Danube Alliance

Resilient Value Networks

Flagship Project of the Priority Area 8 of the
EU Strategy for the Danube Region (EUSDR)

Final Report

Project Duration: 01.01.2021 – 31.12.2022

Project Consortium:

VDI | VDE | IT

Hochschule Reutlingen
Reutlingen University

BIO PRO
Baden-Württemberg GmbH

Steinbeis
Europa Zentrum
Enabling Innovators to Grow

Supported by:

Baden-Württemberg
STAATSMINISTERIUM

DANUBE REGION strategy
Competitiveness

Baden-Württemberg
MINISTERIUM FÜR WIRTSCHAFT, ARBEIT UND TOURISMUS

This report has been produced within the Priority Area 8 Flagship Project Danube Alliance for SME Competitiveness under the EU Strategy for the Danube Region.

It was prepared by Benedikt Sedlmayr and Hannah Herzig (VDI/VDE-IT), Prof. Dr. Dieter Hertweck and Jan Fauser (Reutlingen University), Sergi Costa (BIOPRO Baden-Württemberg GmbH), Katrin Hochberg and Robert Gohla (Steinbeis Europa Zentrum). This report was drafted with input gathered from all project partners over the initial project phase (January 2021 – December 2022). The authors would like to thank all partners for their contributions and significant efforts. Special thanks go to Mateja Dermastia and Jon Goriup from Anteja ECG for the great support of the Danube Alliance in their project work.

Disclaimer

For further information about the Danube Alliance project, you will find a short description at the end of the document. To learn more and to download additional resources please refer to the website https://competitiveness.danube-region.eu/danube-alliance/. The information is provided without assuming any legal responsibility for correctness or completeness. The data presented in the report are based on the information given by the project partners.

01.03.2023

Danube Alliance
Resilient Value Networks

Table of contents

Table of Figures

1 Introduction

1.1 Initial Situation

The requirements for value chains have changed significantly in recent years. For a long time, cost optimisation was the biggest goal in the development of value chains. Supply chains became globally networked and wide-ranging. The goal was to find the cheapest suppliers and to keep storage costs as low as possible. This was achieved through just-in-time production, which was common in many industries for a long time, flexible suppliers and continuous demand. Reliable infrastructure and growing access to information thanks to digitalisation made this possible. But many of these preconditions have recently been compromised by crises and change, highlighting the vulnerability of modern value chains.

The COVID-19 pandemic has shown that global supply chains are much more fragile and prone to crises than thought. Especially supply chains that start in China or India and extend to Europe often did not function as reliably as necessary during the COVID-19 pandemic. In addition, especially at the beginning of the pandemic, there were no "second sources" and thus no alternatives, which had a negative impact on value-added partners in the middle or at the end of the supply chains, including in the Danube region. In Baden-Württemberg, many sectors were heavily affected to varying degrees, especially at the beginning of the pandemic.

Flach and Steininger (2020) looked at the impact of the pandemic on the German economy, addressing in particular the role of globalisation and globalised supply chains. Their work concludes that calls to reduce global production networks and a renationalisation of production are not a solution to the current crisis. According to their calculations, the negative effects of the crisis would be only marginally smaller, while the German economic level would remain significantly below the current one. The most effective factor in surviving crises is competitiveness. Sectors with a comparative advantage can weather crises just as well as healthy, innovative and competitive firms. The free movement of goods within the European Union and among European trading partners is also of particular importance. Diversification of supply chains helps particularly in the event of localised shocks or when certain economies are particularly badly affected.

Unfortunately, in addition to the Corona pandemic other crises have arisen since 2020 that have caused enormous disruptions in transnational value creation structures: first the war in Ukraine and then the global energy crisis which became decidedly worse in the course of 2022. It is therefore becoming increasingly evident what a great challenge and danger value chain collapses represent for the supply of the economy and society. The need for more resilience will become ever greater.

1.2 Objective

Particularly SMEs in the Danube region are forced to form new value chains. Due to recent events, existing ones are fragile, disturbed or must be shortened to become efficient, carbon-neutral, and resilient. However, businesses across the Danube lack knowledge on how to improve value chain management in an efficient and digitalised way and match with the right partners for sustainable value chains. Both suppliers (most often SMEs) on the supply side and buyers on the demand side need targeted support to ensure crisis-proof end-to-end value chains. This results not only in new requirements for value chains but also in an urgent need to provide additional support for the development of value chains. The **new understanding of value chain development** contains three functions:

a) **Reconstruction:** Damaged value chains must be rebuilt after crises.

b) **Resilience:** Existing value chain networks should be strengthened and built for greater adaptability in view of expected further crises.

c) **Development:** Building new sustainable and resilient value chains due to changing (technological) opportunities and new requirements.

A promising key driver for building new sustainable and resilient value chains is the circular bio-economy with its many new possibilities. Still, there are some new technical approaches and potentials that cannot yet be exploited, not least because of the lack of value chains and circular business models.

Figure 1 shows that there is a demand due to a new sustainability awareness among consumers, and also the necessary biomass to meet this demand. The incoming EU regulations (CSRD, EU Taxonomy) will even further push the transition to circularity, forcing companies to establish sustainable value chains and new businesses.

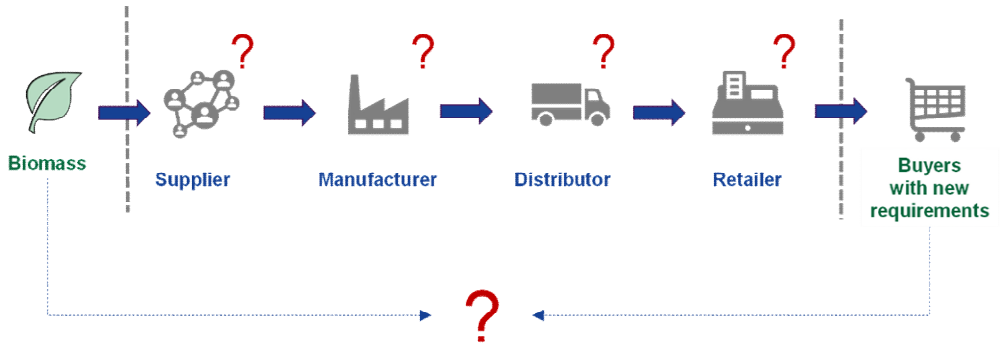


Figure 1: Bio-economy as still unknown enabler

However, the value chains needed in between are still completely missing. Farmers have no buyers for their biomass and the demand side is interested but does not know what and where to source it from. Companies do not know buyers for their residuals outside some recycling options. Instead companies are experiencing high waste management and treatment costs. SMEs do not have the knowledge, time, tools, contacts or information to identify valuable cross-sector feedstock and market opportunities for their waste. Regional intermediaries like clusters and economic development entities can be used to identify the right experts and partners in the Danube region and to support SMEs in this process. Yet, in this still relatively unknown economic field, it is still a great challenge for these intermediary actors to find upstream and downstream partners and develop new digital business models.

Against this background and in view of global crises, the **Danube Alliance** was launched as a flagship project of Priority Area 8 of the EU Strategy for the Danube Region (EUSDR) in early 2021. The overall goal is to **promote resilience of existing and new transnational supply chains in the Danube region, in particular to support small and medium-sized companies in becoming embedded in new value chains, and to contribute to increased competitiveness in the Danube region**. In this way, new crisis-resistant and fruitful economic linkages to Baden-Württemberg are to be established and strengthened. In view of the Russian war of aggression against Ukraine, the Flagship Project and its goals become all the more relevant. Ultimately, this can make an important contribution to reducing dependencies on non-European suppliers and stabilising fragile elements of a supply chain.

2 The Danube Alliance Consortium

The project has been implemented by VDI/VDE Innovation and Technik GmbH (VDI/VDE-IT) as lead partner together with BIOPRO Baden-Württemberg GmbH, Herman Hollerith Zentrum (HHZ) of the Reutlingen University and Steinbeis Europa Zentrum (SEZ). The structure of the consortium is depicted as follows.

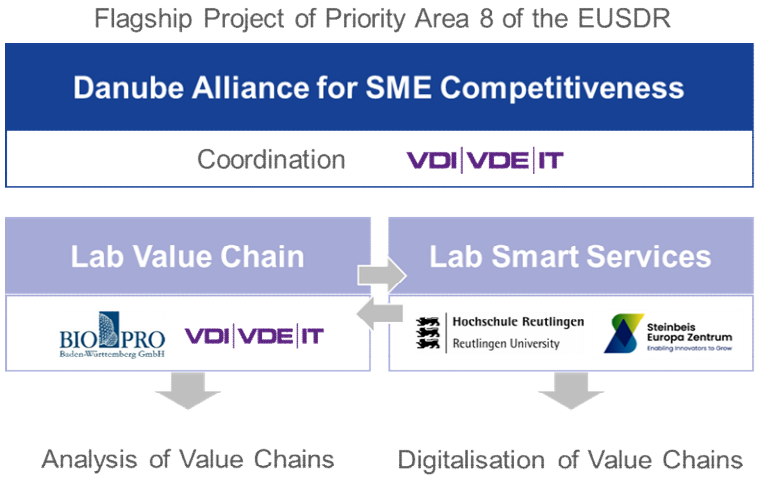


Figure 2: Danube Alliance Consortium - Structure and Roles

The consortium primarily pursued the following approaches in the first project phase until the end of 2022:

1. **Analysis and modelling of selected value networks taking stability, adaptability, resource efficiency and cost structures into account.**

2. **Simulation of the modelled value networks and development of digital pilot applications for optimising supply and value chain management.**

3. **Transfer knowledge across the Danube region with respect to analysing, modelling, simulating, developing and managing resilient value chains by applying digital tools.**

4. **Increasing the visibility of the Danube Alliance and sensitise regional intermediaries and decision makers in the Danube region regarding the importance of value chain resilience.**

The Danube Alliance activities are carried out with the close involvement of partners from the Danube region, mainly cluster organisations, regional development agencies and business associations that have direct access to SMEs and entrepreneurs in their region and who know the regional framework conditions and needs very well. In addition, relevant stakeholders and sector experts from Baden-Württemberg will be involved in the course of the value chain analysis and assessment.

3 Understanding of Resilience in Value Chain Networks

Based on the results of literature review[1], the Danube Alliance has defined three core components of resilience for itself, which are shown in the following figure.

Figure 3: Definition of a *New Resilience*

The goal for the design and management of value networks in the future should therefore be that they are able to **maintain their operations even in times of crisis** and can also **adapt flexibly** to changing conditions in their environment. What is special about the Danube Alliance's definition is the integration of the idea of **circularity**. The value creation networks modelled by the Danube Alliance should be economically viable in terms of a resource-conserving, bio-based and environmentally compatible circular economy.

The goal for the design and management of value chains in the future should therefore be to ensure that they are able to maintain their operations even in times of crisis and to adapt flexibly to changing conditions in their environment. What is special about the Danube Alliance's definition is the integration of the idea of circularity. The value chains modelled by the Danube Alliance should be economically viable in terms of a resource-conserving, bio-based and environmentally compatible circular economy.

In order to reduce the effects of disruptions of any kind as effectively as possible in times of crisis, a stable value network is necessary. **Stability** can be created in various ways. For example, it is important to reduce or avoid dependencies in the system as far as possible by developing different sources of supply in upstream stages - ideally in regions which are themselves already characterized by stable location structures, for example with regard to political conditions, labour market conditions, infrastructures, energy supply, climate conditions, etc. In this way, it is possible to switch to alternative, disruption-free sources of supply. In the event of disruptions, it is thus possible to rely on alternative, disruption-free procurement options and thus maintain the flow of value added. Conversely, stability also affects downstream processes. Diversification of sales markets can also reduce the risk of sales failures if there is a disruption in one sales region. Another stability factor is the transport infrastructure: Infrastructural improvements to the transport systems between individual stages of the value chain make a major contribution to increasing the reliability of processes in the system.

To ensure resilient processes at an early stage, before disruptions or abrupt changes actually occur, it is also important to continuously monitor and evaluate market events and market-relevant influencing factors. In the sense of an early warning system, possible effects can thus be identified and risk-minimizing countermeasures can be initiated. Such foresight also forms the basis for **adaptable value**

[1] Brinkmann et al. (2017); Miroudot (2020); Biggs et al. (2015) and Melnyk et al. (2014)

creation structures and processes. It is crucial that the insights gained from this are also translated into rapid, proactive action. A certain degree of **flexibility and willingness to change** is therefore required on the part of participating players in a value chain system if suddenly changing needs, new requirements or massive disruptions occur and processes have to be readjusted in the sense of a resilient value network. But it is not only psychological or cultural aspects that need to be taken into account here. Legal and regulatory framework factors also have a significant influence on the ability to react and act.

The third important factor is **circularity** in the context of the New Resilience. Sustainable value creation, especially in developing and transition regions, does not mean focusing on "quick wins," i.e., fast income and profit potential. Rather, a holistic and long-term approach to value creation is crucial, one that takes equal account of resource efficiency, environmental protection, fair and safe working conditions, and adequate prices and incomes. Only in this way can the right course be set for value creation models that are designed for the long term and are accepted by society. Economic, social and ecological sustainability are therefore the guiding principles of the Danube Alliance when designing value chain structures and developing digital solutions for value chain management.

Nonetheless, the involvement of regional stakeholders (e.g. farmers in growing regions, political representatives, traders, etc.) and their needs on the one hand, as well as information and sensitisation about the potentials of specific value chains on the other hand, play an essential role when promoting resilient value chain development in Danube sub-regions. These are the foundations for improving value creation structures in the sense of an economically, socially and ecologically sustainable regional development.

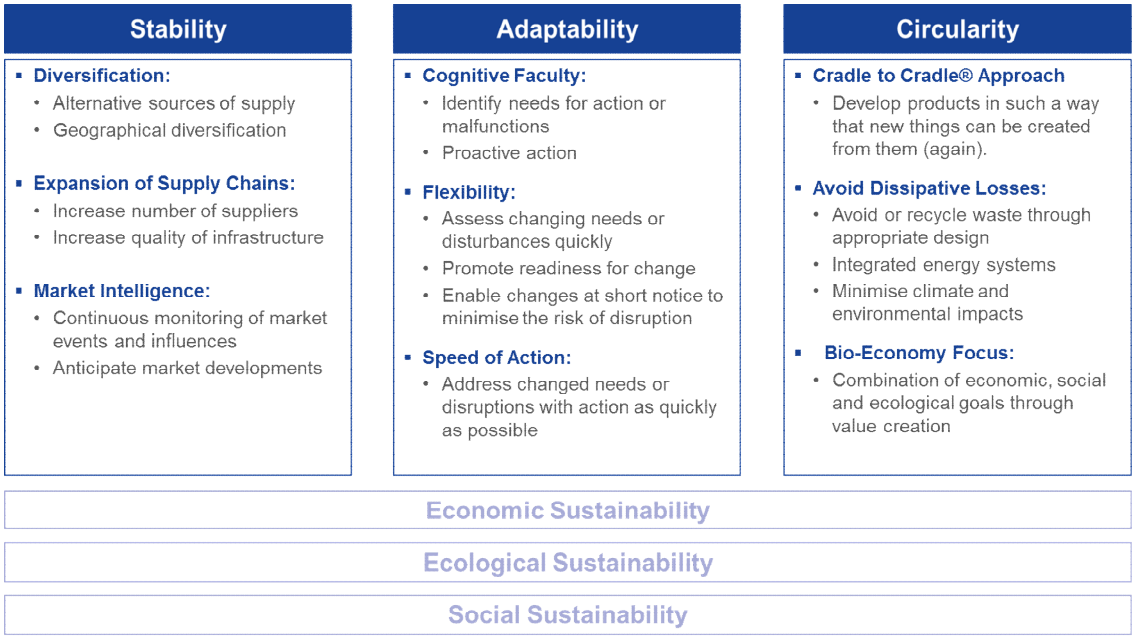


Figure 4: New Resilience Criteria for the analysis, modelling and development of resilient value chains

4 Activities

4.1 The Danube Alliance Methodology

In order to address the above-mentioned new understanding of value chain development the consortium has defined a methodical approach – the Danube Alliance Methodology for value chain development. It contains three main process phases, which are shown in the following overview and explained afterwards.

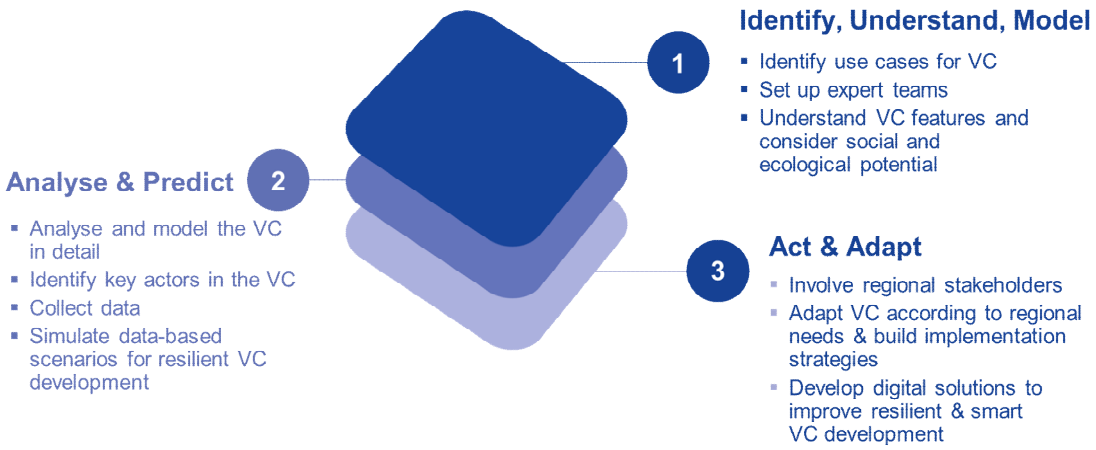


Figure 5: The Danube Alliance Methodology for Value Chain Development –
own illustration by VDI/VDE-IT, modified based on *3 steps to safeguard the supply chain*, Accenture, 10/06/2021

Step 1: Identify, Understand and Model

Prior to analysis and modelling, a concrete use case for resilient value chain development is selected. In the context of the Danube Alliance it is important that this use case has (value-added) potential for Danube sub-regions in the sense of a *New Resilience* and addresses real needs of stakeholders within the region. In the initial screening and selection process, the technical expertise of BIOPRO Baden-Württemberg GmbH as well as relevant network partners is of particular relevance in order to get a feel for the value chain.

Once a concrete use case has been determined and main characteristics of the starting product or raw material are captured, the step-by-step modelling of a value network begins, taking into account the New Resilience criteria. The essential steps are illustrated in the following in an ideal-typical sense.

Initial modelling of a (bio-economic) value chain network[2]

- ❑ Outline central value creation activities and value creation flows
- ❑ Identify key actors in the pre-sketched value chain network
- ❑ Define ecological, social and economic resilience criteria and added values for the use case
- ❑ Define essential components of the system on which value creation directly depends (e.g. resources, infrastructure, purchasing power, trust among trading partners, etc.).
- ❑ Define critical or neuralgic points in and between the value network segments. These can be:

[2] Vroegindewey et al. (2018) and Olafsdottir (2018)

- Sudden shocks (short-term): e.g. droughts, landslides, pandemics, terrorist attacks.
- Gradual stressors (long-term): e.g. privatisation, urbanisation, climate fluctuations

❑ Identify regional and supra-regional influencing factors and map them in the model. Examples include regulatory framework conditions, political factors, corruption, price structures, environmental/weather influences, cultural aspects, educational conditions, infrastructure quality, energy supply quality, etc.

Table 1: Steps towards modelling a (bio-based) value chain network

Step 2: Analyse and Simulate

In the second step, the initial value chain model is modelled and analysed in more detail. Each individual process step or activity at different levels will be examined now. In addition to an overall overview, a complete process map is now being created that can be broken down to different levels. To achieve this, it is crucial to enrich every process activity with data. To incorporate data and create the process map, the Business Process Model and Notation (BPMN), the leading standard for creating business process models, is particularly suitable.

After having elaborated the process model, model simulations can be created for different scenarios and input-output-calculations. For this purpose, System Dynamics, a computer-based mathematical modelling approach for strategy development and better decision making in complex systems, is used.

The data-based simulation not only focuses on hard business factors (prices, volumes, revenues etc.) but takes also social and ecological factors taken into account. Potential digital solutions to promote *New Resilience* within the value chain network are to be considered in this regard.

Analysing and simulating a (bio-economic) value chain network[3]

❑ Model value creation activities and value creation flows in more detail

❑ Collect data for every value creation activity in the model, including price and quantity structures

❑ Allocate key actors and their relationships in the pre-sketched value chain network

❑ Build a detailed process model based on data and by using BPMN

❑ Apply system dynamics methodology to create a model simulation for different scenarios, taking into account relevant ecological, economic and social parameters.

❑ Simulate the effects of disruptions on the value network or individual segments

Table 2: Steps towards analysing and simulating a (bio-based) value chain network

Step 3: Act and Adapt

The third step of the Danube Alliance methodology comprises the presentation, discussion, modification and stress-testing of the simulation model among relevant regional stakeholders, such as political decision makers, intermediary actors like economic development entities, clusters and business associations as well as key actors from businesses (e.g. suppliers) who might have an essential role when building up the value chain in the region.

As soon as the simulation model is validated by regional actors, the first steps towards implementation follow. This particularly includes the elaboration of a business model.

[3] Vroegindewey et al. (2018) and Olafsdottir (2018)

Developing and Implementing a (bio-economic) value chain network[4]
❑ Involve business and value chain experts in order to validate and refine the system dynamics model
❑ Involve regional beneficiaries, decision makers and potential key actors of the value chain network
❑ Adapt/Refine the model according to regional expertise and needs
❑ Define key challenges for implementation (e.g. financial bottlenecks), develop implementation paths/strategies together with regional stakeholders and start creating a business model
❑ Pre-define governance structures and rules: e.g. quality standards, cooperatives, contracts.
❑ Develop measurable parameters to measure the structures, dynamics and governance.

Table 3: Steps towards developing and implementing a (bio-based) value chain network

4.2 Case Study: Miscanthus

Miscanthus (elephant grass) was selected[5] by the Danube Alliance as the first use case for the analysis and modelling of a value chain. Miscanthus originates from Asia and was first cultivated in Europe in the 1930s. In particular, the species *Miscanthus x gigantheus* (also known as Chinese grass/reed, elephant grass) has a number of characteristics that make it interesting for a variety of different applications. It shows high adaptability in terms of location, temperature and water availability, so it can be cultivated in a wide variety of places.[6] At harvest time, the plants are mowed, leaving the root in place. This has been observed to have positive effects on the soil in question by increasing humus formation.[7] Miscanthus is perennial over 25 years and can grow three to four meters high within a few months. Accordingly, the plant is characterized by high yields with a simultaneously low use of pesticides and fertilizers. Due to its diverse uses, the plant has a special potential to become an important raw material for the bio-economy in Europe. It appears particularly suitable for replacing fossil fuels with biogenic raw materials. Compared with other biomass, miscanthus has a relatively good calorific value. When miscanthus is burned, it releases the previously absorbed CO_2 back into the atmosphere, but the roots also absorb additional CO_2 and permanently store it in the soil.[8] In addition to its use as a fuel, miscanthus can also be used to establish a biogenic recycling economy. As a building material, it can be used in pressed boards for insulation on the one hand, but also as a renewable additive to cement in concrete production.[9] Here, too, the good yield and negative CO_2 balance play an important role. Under favourable conditions, 30 tons of dry matter can be obtained per hectare. This can produce enough building material for a single-family house and at the same time remove 30 tons of CO_2 from the atmosphere. In addition to building material, miscanthus is also suitable as bark mulch, livestock

[4] Vroegindewey et al. (2018) and Olafsdottir (2018)

[5] The miscanthus use case was initiated through cooperation with Advanced Ecologics GmbH. The company is pursuing the goal of establishing a sustainable biogenic circular economy in the Vidin region in northwestern Bulgaria with the help of a transport and storage system and a central biomass processing plant. Among other things, residual materials from corn straw and the cultivation of miscanthus serve as biomass.

[6] Lewandowski, et al (2000)

[7] Kahle, et al (1999)

[8] Brosse, et al. (2012) and Emmerling u. Pude (2017)

[9] Lewandowski, et al (2000)

bedding, heating material, and for use in paper and plastics production. Since *Miscanthus x gigantheus* is a cross between two other *Miscanthus species*, the plant is also infertile. It can only spread by sprouting, not by seed. This means that uncontrolled spread and potential disturbance of the ecosystem can be ruled out. [10]

Step 1: Identify, Understand and Model

Due to its high bio-economic properties and its potential in terms of New Resilience, miscanthus was selected by the Danube Alliance as the first use case. To get a feel for the entire value chain, the Danube Alliance consortium invited various miscanthus experts to gain a deeper understanding of the plant and potential uses. Social and environmental factors were also included as part of the knowledge building process. Then, an initial model defined the key stages of the value chain. Figure 6 depicts the miscanthus value network based on the consortium discussion. The key stages for miscanthus consist of **cultivation**, which ranges from cultivation to harvesting to transportation, and **conversion** of the raw material. In the conversion of the raw material, a distinction is made between feedstock conversion (also called pyrolytic conversion) and mechanical conversion, which is partly based on the feedstock. Mechanical conversion can be used, for example, to produce insulation materials, cardboard and bedding directly. On the other hand, mechanical conversion can also build on pyrolytic conversion. Thus, pyrolytic conversion can be used to obtain basic materials such as pyrolysis gas, oil and biochar from the biomass. Subsequently, further processing is possible with the aid of mechanical conversion to produce, for example, energy, synthetic gases and fuels, basic chemicals, activated carbon and soil improvers.

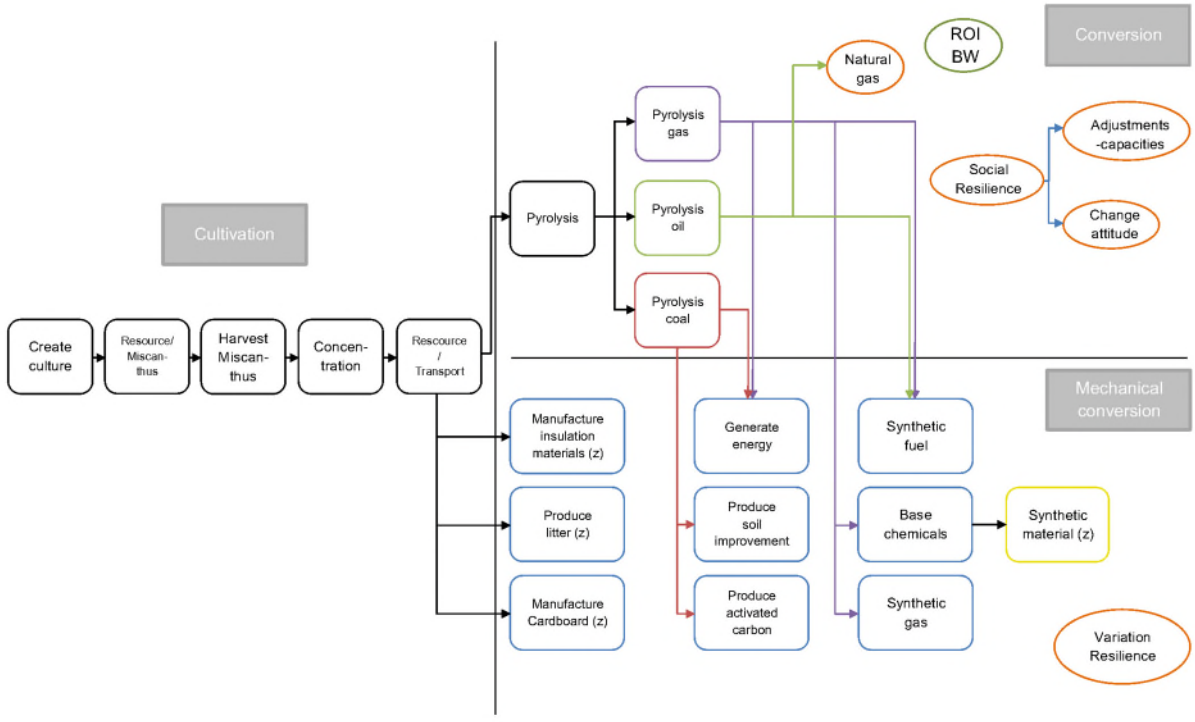


Figure 6: Key stages of the Miscanthus value network (Own illustration by Fauser & Hertweck, HHZ Böblingen)

[10] Emmerling and Pude (2017)

For the use case of the miscanthus value network, different contexts could be identified in which resilience factors play a role. For example, the Miscanthus project is expected to have a positive impact on local employment through the return of skilled labour, as well as to create new confidence in the future viability of the region. By promoting a readiness for change amongst regional society, the aim is to achieve a reduction in the outflow skilled workers and well-educated young people in the medium term and to stimulate local investment in sustainable start-ups and infrastructure. Overall, the resilience of the socio-regional system should thus be achieved. The main aspects of ecological resilience lie in the raw material source itself: Miscanthus, as previously described, is highly adaptable to its environment and to temperature and water fluctuations. In addition, the goal of establishing a biogenic circular economy with simultaneous CO_2 reduction, as well as the good suitability as a substitute for fossil fuels, is also part of the ecological resilience of the plant and thus of the entire use case. Economic resilience is achieved by the project's active resistance to a single-product economy. The ability to adjust the quantities of conversion products based on environmental signals (e.g., financial market, ecology, etc.) creates a high degree of independence from market fluctuations. This agility of the system, referred to as variation resilience, contributes to a sustainable stabilization of the value network.

In the next step, the preliminary model was mirrored and further developed in another workshop with the involvement of Ingo Dreher (Dreher Präzisionsdrehteile GmbH and Advanced Ecologics GmbH), an expert in plant engineering and conversion technologies. In the process, corn straw was also included in the miscanthus value network. In the course of this further development of the model, one challenge became very clear: Both sides of the model, cultivation as well as conversion, already exist or could be technically implemented at any time and are interesting for both sides. At the moment, there are not enough interested buyers for farmers, while there is not a large enough source of raw material for industrial buyers. Accordingly, the Danube Alliance has set itself the task of closing this gap. For this purpose, relevant stakeholders and their needs as well as potential challenges were included in this phase, recognizable by the yellow outlines. At the beginning of the chain, for example, there is security of supply and contracts for the farmers, while at the end of the value network there are potential buyers, such as the local communities or in the entire Danube region, large mineral oil and energy companies and associations. Important points to be clarified, such as the regulation of the local power grid or the maximum competitive level of the price per litre for synthetic fuel, have also been included here and marked in orange.

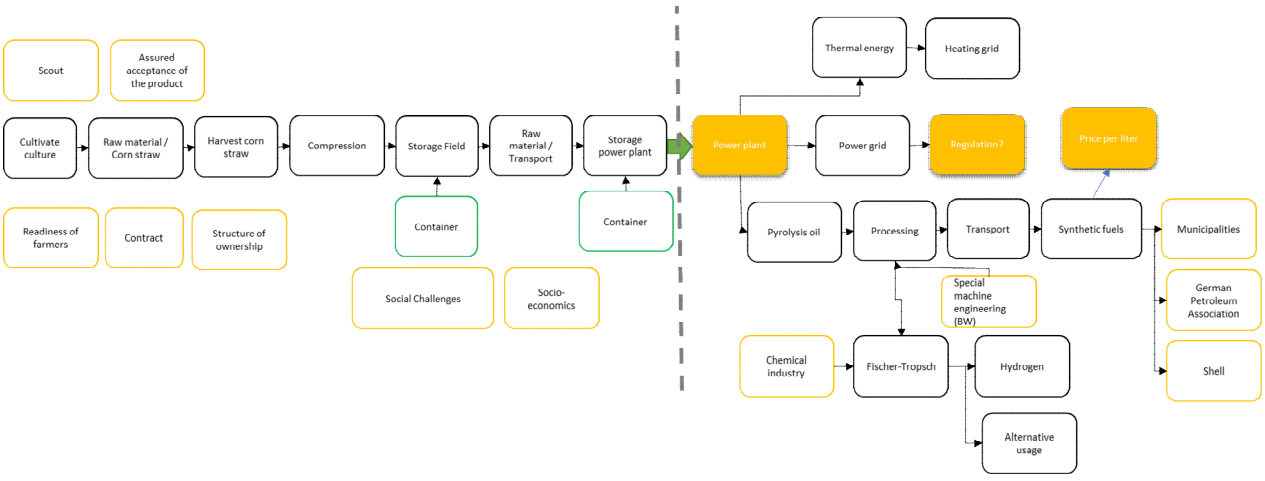


Figure 7: Further development of modelling with actors (Own illustration by Fauser & Hertweck, HHZ-Böblingen)

Step 2: Analyse and Simulate

Subsequently, the value network was to be presented in more detail to enable enrichment with data and deeper analysis. In a third workshop, detailed modelling was created for each individual process at

different levels. In addition to an overall overview, a complete process map was created that can be broken down to different levels. Figure 8 shows the top level according to the process modelling language BPMN[11]. The circles represent start and end results, respectively. The blue boxes represent activities, i.e. process steps such as cultivation and harvesting. For each of these activities, a more detailed, subordinate process has been defined. The parallel gateways ("plus symbols") on the left represent that the processes for cultivating corn and miscanthus run in parallel. There are then two scenarios for biomass use, both of which have been depicted on the map. According to the scenario one, once a central biomass processing plant is installed, the mass can be used for material use. Scenario two envisions that once the plant is operational, it will purchase a baseload from the region's farmers each year that can be recycled for energy production and use in the region.

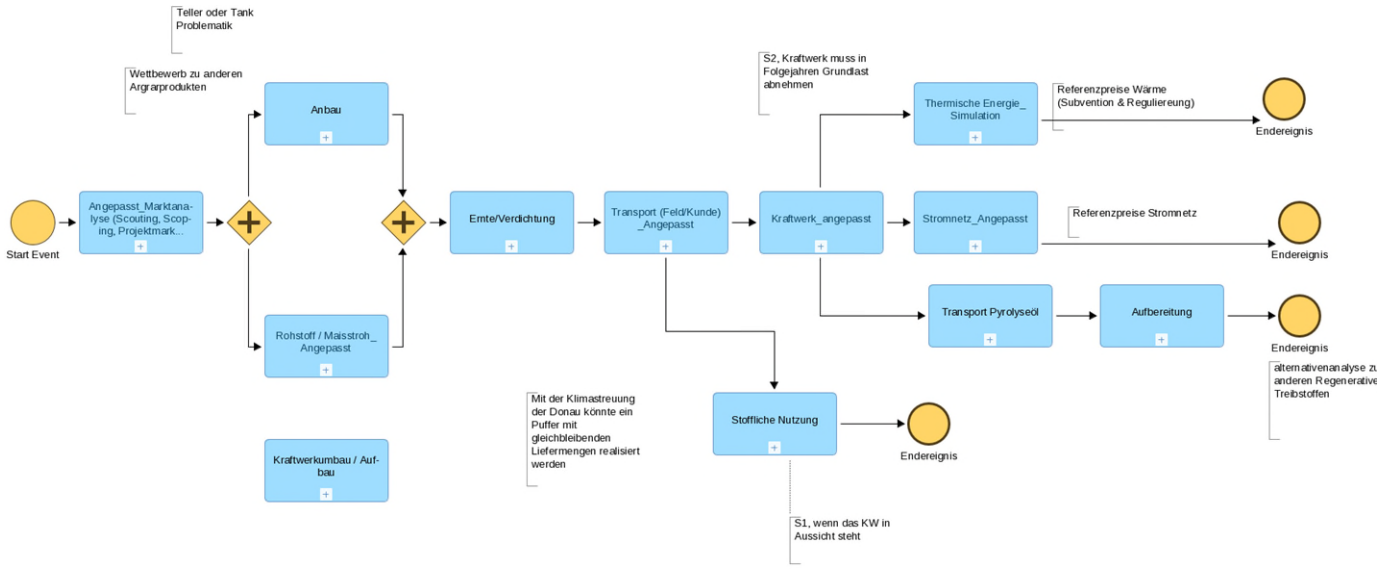


Figure 8: Higher-level process map modelled according to BPMN (Own illustration by Fauser & Hertweck, HHZ-Böblingen)

After a detailed presentation of all relevant process steps and scenarios, price-quantity frameworks are integrated into the process model using different input data (including cultivation areas, harvesting times, weather data, investment and operating costs, purchase prices and quantities, estimated energy consumption quantities). Finally, model simulations for different scenarios and calculation purposes will be created on this basis. With the help of these analyses, the planned value network will be examined in more detail for further possible critical points.

In the course of the further development of the model, it became clear how important it is, especially at the beginning of the project, to have a well-connected and informed scout who is familiar with the region, the population and the general conditions on site. This person would also be there to network the Danube Alliance with the relevant actors and to involve them. In this case, this means analysing the ownership structures on the ground, inquiring about the willingness of farmers and mediating in negotiations regarding contracts and purchase guarantees. While the necessary conditions are already established for the first part of the process (cultivation), social and socio-economic challenges also arise in later process phases. For example, local support and willingness to make changes and adjustments are just as important for the conversion and use of the power plant as they are for the development of knowledge or a medium-sized artisanal economic structure.

[11] Business Process Model and Notation (**BPMN**) is the leading standard for creating business process models

Within the framework of the Danube Alliance, it is planned to determine a numerical calculation of concrete value creation and resource efficiency potentials after completion of the model simulation (see Fig. 9). This will be combined with a qualitative description of the social added values for the pilot region of Vidin. The potential identified is to be discussed and validated with regional stakeholders in order to identify regional needs and define further requirements and, on this basis, to determine the next development steps. In particular, regional energy producers, representatives of the regional farmers' association as well as representatives of regional politics and economic development are to be addressed in this phase. The concrete price-quantity frameworks as well as the economic and ecological potentials derived from them for the region also form the basis for the planned pilot development and application of digital smart services (e.g. predictive maintenance solutions, digital weather forecasting tools) as well as for load balancing for intelligent control of the value network. Finally, it remains to be noted that the central challenge in the development and implementation of a miscanthus and corn straw-based value-added system for energy and fuel production as well as for material recovery lies primarily in the financing of the power plant installation for biomass conversion. The plant is the important linchpin in the system on which bio-economic utilization opportunities depend. Discussions regarding potential investment and co-financing options have already been initiated. In this way, the gap between the supply- and demand-side for bio-economic value creation processes described above is to be closed.

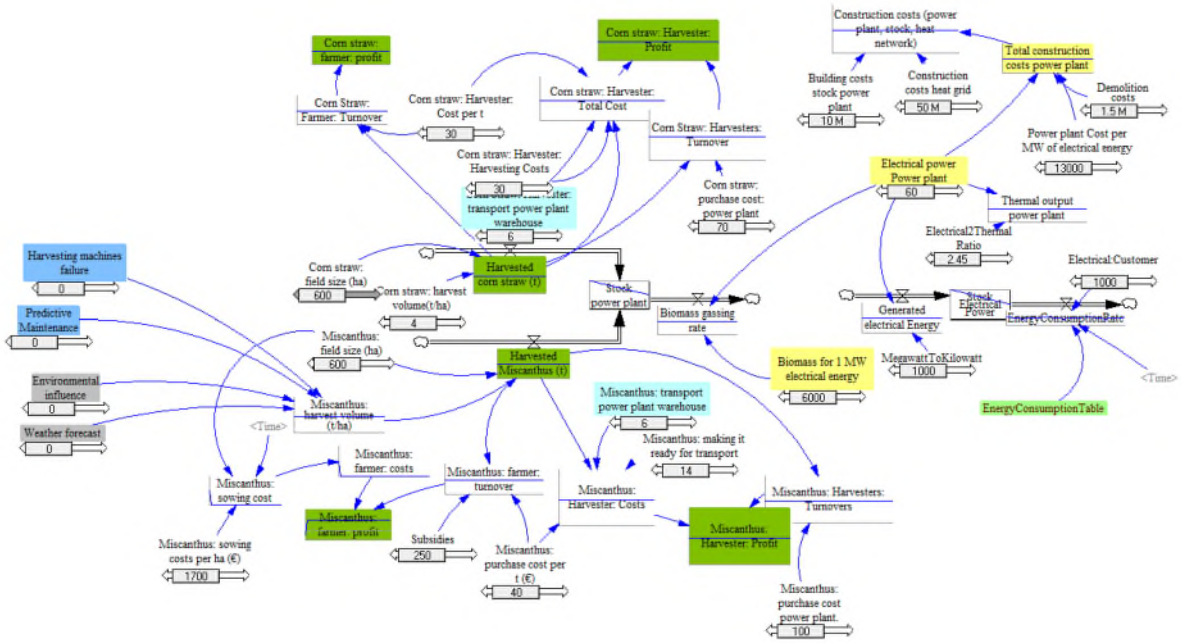


Figure 9: Evaluated, simulatable system dynamics model (Own illustration by Fauser & Hertweck, HHZ Böblingen)

Step 3: Act & Adapt

In the third step, the simulation model was discussed and further developed towards implementation among stakeholders from the Danube region. In 2022, two main measures were carried out in the form of a trip to Bulgaria and a business model workshop.

Trip to Bulgaria

The Danube Alliance consortium organised a trip to Bulgaria, more precisely Sofia and Vidin, from 14 to 16 September 2022. The aim of the trip was to meet with regional stakeholders for the Miscanthus pilot case. The focus was on regional needs as well as a possible implementation strategy. In addition

to the Danube Alliance consortium, the Baden-Württemberg delegation included Carmen Hawkins, coordinator of Priority Area 8 for the Danube region, and Ingo Dreher of Advanced Ecologics GmbH, accompanied by Mayor Markus Hugger (town of Spaichingen). The delegation held talks with various authorities on site. With the Governor of the Vidin Oblast, the model of a possible future "Public Private Partnership" was discussed. For this purpose, a special purpose vehicle is to be founded in which the activities for the development of industrial production are to be bundled and financed. The special purpose vehicle would then be owned in shares by various persons or institutions such as the city or the district as well as private shareholders. After the start-up phase, it is planned that the private shareholders will withdraw from the company, except for a small share of 2 to 5%, and the operation and ownership will then be transferred to the public partner.

Mr. Dreher plans to set up the larger, central power plant and the fuel plant within the framework of such a special purpose vehicle. The power plant is to supply heat and electricity for the city of Vidin. The city of Spaichingen is envisaged as a potential owner of one or more decentralised power plants. It has signalled that it would like to have a share in the fuel plant as well as in the pyrolysis oil and the climate-neutral fuel produced. It is conceivable that all other operators of one of the decentralised power plants have similar interests. In the meeting with the mayor of the city of Vidin, possible impacts for Vidin were discussed as well as possible areas for use.

A possible future source of income for the farmers is the sale of agricultural residues for energy or other use. According to information from Mr. Dreher, between 3 and 6 tonnes of agricultural residues (colloquially known as "harvest waste") are produced per hectare in the region, depending on the crop (maize, wheat, sunflower) and the yield/weather, which are currently mainly burnt on the fields or worked into the soil at great expense. The burning produces CO_2 and a health hazard for people cannot be ruled out. In the context of a sustainable bio-economy, these agricultural residues represent a valuable and important source of carbon.

In addition, according to information from the district's chief agricultural director, Mr Yancho Vasilev, there are about 26,800 hectares of unused land in the district (state-owned land 3,800 ha, 18,000 ha owned by municipalities and 5,000 ha privately owned). This land is so-called marginal land, which is not suitable for growing food because the yield is too small (slopes, too dry, stepped, etc.). These areas can be used for the cultivation of the energy grass miscanthus. In the long term, such use has a soil-improving effect. With miscanthus, however, crop rotation is not possible; the soils should be used continuously for the cultivation of miscanthus for about 20 years. Apart from energetic use by burning, miscanthus can also be fermented to biogas in a biogas plant or used materially (e.g. insulation, instead of bark mulch, cattle bedding).

In addition, the disused site in Vidachim, very close to Vidin, was visited. On the site there is a tyre factory that closed down in 2014, as well as several other disused factories that used to be supplied with energy by the site's own power plant. In the spirit of the circular economy, the modelling of potential value chains considered converting this power plant to make it usable for bio-economic energy production. The extent to which this is feasible also depends on further discussions with the owner of the site, Borislav Lorinkov. During the visit, a letter of intent for further cooperation was signed between Mr. Dreher, the municipality of Vidin and the owner of the site in Vidachim.

The Danube Alliance and the pilot project were also presented to the Bulgarian Investment Agency. The meeting was used to discuss possible implementation and potential funding opportunities within Bulgaria. The agency showed a general interest in bio-economy projects and the Miscanthus project in Vidin. During the discussion, promotional measures such as certification of the required investment project and related simplified administrative processing as well as additional financial support were also recommended. The Bulgarian Investment Agency also issued a letter of support for Mr. Dreher in connection with the Danube Alliance project.

The last appointment of the trip was a meeting with the Bulgarian Vice-Minister for Regional Development Desislava Georgieva. She is also the Bulgarian coordinator of the EU Danube Region

Strategy, which made it possible to discuss the potential of the bio-economy from the Bulgarian and Baden-Württemberg perspective as well as the potential of value chain development for the Danube region. Furthermore, Ms Georgieva promised her support for the Miscanthus project in Vidin. Her many suggestions and references to other relevant contacts in Bulgaria contained important aspects for the implementation of the project. For example, Ms Georgieva offered to network the Danube Alliance with relevant contact persons from the Ministry of Innovation and the Ministry of Agriculture.

Developing a business model

Together with the company Dreher Präzisionsdrehteile GmbH and and representatives of the Reutlingen University (HHZ) and Steinbeis-Europa-Zentrum, a full-day business model workshop was held in Böblingen in October 2022. The aim of the meeting was to discuss possible steps with regard to realising the business idea on the basis of the knowledge gained so far and to translate this into concrete measures for action. The business idea itself consists of several technical sub-projects (modules) that needed to be defined and staffed with possible actors.

d) Module 1 comprises the **development of an innovative harvesting technology**. A vehicle is currently being developed that can be used to harvest or pick up biomass, press it into a specific shape and deposit it. Another project involves the development of a machine that picks up the pressed material and optimises it for efficient transport.

e) Module 2 refers to **technical improvements of the carbonisation process**. The aim is to optimise existing plant technology with regard to the biomass feed and a system control adapted to it. A particular focus here is the sensory recording of the supplied carbonisation material with regard to composition, density, moisture, etc., for highly efficient plant management.

f) Module 3 concerns issues related to the **use of pyrolysis oils**, which are a by-product of biomass carbonisation. In this respect, the participants agreed that this complex of topics should be addressed in a separate workshop together with experts from KIT (see below).

g) Module 4 covers the **recycling of the residual materials**. The first promising tests show possible uses in the packaging and building materials industries (tiles, insulation materials), which now need to be fleshed out with industrial partners and translated into concrete user solutions.

Some of the development steps build on each other, so that not all modules can be implemented at the same time. Furthermore, especially with regard to modules 3 and 4, there is a lack of industrial implementation partners, some of whom have yet to be found and integrated.

After successful implementation of the sub-modules, an EU-funded demonstration project should be initiated, if possible, in which all sub-developments are brought together and feasibility and marketability are demonstrated. In addition to a large-scale plant, the feasibility should also be demonstrated in the context of a smaller plant, for which the locations of Spaichingen and Vidin, for example, would be very suitable.

The developments for Module 1 are already being implemented and are being funded primarily by the BW-Invest programme in Baden-Württemberg. The aforementioned R&D measures within the framework of Modules 2-4 are to be funded primarily by the federal government's ZIM programme. With regard to Module 3, specific technical programmes of the FNR or NOW may also be considered, which aim to decarbonise the transport sector.

In December 2022, another workshop was held in Karlsruhe at the Institute for Catalysis Research and Technology (IKFT) with representatives of Dreher Präzisionsteile, Karlsruhe Institute of Technology (KIT) and the Danube Alliance partners BIOPRO and SEZ. The meeting focused on the question of the extent to which the pyrolysis oil produced during the carbonisation process can be used and converted into usable biofuels in a chemical process. The IKFT has proven the basic technical feasibility of this. In

a separate sub-project (Module 3), the necessary processes, for example in the area of hydrogenation, are to be optimised. In order to be able to set up a corresponding funding project, it is necessary to approach and involve other actors (plant manufacturers, refinery operators, raw material/additive suppliers, etc.). The ZIM programme of the federal government is available as a possible funding instrument.

With regard to the further implementation of the Miscanthus project, SEZ proposes the following **implementation roadmap**:

a) Implementation of Module 1 – Objective: Optimisation of the harvesting process and technology

The development and construction of corresponding prototypes is already underway; funding is provided by the BW-Invest programme.

b) Development of a federal proposal for module 2 – Objective: Optimisation of the smouldering process

Coordination with plant manufacturers (e.g. Regawatt) and the involvement of other industrial partners (sensors, software, etc.) is necessary. On the research side, participation by HHZ (business modelling) and the University of Stuttgart (IFK) and KIT (IFKT) could be considered. Funding could be provided by a ZIM joint project.

c) Preparation of a funding application for module 3 – Objective: Utilisation of pyrolysis oil as biofuel

At this point, it is also necessary to approach and involve other industrial partners (additive manufacturers, plant constructors, refinery operators, etc.). On the research side, IFKT and HHZ should also be involved. Project funding could be provided either through a ZIM joint project or alternatively through an FNR/NOW technical programme.

d) Implementation of Module 4 – Objective: recycling the remaining biomass

Further discussions are needed with relevant actors and groups of actors. Initial studies allow the justified assumption that the biogenic residues can be used, for example, in the packaging and insulation industry. In this context, it is necessary to record the chemical and physical properties and to optimise the technical processes accordingly in order to arrive at marketable target products. Initial talks have already been held with potential research partners, but industrial partners still need to be approached and involved.

The goal is to combine all partial results in a European demonstration project in order to implement the necessary measures for system integration and to provide proof of function at demonstration level. If possible, the latter should take place in the form of two plants with different power ratings. The project is to be financed primarily by the European research framework programme HORIZON Europe. SEZ can provide support in this regard by approaching European partners and preparing the funding application.

In anticipation of the implementation of Module 5, it is necessary to intensify existing contacts in neighbouring countries. In this respect, the trip to Bulgaria offered a very good opportunity to sound out potential (energy) partnerships and to clarify the willingness to cooperate. An accompanying measure is to inform regional actors about the advantages of biogenic energy sources and their potential uses. In Bulgaria, for example, a national bio-economy network is to be established in which regional actors can exchange information and discuss concrete projects. Preparatory measures for the establishment of such a network are to be funded through an INTERREG project, which has been submitted for funding by SEZ in the current Danube Programme. The DaRePORT project deals with the use of Danube ports as future locations for the production and transhipment of "green energy". The city and region of Vidin participate in this project as associated partners, so that an exchange of experience is guaranteed at all times.

At the end of the effort is the goal of a continuous value chain, which – underpinned by a marketable overall technical system – is able to make a significant contribution to achieving the national and European climate goals. The "Technologies made in BW, Germany & Europe" to be developed will not only contribute to a much more resilient energy supply and secure existing jobs, but also have the potential to create thousands of new jobs, according to the conviction of the Danube Alliance partners.

4.3 Case Study: Sorghum

The election of sorghum as a use case was based in preliminary talks with Professor Peter Nick from the Botanical Garden of the KIT (Karlsruhe Institute of Technology). Prof. Nick and his team have researched sorghum for years. Sorghum is an important warm season crop that belongs to the millet family. Considered an ancient grain, sorghum was first domesticated in north-eastern Africa and is currently mainly cultivated in South Asia, Africa and Central America. In India and in several countries in Africa it is used primarily as a food crop and even in the production of locally brewed alcoholic beverages. Sorghum is more drought tolerant than corn, so is often the preferred cereal crop in areas of low rainfall or that experience frequent droughts. It also tolerates some soil toxicities and a wide range of temperatures and high altitudes.[12] That makes sorghum a resilient crop against the climate change.

Globally, about 50% of sorghum is consumed by humans. In Europe, United States (U.S.) and Australia, this crop is mainly used for animal feed (sweet sorghum or *Sorghum bicolour (L.) Moench*), ethanol production (biofuels), human food (for limited use e.g. gluten free flour, sweetener, baby food or snack food[13]). In Europe, a French company commercialises plant extracts and natural pigments taken from the stems and leaves from *Sorghum bicolour subsp bicolour (L.) Moench* (or *Dye Sorghum*).[14]This variety is also used in Benin (Africa) as a food colorant in cereal-, legume-, tuber- and milk-based foods. However, limited data is available on the optimal extraction conditions for *Sorghum biocolour* and its properties in a wider range of food products.[15] In Japan, it is used in making pancakes and noodles. It can also be steamed and popped. In the U.S. its use in aquaculture is being developed and promoted. Archer Daniels Midland, a former American agri-food company, produces wallboard for the housing industry using sorghum. Due to its lack of conductivity, sorghum is becoming a popular material for biodegradable packaging materials.[16]

Moreover, the crop is a good fit for different types of ethanol production including the traditional starch from grain, sugar from pressed juice and biomass. In fact, the entire sorghum plant can be used as biomass. Sorghum grain produces the same amount of ethanol per bushel as comparable feedstocks but uses on-third less water in its production.[17] The use of this crop as feedstock, food (baked products, beer production, snack or food ingredient) as well as for the food industry (sweetener), biofuel (bioethanol) and biogas is in average well reviewed. The physical features and nutritional qualities of sorghum products, experience and awareness gaps, and consumer perceptions remain to be the major barriers that limit the competitiveness of sorghum.[18] Other applications found through a thoughtful desk research are: as edible cutlery in India[19], as sorghum wax for coating for foods (by-product of wet milling

[12] Ag Marketing Resource Center (Revised April 2022)
[13] Dordoni, R. et al. (2015)
[14] Couleurs de Plantes (2022)
[15] Folachodé, U.G.A. (2018)
[16] Ag Marketing Resource Center (Revised April 2022)
[17] ibid.
[18] Y. Deribe & E. Kassa (2019)
[19] Bioplastics NEWS – Axel Barrett (June, 2018)

and ethanol production) and as source of bioplastics films, based on the kafirin protein from sorghum flour.[20] Based on this research, it can be concluded that this crop seems to attract more interest from non-European researchers, patent-users and companies.

Step 1: Identify, Understand and Model

Sorghum covered 250,000 ha in the EU-28 in 2016. A 3-year promotional programme co-funded by the European Union started in 2017 and focused on two geographical areas: southern EU (Italy, Spain and France) and eastern EU (Romania, Bulgaria). The aim of this campaign was to improve farmers' knowledge about sorghum, increase sorghum acreage and expand market shares for EU sorghum seed producers.

From the perspective of the Danube Alliance this crop offers a relevant bio-economic potential under the principles of the New Resilience: Sorghum is a crop of marginal and vulnerable areas that are highly susceptible to the changing climate. Its resistance under water stress and poor soils, and its above-of-the-average growth rate (growing season of 115–140 days in U.S. and 100-120 days in Germany for ecological agriculture) made this crop valuable of modelling. Sorghum shares with miscanthus the main aspects of ecological resilience: is highly adaptable to its environment, temperature fluctuations and water stress. However, the scope of applications of sorghum in Europe at the time of writing are much reduced. While its use for biogas, biofuel, feed and, in some parts of the world, food is out of doubt, applications following the cascade use principle are fewer, probably due to low TRL, less data available, and consequently, a smaller market. Its use for packaging, wallboard, cosmetics or biochar / biofertilizer needs further research and development.

Figure 10 shows the value chain that emerged as a result of the discussion with Prof. Nick. A general distinction is made between sorghum as an energy crop and food. In both paths, the first activity is cultivation. In the case of use as an energy crop, sugar juice is obtained by squeezing. Here, Prof. Nick mentioned fermentation and refining as possible further processing. Bagasse is a waste product that is produced by obtaining the sugar juice. Through fermentation it is possible to produce bioethanol. In order to obtain the grains, they are separated by threshing and then used for food or cattle fodder. Prof. Nick also mentioned that the bagasse can be transformed into a biofertilizer. There is also the possibility to produce a yarn based on the bagasse.

[20] Guangyan, Q. et al. (2019)

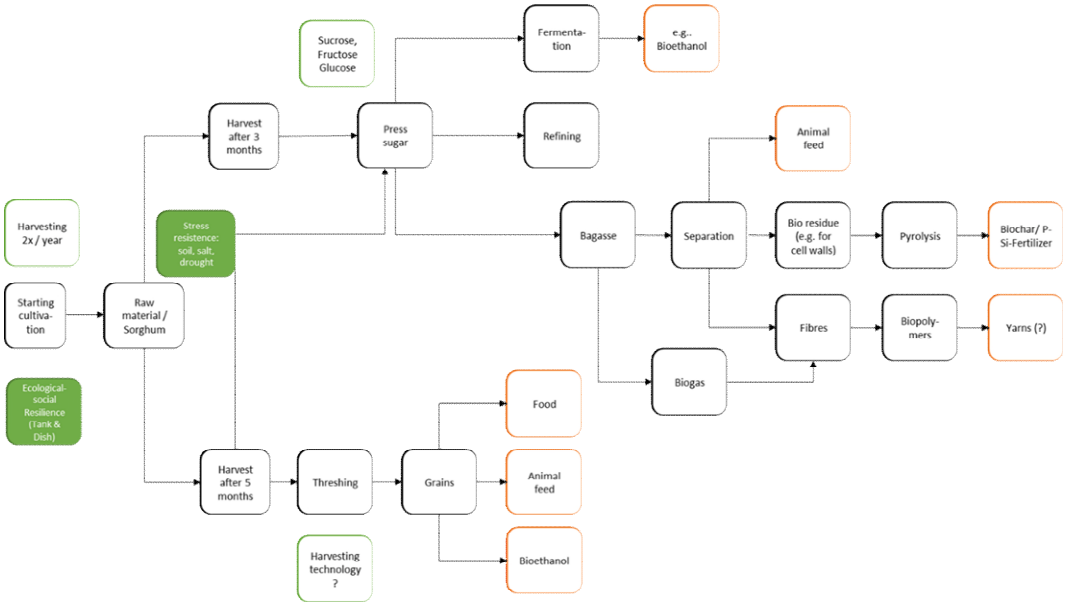


Figure 10: Key stages of the Sorghum value network.

Step 2: Analyse and Simulate

For a second workshop, which served to validate and further develop the models and to collect simulation data, HHZ transferred the results from the first workshop with Prof. Nick into a system dynamic (SD) model. As experts for the second workshop Prof. Nick from KIT, Dr. Maendy Fritz of Technologie- und Förderzentrum im Kompetenzzentrum für Nachwachsende Rohstoffe Bayern (TFZ) and a colleague of Prof. Nick, Dr. Adnan Kanbar participated. Figure 11 summarizes the main stages of the sorghum value network resulted from this meeting and further research by HHZ based on the report of TFZ.[21] We used Vensim for modelling and simulation of SD model. On the one hand, a model was created for sorghum as an energy crop and on the other hand for use as food and fodder. In order to collect the costs for the farmer, we were referred to the sorghum LfL calculator[22] by Dr. Maendy Fritz. This allowed HHZ to identify the main costs for the farmer and transfer them to the model. Additional parameters could be identified and collected through further research by the HHZ and BIOPRO. The costs are mostly related to the crop quantity, which results from the field size and the harvest amount per hectare. Products which can be obtained from the energy sorghum are for example biogas or bioethanol. Using a squeezer, the sugar juice can be extracted from the sorghum. The sugar juice is then fermented and processed into ethanol. The resulting bagasse can then be processed into a biofertilizer. This represents a bio-economic cycle, although it is mainly related to the end of the cascade use. It is also possible to produce biogas or bioethanol from the resulting bagasse.

[21] Witzelsperger et al.,Technologie- und Förderzentrum (TFZ) & Technische Universität München (2012)

[22] Bayerische Landesanstalt für Landwirtschaft – LfL (Revised February 2023)

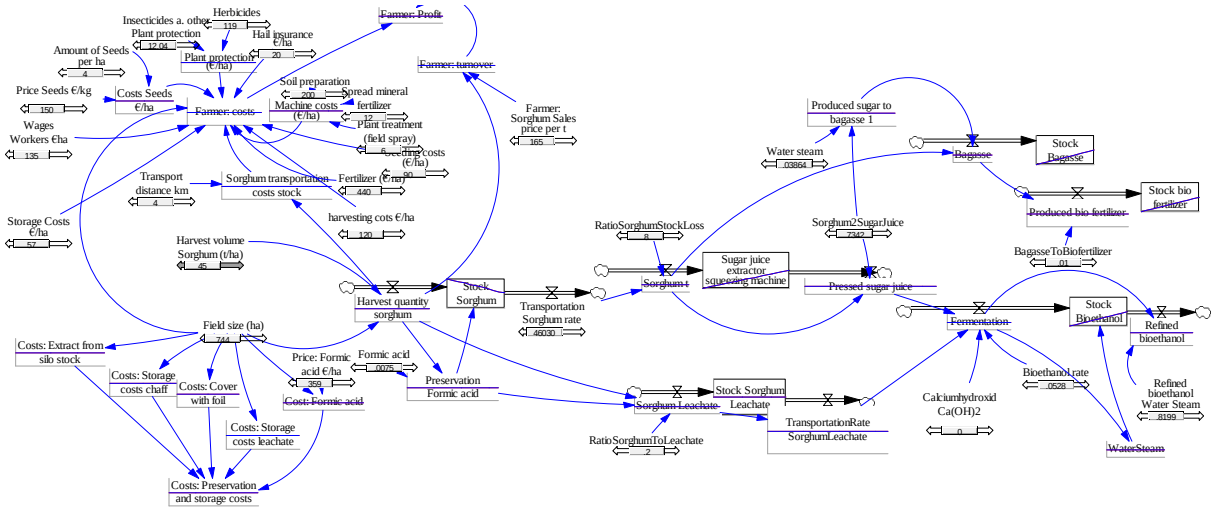


Figure 11: Value Network Energy Sorghum

Figure 12 shows the model for food / fodder. *Sorghum bicolorr* used then has a higher yield in grains. Here, the grains can be used as food or cattle feed. Also, the high value grains can be sold as food and the rest of the grains can be used as cattle feed. We did not distinguish between the identified variables of the costs of cultivation of energy and food sorghum. In the simulation of the models, the variables can be adjusted dynamically by using a slider. A suggestion was made by Dr. Maendy Fritz to use sorghum straw for energy production.

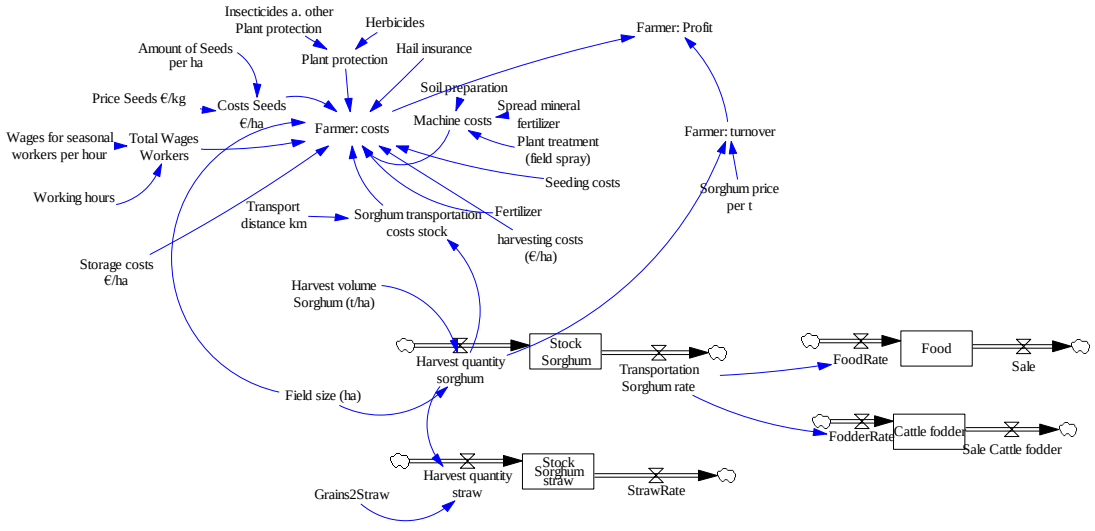


Figure 12: Value Network Food/Fodder Sorghum

Step 3: Act & Adapt

The next step was contacting and discussing further potential applications with interested parties of the Danube region. During the summer 2022, meetings were held with representatives of the Hungarian packaging cluster OMNIPACK, the Pulp and Paper Institute, Ljubljana (ICP) and MOME University in Budapest interested in packaging applications of sorghum. They reported research experiences related

with fungal mycelium-based biodegradable composites, but the TRL eventually showed to be too low. The use of sorghum varieties for the production of biopolymers is still at the stage of applied research, as there is as yet no experience with large-scale fermenters and on an industrial scale.

The high drought tolerance of sorghum is cited as an advantage and its cultivation on marginal land is therefore discussed as a way of defusing the competition between food and bio-fuel. The “tank or dish” discussion that took place in the beginning of the Sorghum case could not be further addressed in the context of this use case; further research is needed. Especially with regard to climate change and longer dry periods. Therefore, further studies on the cultivation of sorghum in Germany are necessary.

In conclusion, sorghum has a wide range of potentials for the production of bioenergy or especially in the context of climate change. We could not identify a partner with a concrete business intention or with more advanced experience in terms of market potential as in the case study miscanthus and corn straw. In addition, the use cases related to packaging were still in a research stage. There have already been studies on the application of sorghum, especially in relation to bioenergy, carried out and published by the TFZ. These results and the models created within the Danube Alliance can be used for further research to achieve a higher technology readiness level and develop concrete business opportunities.

The EU has already recognised the need for further research activities. For example, a 3-year promotional programme co-funded by the European Union started in 2017 and focused on two geographical areas: southern EU (Italy, Spain and France) and eastern EU (Romania, Bulgaria). The aim of this campaign was to improve farmers’ knowledge about sorghum, increase sorghum acreage and expand market shares for EU sorghum seed producers.[23]

4.4 Communication and Dissemination

In the first project phase from 2021 to 2022, various communication measures were carried out within the PA8 Flagship Project Danube Alliance. The main goal was to raise awareness and to initiate partnerships with stakeholders from the Danube region – mainly cluster management organisations and regional development entities – in order to pave the way for collaborative activities conducive to promoting resilient value chains. In the following, the most important communication and dissemination measures are depicted.

Danube Alliance events for information & exchange

The Danube Alliance organised several events and meetings to raise visibility of the Danube Alliance and its methodological approach as well as to create a platform for exchange among stakeholders from the Danube region with regard to the development of resilient value chain networks. In the following, a number of these events are briefly described:

a) Online Kick-off Event on 25 February 2021 with welcoming remarks of Theresa Schopper, State Minister for policy coordination in the Baden-Württemberg State Ministry

b) Info Event "Promoting Value Chain Resilience in the Danube region - The Danube Alliance Approach & Value Chain Generator (VCG.AI)" on 13 April 2022 (in cooperation with Anteja ECG) | Objective: Increasing visibility of the Danube Alliance approach and the Value Chain Generator Tool (VCG), which has been developed, among others, by Anteja ECG

[23] European Commission (Revised February 2023)

c) Danube Alliance meets Strategic Cluster Alliance Hungary on 4 May 2022 | Objective: Initiating partnerships for value chain development projects, primarily focusing on sorghum

d) Interactive Workshop: Danube Alliance – Developing resilient bio-economy networks on 19 July 2022 | Objectives: (1) Sharing knowledge with regard to modelling and simulating value chain networks among regional development agencies and clusters with focus on bio-economy in the whole Danube region, and (2) capturing their potential and needs regarding the promotion of resilient value chain networks

Online Survey (Follow-up of Interactive Workshop on 19 July 2022)

As the online survey was planned to build on the results of the interactive online workshop, questions were developed based on those of the workshop whiteboard. In sum, 7 questions in addition to collecting personal data were used for the survey (see questionnaire in the appendix), which was realized as an online survey with Microsoft Forms.

Once agreed on with all partners of the Danube Alliance consortium, the survey was sent via email to 104 stakeholders, some of which were participating in the workshop. In addition, the survey was advertised via LinkedIn and personal channels. Answering the survey was possible between beginning of August and mid of September. In sum, 17 answers to the questionnaire were collected. Participants came from Bulgaria, Croatia, Hungary, Romania, Serbia, Slovakia and Slovenia, working for clusters, regional developments agencies or other business support organisations (e.g. Technology Parks), civil society organisations as well as associations, public administration on local or transnational level or higher education and research.

The survey showed that the Danube Alliance placed its focus right: Miscanthus and sorghum were assessed as relevant value chains by many participants. In addition, hemp seems to be a promising value network for future activities, especially in Hungary and Serbia, where projects could build on an existing tradition of growing hemp.

For future activities of the Danube Alliance, the survey revealed the following main needs:

a) Knowledge transfer is needed, on one hand as capacity building for farmers and industry, but on the other hand also as policy recommendations. For this, mappings and stakeholder dialogues are needed to facilitate exchange between stakeholders and provide insights for evidence-based policies.

b) Financing in the form of private investment or public funding is needed to catalyse the start of the development process of resilient value networks in most countries. This could be realized by applying for joint transnational projects with partners, e.g. in the INTERREG DRP program, but also by building capacities regarding investment readiness and by providing funding recommendations to help stakeholders navigate the great variety of possible funding sources.

c) Actively involving intermediaries such as cluster organisations, regional development agencies and business associations as they can provide the regional link between industry and policy, academia and civil society and hence facilitate a quadruple helix approach, which is needed to involve all relevant stakeholders for a sustainable development of resilience value networks.

Other events with active participation of the Danube Alliance consortium

In addition to specially organised events by the Danube Alliance, the consortium was actively involved in various politically relevant events with the aim of raising awareness of the project at both political and professional level in the cluster, economic development and scientific communities. The focus was on highlighting the relevance of the topic – creating and nurturing resilient value chains in the Danube region – and presenting and discussing the corresponding methodological approach of the project

consortium as well as initial findings. In the following, the high-profile events are listed where the project consortium actively contributed, e.g. in the form of presentations, by moderating discussion rounds or conducting live votings:

a) Danube S3 Cluster – 4th Policy Dialogue Workshop on 21 October 2021 | Objective: Presenting the Danube Alliance flagship project and its methodological approach

b) THE 10th ANNUAL FORUM of the EU Strategy for the Danube Region (EUSDR) on 27 October 2021 | Objective: Presenting the Danube Alliance flagship project and its methodological approach using the example of the Miscanthus case

c) 3rd EU Macro-Regional Strategies Week on 10 March 2022 with own interactive online session called “How to Promote Resilience and Digitalisation of Bio-based Value Chains – The Danube Alliance Approach”, organised by the Danube Alliance consortium

d) EUSALP - WG 2 Economic Development - Plenary Meeting in Lyon on 28 June 2022 | Objective: Presenting the Danube Alliance methodological approach in the context of increasing relevance of resilient value chain development in times of crises

e) Danube Festival in Ulm on 1 July 2022 | Objective: Presenting of the Danube Alliance approach and previous findings in the context of the changed role of value chain resilience in times of uncertainty

f) THE 11th ANNUAL FORUM of the EU Strategy for the Danube Region (EUSDR) on 20 October 2022 | Participation in Parallel Session “STRENGTHENED COOPERATION AND INTEGRATION OF EU AND UKRAINIAN COMPANIES IN EUROPEAN VALUE CHAINS”

g) Eastern Europe Forum “Rethinking Europe: Eastern Europe as a close partner in times of the Zeitenwende” at Global Connect on 15 November 2022 | Participation in the in the discussion “Supply chains and value chains – How can Eastern, South Eastern Europe and Baden-Württemberg benefit from each other?”

Working paper on the impact of the Ukraine crisis on the Danube region

On the occasion of the Russian war of aggression on Ukraine and the resulting problems with regard to supply chains, especially in energy supply and in the food industry, VDI/VDE-IT as lead partner commissioned Anteja ECG to prepare a study to determine the impacts and potential of the Ukraine crisis on supply chains development for the Danube region. The study focused on supply chains in the bio-economy sector, including agroforestry, agriculture, food and the wood industry.

In coordination with the Danube Alliance, the working paper "Impacts and Potentials of the Ukraine crisis on Supply Chains Development for the Danube region" was created and communicated to the public (including at the Donaufest Ulm on 1 July 2022).

Based on the results obtained in the study, three central recommendations could be formulated.

a) Raising awareness at political and intermediary levels of the importance of supply chain development as a long-term task

b) Strengthening the role of the Danube Alliance as a platform and source of support for the development of resilient supply chains

c) Support of PA8 of the EUSDR for the broad dissemination of the topic "Resilience of Value and Supply Chains" in the Danube region

The study is publicly available at: https://anteja-ecg.com/wp-content/uploads/2022/07/Anteja_Ukraine_workingpaper_-Final.pdf

Danube Alliance website

At the beginning of 2022, a web page for the Danube Alliance was set up on the website of Priority Area 8 (Competitiveness). Under https://competitiveness.danube-region.eu/danube-alliance/, the background, motivation and objectives of the flagship project are described, the methodological approach is explained and a concrete use case is presented. The website also contains current news and links to studies that are relevant or related to the project context.

PR measures (press releases / blog posts / social media posts)

The above-mentioned events were accompanied by a series of PR measures, especially in the form of press releases, blog posts and social media posts. In the aftermath of the Kick-off event on 25 February 2021, the consortium prepared a **press release** for the Baden-Württemberg State Ministry.

Furthermore, Anteja ECG, a close partner of the Danube Alliance from Slovenia, created a **blog post** in cooperation with VDI/VDE-IT as the lead partner of the flagship project. This was published in April 2022 at https://anteja-ecg.com/de/danube-alliance-for-sme-competitiveness/ and also shared via LinkedIn.

Trip to Bulgaria

As already described in chapter 4.2, the Danube Alliance consortium, together with Carmen Hawkins, coordinator of Priority Area 8 for the Danube region, Ingo Dreher of Advanced Ecologics GmbH, and Mayor Markus Hugger (town of Spaichingen), went on a trip to Bulgaria (Vidin and Sofia) from 14 to 16 September 2022. The main goal was to present the Miscanthus case and to have an exchange with relevant actors from local and regional politics on how to implement the value chain network – in terms of organisational structures, financing, infrastructure etc. On the other hand, the awareness of the Danube Alliance was further increased during the trip in Sofia at professional policy level. In this context, expectations and needs on the part of the Bulgarian economic policy were discussed. Conceptual and organisational preparations for the trip had already been made in the first half of 2022.

In the course of all these communication activities, numerous connections were made with stakeholders. A list of the partners can be found in the appendix.

4.5 Key Results and Learnings

Despite the fact the Danube Alliance started very successfully since January 2021, the overall approach and topics covered are very new. Nevertheless, the recent Ukraine war revealed that the topic is more relevant than ever. After two years of operation, the following key learnings were obtained:

1. **The overall Danube Alliance Approach works**
   With a focus on bio-economic value chain use cases, the Danube Alliance consortium, together with experts from Baden-Württemberg and stakeholders from the Danube region, have established a multi-method-approach that has proved to work well in two use cases regarding the development of resilient value chains. A great demand in further activities could be identified. Yet, project experience to date has shown that the ideal scenario, a resilient value chain in the

sense of a circular bio-economy ('New Resilience'), is difficult to accomplish in many cases and often not feasible.

2. **The active involvement of regional intermediaries is essential**
   Cluster organisations, regional development agencies and business associations are key for value chain projects as they can provide the regional link between industry and policy, academia and civil society and hence facilitate a quadruple helix approach, which is needed to involve all relevant stakeholders with their specific needs.

3. **Comprehensive knowledge transfer is needed**
   It became clear that the topic of dedicated value chain development is comparably new for most stakeholders of the Danube region. Capacity building for farmers and industry as well as policy recommendations are necessary to scale up resilient value chain development. For this, further mappings and stakeholder dialogues are necessary to facilitate exchange between stakeholders and provide insights for evidence-based policies.

4. **Access to financing options needs to be facilitated**
   To catalyse the start of the development process of resilient value networks in most countries, suitable funding / financing options are essential. This, for example, could be realized by applying for joint transnational projects with partners or providing funding recommendations to help stakeholders navigate the great variety of possible funding sources.

5. **Awareness must be further raised**

   The relevance of promoting resilience and competitiveness through new approaches for value chain development needs to be further disseminated. The work of the Danube Alliance has shown that cluster and regional development organisations, SMEs as well as policy makers have a need for more information about innovative approaches, tools and good practice examples for resilient value chains. For this, framework conditions have to be improved through adequate political programmes and hands-on support for intermediaries. Since the Danube Alliance PA8 flagship project officially ended in December 2022, further public outreach activities are necessary to follow up on the findings and potentials so far, and to address the need for awareness raising on the topic of resilient value chains.

5 Future Perspectives and Challenges

The main objective is to develop the Danube Alliance further towards the **Danube Alliance Network**, to assure continuation, and to integrate different Digital services (e.g. Value Chain Modeller, Value Chain Generator, Value Chain Simulator, Value Chain Digital Twin) for targeted value chain development. In particular, the digitisation of value chains and their mapping into digital twins via IoT offer completely new possibilities for the development and control of integrated value chains, according to HHZ research and the status of digital tools such as the VCG. An architecture of digital services suitable for the visionary development of circular and resilient value chains has been developed by HHZ research in the past and within the framework of the Digital Service Lab of the Danube Alliance project (see Figure 13).

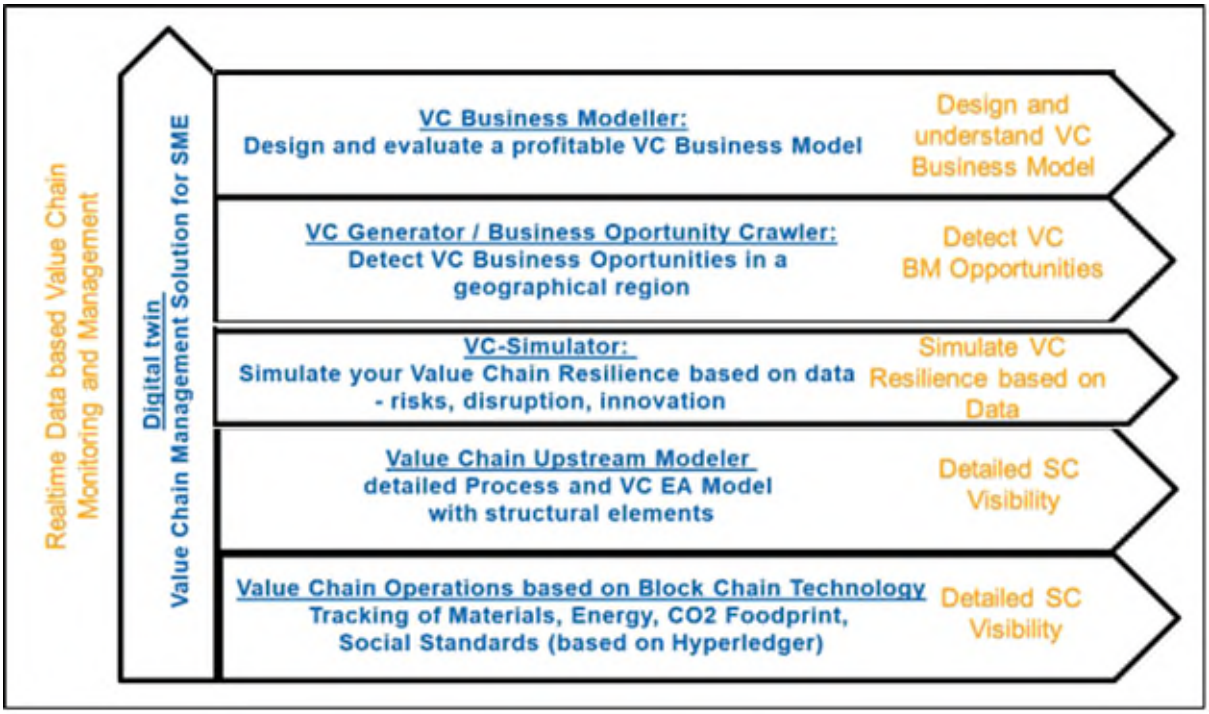


Figure 13: Digital VC Service Architecture (Own illustration by HHZ)

The future concept focuses on a well-integrated and recognised approach for resilient value chain development in the Danube region. The Danube Alliance Network shall help to integrate more Danube region partners into the network and to jointly develop and strengthening more identified value chain with focus on circular bio-economy. This effort will help to integrate more SMEs in existing or new value chains. Thus, the Danube Alliance Network shall contribute to SME internationalisation along value chains and mitigate against the current challenges that many SMEs from the Danube region face, and gain access to proper markets for business generation.

In sum, the continuation concept, as Danube Alliance Network, pursues the following goals:

- Extend the successful Danube Alliance Approach by providing knowledge and tools, developed in the first phase for additional partners
- Initiate a transregional cooperation platform by involving more partners and expand the network for joint skills development and application of tools for circular bio-economy value chain incubation based on a common approach.

- Generate knowledge transfer and develop skills of Danube Alliance Network members to improve capacities for cross-regional value chain incubation and apply digital tools for Resilient Value Chain Development (e.g. VCG)
- Implement pilot actions to test and implement approaches, tools and action plans and incubate pilot value chains

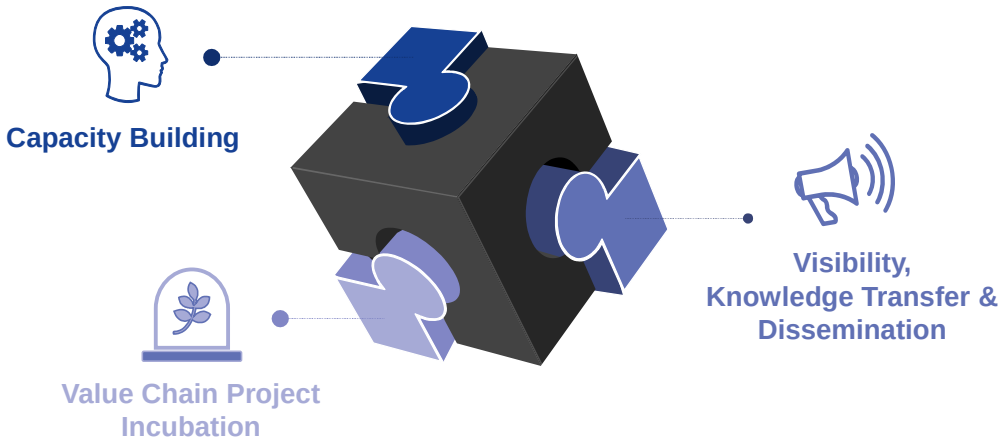


Figure 14: The Danube Alliance Network as a cooperation platform for joint development of resilient value chains

In order to realise the continuation as Danube Alliance Network, a proposal for the Danube Transnational Programme 2021 -2027 was prepared and submitted.

Bibliography

Biggs, R., Schlüter, M. & Schoon, M.L. (2015): Principles for Building Resilience: Sustaining Ecosystem Services in Social-Ecological Systems; Cambridge University Press: Cambridge, UK.

Brinkmann, H., Harendt, C., Heinemann, F. & Nover, J. (2017): Ökonomische Resilienz—Schlüsselbegriff für ein neues wirtschaftspolitisches Leitbild? Wirtschaftsdienst, 2017, 97. Jg., Nr. 9, 644-650.

Brosse, N., Dufour, A., Meng, X., Sun, Q. & Ragauskas, A. (2012): Miscanthus: a fast-growing crop for biofuels and chemicals production. Biofuels, Bioproducts and Biorefining 6(5), 580–598.

Dordoni, R., De Cesare, S., Dioni, M., Mastrofilippo, T., Quadrelli, D., Rizzi, R., Corrado, S., Marco, D et al. (2015): Design and Development of an Eco-Innovative Sorghum Snack.

Emmerling, C., Pude, R. (2017)
Introducing Miscanthus to the greening measures of the EU Common Agricultural Policy.
GCB Bioenergy, 9(2), 274-279.

Folachodé, U.G.A. (2018): Natural food colouring with dye sorghum leaf sheaths (Thesis, Wageningen University).

Flach, L. & Steininger, M. (2020): Globalisierung nach Covid-19: Die Folgen der Pandemie für die deutsche Wirtschaft, ifo Institut – Leibniz-Institut für Wirtschaftsforschung an der Universität München, München, Jg.73, Nr. 07, 17-23.

Guangyan, Q., Ningbo, L., Xiuzhi S. S., Dongha, W. (2019): Overview of Sorghum Industrial Utilization

Kahle, P., Boelcke, B., & Zacharias, S. (1999): Auswirkungen des Anbaus von Miscanthus x giganteus auf chemische und physikalische Bodeneigenschaften. Journal of Plant Nutrition and Soil Science, 162(1), 27-32.

Lewandowski, I., Clifton-Brown, J. C., Scurlock, J. M. O., & Huisman, W. (2000): Miscanthus: European experience with a novel energy crop. Biomass and Bioenergy, 19(4), 209-227.

Melnyk, S. A., Closs, D. J., Griffis, S. E., Zobel, C. W., & Macdonald, J. R. (2014): Understanding supply chain resilience. Supply Chain Management Review 18(1), 34-41.

Miroudot, S. (2020): Resilience versus robustness in global value chains: Some policy implications. COVID-19 and trade policy: Why turning inward won't work, 117-130.

Olafsdottir, A.H., Gudbrandsdottir, I., Sverdrup, H.U., Bogason, S.G., Olafsdottir, G., & Stefansson G.I. (2018): System Dynamics Modelling and System Analysis Applied in Complex Research Projects - the Case of VALUMICS. International Journal on Food System Dynamics 9(5), 409-418.

Vroegindewey, R. & Hodbod, J. (2018): Resilience of Agricultural Value Chains in Developing Country Contexts: A Framework and Assessment Approach. Sustainability 2018, 10(4), 916.

Witzelsperger et al.,Technologie- und Förderzentrum (TFZ) & Technische Universität München (2012): Ethanol aus Zuckerhirse - Gesamtkonzept zur nachhaltigen Nutzung von Zuckerhirse als Rohstoff für die Ethanolherstellung.

Deribe, Y. & Kassa, E. (2019): Value creation and sorghum-based products: what synergetic actions are needed?

Internet Sources

Ag Marketing Resource Center (Revised April 2022): Sorghum
Source: https://www.agmrc.org/commodities-products/grains-oilseeds/sorghum (last visited on 25/11/2022)

Anteja (April, 2022): Danube Alliance for SME Competitiveness
Source**:** Danube Alliance for SME Competitiveness | Anteja (anteja-ecg.com)

Bayerische Landesanstalt für Landwirtschaft – LfL (Revised February 2023):
LfL-Deckungsbeiträge und Kalkulationsdaten - Hirse (Sorghum)
Source: https://www.stmelf.bayern.de/idb/hirse.html (last visited on 15/02/2023)

Bioplastics NEWS – Axel Barrett (June 4, 2018): TOP 5 Biobased Materials Selected by the UN
Source: https://bioplasticsnews.com/2018/06/04/top-5-biobased-materials-selected-by-the-un/ (last visited on 28/11/2022)

Couleurs de Plantes: Sorghum
Source: https://www.couleurs-de-plantes.com/en/produit/sorghum/ (last visited on 28/11/2022)

European Commission (Revised February 2023): Promotion of sorghum and sorghum seeds on the internal market.
Source: https://ec.europa.eu/chafea/agri/en/campaigns/promotion-sorghum-and-sorghum-seeds-internal-market (last visited on 28/02/2023)

Promotion of sorghum and sorghum seeds on the internal market (2016)
Source: https://ec.europa.eu/chafea/agri/en/campaigns/promotion-sorghum-and-sorghum-seeds-internal-market (last visited on 24/02/2023)

Appendix

List of Partners

Partner Institution	Country	Contact Person
Business Upper Austria	Austria	Eva Breuer
Universität für Bodenkultur Wien	Austria	Regine Schönlechner
ecoplus	Austria	Simone Hagenauer
GREENLINE Western Balkans Cluster	Bosnia & Herzegovina	Darijo Lazic
Bulgarian Biomass Association	Bulgaria	Anna aladjadjiyan
Bulgarian-Romanian Chamber of Commerce and Industry	Bulgaria	Desislava Pencheva
Bulgarian Furniture Cluster BFC	Bulgaria	Genoveva Christova-Murray
Bulgarian Wood & Furniture Cluster	Bulgaria	Genoveva Christova
WWF Bulgaria	Bulgaria	Giorgi Stefanov
Bulgarian SME Promotion Agency - BSMEPA	Bulgaria	Iva Tsvetkova
Biobased Industries Bulgaria SL - BIB	Bulgaria	Ivan Pankev / Jürgen Eisele
Energy Agency Plovdiv	Bulgaria	Liyana Adjarova
Association of Danube River Municipalities	Bulgaria	Maria Tzankova
RAPIV	Bulgaria	Mariya Zlateva
Energy Utilisation Biomass Association - EUBA	Bulgaria	Nikolay Pavlov
Energy Utilisation Biomass Association - EUBA	Bulgaria	Nikolay Vangelov
Green Synergy Cluster	Bulgaria	Stoyan Dimitrov
Cleantech Bulgaria	Bulgaria	
National association of the municipalities in republic of Bulgaria	Bulgaria	
National Biofuels Association in Bulgaria	Bulgaria	
Agency for Regional and Economic Development	Bulgaria	Nesrin Doneva
Croatian Wood Cluster	Croatia	Ana Dijan
Ministry of Economy and Sustainable Development- EUSDR PA08	Croatia	Helia Kovačević Grčić
Wood Cluster SLAVONIAN OAK	Croatia	Ivan Ambros
Agencija za razvoj i investicije grada Vinkovaca VIA d.o.o.	Croatia	Magdalena Vidović
Vukovar-Srijem County Development Agency	Croatia	Vedrana Đermadi
Vukovar-Srijem County Development Agency	Croatia	Vedrana Dzoic
NATIONAL WOOD PROCESSING CLUSTER	Czech Republic	Ludmila Maková

National Cluster Association, Czech Republic	Czech Republic	Pavla Bruskova
CZ	Czech Republic	Sarka Stejnarova
Regional Development Agency of South Bohemia - RERA	Czech Republic	Matous Radimec
Czech Pellets Cluster	Czech Republic	Vladimir Stupavsky
Cluster Food Industry Brandenburg	Germany	Detmar Leitow
Bio-economy in the metropolitan area BioBall	Germany	Dorit Lehr
Agronym - Network for Sustainable Bio-economy	Germany	Herlitzius Thomas
food.net:z Lebensmittelnetzwerk Rhein-Neckar e.V.	Germany	Isabel Bergerhausen
foodRegio	Germany	Jacobsen Björn P.
Bio-economy Cluster Central Germany	Germany	Prof. Dr. Zscheile Matthias
Food-Processing Initiative e.V. FPI	Germany	Reichl Norbert
Bavarian Food Cluster	Germany	Simon Reitmeier
Dreher Präzisionsdrehteile GmbH	Germany	Ingo Dreher
SEZ	Germany	Manuel Selinsek
Nick-Labor am KIT	Germany	Prof. Dr. Peter Nick
Wein- und Obstbau-Institut Weinsberg	Germany	
BIOEAST Initiative	Hungary	Barna Kovacs
IFKA	Hungary	Bence Janek
Westpannon Nonprofit Ltd.	Hungary	Gál Kormendy
iFood (Innovation, Food) Cluster	Hungary	Margit Weiss
PBN – advanced management	Hungary	Martin Dan
PBN – advanced management	Hungary	Mátyás Lazáry
MOME Budapest	Hungary	Mihály Minkó
Agro ICT Cluster	Hungary	Veronika Erős
Pannon Business Network	Hungary	Zsófia Kocsis
Omnipack First Hungarian Packaging Techology Cluster	Hungary	Zsolt Keresztúri
Hungarian Medical Cluster	Hungary	
Innoskart Digital	Hungary	
Mirbest Gastro-Innovation Cluster	Hungary	
Energy and Biomass Cluster	Moldova	Vladimir Bragaru
SMRDA	Romania	Andreea Tudose
ADRSM	Romania	Andrei Georgescu
South Muntenia RDA	Romania	Ani Mihai
Green Energy Biomass Cluster	Romania	Boglarka Vajda

National Committee of WEC	Romania	Calin Vilt
Transylvanian Furniture Cluster	Romania	Ciprian Morcan
INMA Romania	Romania	Cornelia Muraru-Ionel
USH ProBusiness/Inter-Bio	Romania	Costin Lianu
CLUSTERO	Romania	Daniel Cosnita
SMRDA	Romania	Dinu Madalina
INSTITUT FOR RESEARCH IN CIRCULAR ECONOMY AND ENVIRONMENT ERNEST LUPAN	Romania	Elena-Simina Lakatos
AgroTransilvania Cluster	Romania	Felix Arion
North-West Regional Development Agency	Romania	Ioana Dragos
North-West Regional Development Agency	Romania	Ioana Pavel
Danube Engineering Hub	Romania	Irina Radulescu
PRO WOOD Regional Wood Cluster	Romania	Kádár Rezső
Wood and Furniture Cluster Consortium	Romania	Kádár Rezső
Agro Food Covasna	Romania	Lajos Vajda
USAMV CLUJ-NAPOCA	Romania	Lucian Cuibus
North-East Regional Development Agency	Romania	Mitrea Claudiu
Software Imagination & Vision	Romania	Monica Florea
Green Energy Innovative Biomass Cluster	Romania	Ms. Boglarka Vajda
INTER-BIO Association	Romania	Prof. Costin Lianu
North-East Regional Development Agency	Romania	Raluca Ursaciuc
Ministry of Economy, Entrepreneurship and Tourism of Romania	Romania	Ruxandra Popovici
Bio Danubius Regional Cluster	Romania	Stefan Lianu
Ghelinta Commune	Romania	Tihamer Sebestyen
Center for organic production Selenča	Serbia	Biljana Viduka
Agroindsutrija	Serbia	Branko Malgurski
Cluster AGRO START UP	Serbia	Dejan Joksimović
BIO-ECONOMY Cluster	Serbia	Dr. Goran Vasic
Krajina	Serbia	Iskra Arapović
Association Cluster Agroindustry	Serbia	Ksenija Albunovic
Alma Mons, Ltd.	Serbia	Milica Vračarić
Chamber of Commerce and Industry of Serbia	Serbia	Svetlana Jovanovic
Standing Conference of Towns and Municipalities – National Association of Local Authorities in Serbia	Serbia	
Union of Slovak Clusters	Slovakia	Daniel Ács
Food Chamber of Slovakia	Slovakia	Jana Venhartová

Bio-economy Cluster	Slovakia	Katarina Blicklingova
Danube Transfer Center Slovakia	Slovakia	
TECOS	Slovenia	Ales Hancic
Pulp and Paper Institute Ljubljana	Slovenia	Andrej Sinkovec
Slovenian Wood Industry Cluster	Slovenia	Bernad Likar
Regional Development Agency for Podravje - Maribor	Slovenia	Boris Pukšič
Pomurje Technology park	Slovenia	Borut Zrim
Pulp and Paper Institute Ljubljana	Slovenia	Igor Karlovits
Wood Industry Cluster Slovenia	Slovenia	Igor Milavec
Anteja ECG	Slovenia	Jon Goriup
Styrian Technology Park	Slovenia	Tanja Berglez Krivec
Slovenia agrifood cluster - SRIP Food	Slovenia	Tatjana Zagorc
Pulp and Paper Institute Ljubljana	Slovenia	Tea Kapun

Online Questionnaire

Information about resilient bio-economy value chains in your region

1. The Danube Alliance project developed a methodology to model bio-economy value chains and improve their resilience with transnational cooperation and the use of digital tools. Which are the most relevant value chains in your region which would benefit from such an approach?

   ❑ Miscanthus Grass
   ❑ Sorghum
   ❑ Hemp

2. Please comment on your answer.

3. The Danube Alliance project defines “New Resilience” as a combination of the stability of a value chain or value network in times of crises, the adaptability in light of changing framework conditions and the resource efficiency and circularity of value creation. What are the most pressing problems and challenges for the resilience of bio-economy value chains in your region?

4. Who are the most important players in your region who can drive the process of improving the resilience of bio-economy value chains? (from policy, industry, research, civil society…)

5. Which political frameworks in your country increase or limit the potential of resilient bio-economy value chains, or further or hinder the process of improving value chains?

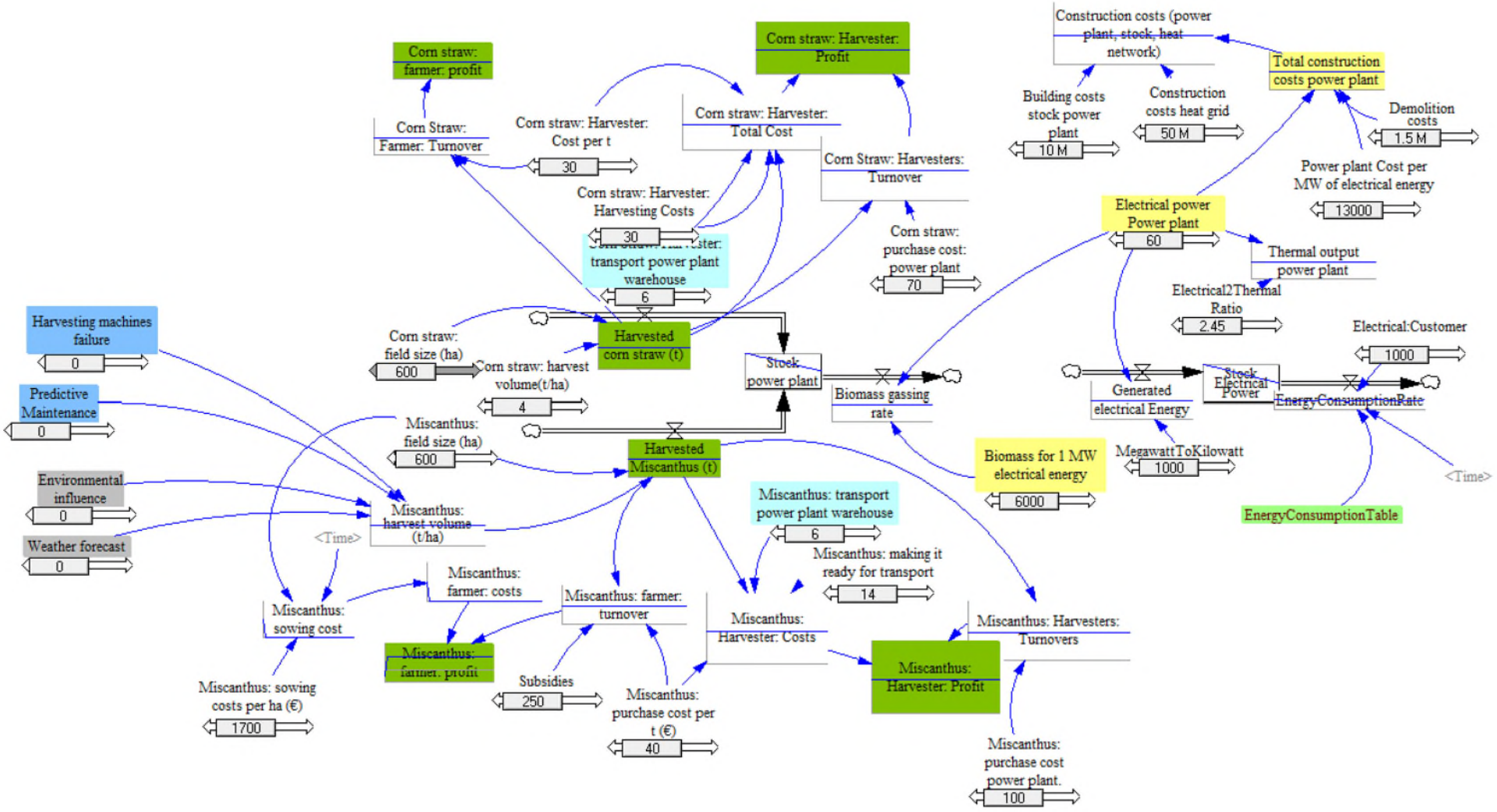
6. What is or what could be in the future the role of intermediaries (e.g. clusters, regional development agencies) in the process of improving the resilience of bio-economy value chains?

7. How might the Danube Alliance support resilient bio-economy value networks in your region?

8. Please use this field for any comments or remarks.

Danube Alliance
Resilient Value Networks

Miscanthus

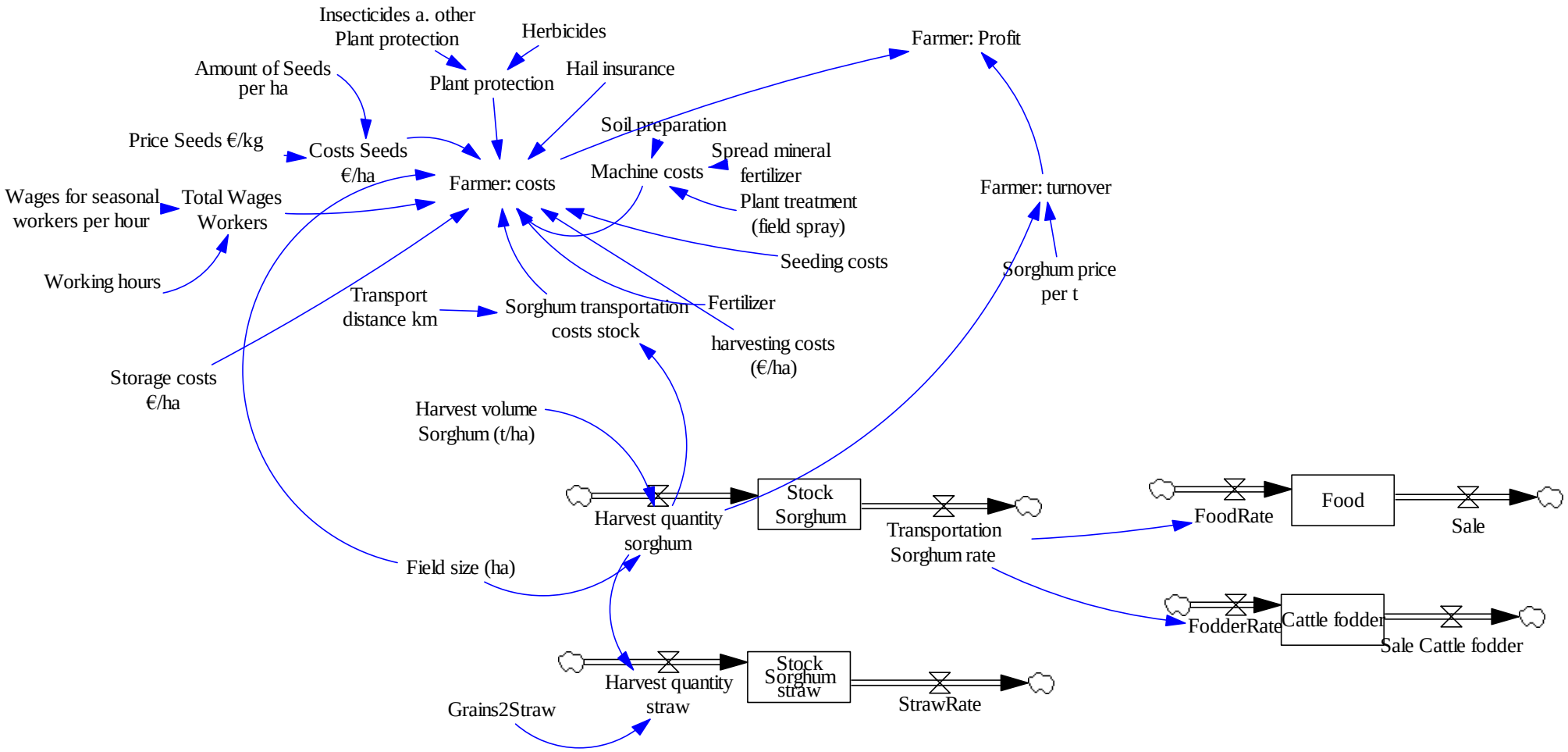


Baden-Württemberg
STAATSMINISTERIUM

DANUBE REGION strategy
Competitiveness

Baden-Württemberg
MINISTERIUM FÜR WIRTSCHAFT, ARBEIT UND TOURISMUS

Food Sorghum



Energy Sorghum