacturing simulation tools.

The bioeconomy model is interdisciplinary, as it encompasses and influences many areas of the economy, science and society. Thus, the bioeconomy concept must be understood as a system, within which many subsystems and processes are interlinked. The transition from a fossil-based to a bio-based economy will only be successful when many stakeholders are involved and when we are ready to change our mindset.²⁵

26) Luoma P., Vanhanen J., Tommila P. (2011). Distributed Biobased Economy – Driving Sustainable Growth



6. About DanuBioValNet

Cross-clustering partnership for boosting eco-innovation by developing a joint bio-based value-added network for the Danube Region

The DanuBioValNet project is a cross-clustering partnership which seeks to boost eco-innovation by developing a joint bio-based value-added network for the Danube Region. DanuBioValNet stands for the development of a joint bio-based industry cluster policy strategy, clusters connecting enterprises transnationally, new bio-based value chains in the Danube Region, and eco-innovations supporting regional development.

The DanuBioValNet project, launched in 2017 through a cross-regional partnership involving 17 partners from 10 Danube regions, will enhance the transformation from a fossil-based economy towards an economy using renewable resources by creating bio-based value-added networks. The project will connect Danube actors in bio-based industry to minimize greenhouse gas emissions and optimize biomass resource utilization. These measures seek to enhance sustainability and regional development through diversification of the local economy, with a positive impact on the workforce. The focus on emerging transnational cooperation among clusters will serve to foster the bioeconomy and eco-innovations, leading to a strengthening of regional economies.

In order to develop new bio-based value chains leading from primary production to consumer markets, it is essential to connect enterprises from different regions and industries. However, due to the current lack of a holistic transnational approach, the Danube actors in the current bio-based industry still operate disconnected from each other, and cannot

properly benefit from their mutual potential. Therefore, the aim of this project is to develop new methods, strategies and tools to connect enterprises transnationally. Clusters represent groups of industries that are closely linked by their products, markets, technologies and interests. They are chosen to organize and spearhead the industry cooperation that is necessary to create new value chains. Properly performing clusters can help upgrade industrial practices, generate new knowledge, and contribute to regional policymaking.

The partners in the DanuBioValNet project have agreed that phytopharma, eco-construction and bioplastic/advanced packaging (bio-based packaging) are three areas where there exists strong potential for improvement in their respective value chains; hemp is considered to be an appropriate raw material for all three value chains. The project activities are designed to enable partners to form links with SMEs, farmers, universities and research institutes within the value-added DanuBioValNet network. The partners intend to develop and implement a long-term, industry-driven roadmap for this collaboration encompassing the entire value chain, based on cluster partnerships. Focusing on the three selected high-potential areas, and harnessing the potential of regional clusters within wider cross-regional value chains, DanuBioValNet will implement pilot actions involving SMEs, universities, research institutions, policymakers, civil society groups and other stakeholders. The pilot actions are an essential first step before creating a blueprint for cross-regional cooperation.