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MAINSTREAMING SMALL-SCALE BIO-BASED SOLUTIONS ACROSS RURAL EUROPE

D1.3

Mapping of regional bio-based value chains

MTU

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ABBREVIATIONS

AAMCHAA	Asociación de Amigos del Maíz de Consumo Humano y semilla Alfalfa Aragón
AAU	Agricultural Area Used
ACCRES	project
ACRRES	Application Centre for Renewable Resources
AEFA	Asociación Española de Fabricantes de Alfalfa Deshidratada
APS	Agroindustrial Pascual Sanz
AUP	Agraren Universitet - Plovdiv
BBI JU	Bio-based Industries Joint Undertaking
BE	Bioeconomy
BG	Bulgaria
BLTCs	Biomass Logistic and Trade Centres
BSG	Brewery Spent Grain
CAP	Common Agricultural Policy
CAPEX	Capital Expenditure
CBD	Cannabidiol
CBEO	Centre for Bioeconomy and Renewable Energy
CEE	Central and Eastern European
CGI	Central Grid Injection
CHP	Combined Heat and Power
CO	Coordinator
CO_2	Carbon Dioxide
CR	Contractor
CTFC	Centre for Forestry Science and Technology of Catalonia

DDGS	Dried Distilled Grains
DDGS	Dried Distillers Grains and Solubles
DK	Denmark
DKK	Danish Krone
DLG	Dansk Landbrugs Grovvareselskab
DRAXIS	Draxis Environmental SA
DS	Dry Substance
DTU	Technical University of Denmark
ES	Spain
EU	European Union
EU JRC	European Joint Research Centre
FA	Furfuryl Alcohol
FBCD	Food & Bio Cluster Denmark
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GIS	Geographic Information Systems
GROT	Logging residues
GUDP	Green Development and Demonstration Program
GWh	Gigawatt hours
ha	hectares
HE	Horizon Europe
HPRA	Health Products Regulatory Authority
HTL	Hydrothermal Liquefaction
IE	Ireland

IKEM	Innovation and Chemical Industries in Sweden
INNV	EURIZON SL
IRTA	Institute of Agrifood Research and Technology
IUNG	Institute of Soil Science and Plant Cultivation State Research Institute
JRC	Joint Research Centre
KPI	Key Performance Indicator
Kton	Kiloton
LODR	Lublin Agricultural Advisory Centre
MIP	Multi-actor Innovation Platforms
MTU	Munster Technological University
MUDP	Environmental Technology Development and Demonstration Program
MVCRI	Marista Vegetable Crops Research Institute
MW	Megawatt
NGO	Non-Governmental Organization
NL	Netherlands
PL	Poland
PPBS	Pulp and Paper Bio-sludge
PROC	Rise Processum AB
Q-PLAN	Q-Plan International Advisors PC
R&D	Research and Development
RISE	Research Institutes of Sweden
SDE	Sustainable energy transition subsidy scheme
SE	Sweden
SEK	Swedish krona

SME	Small and Medium-sized Enterprise's
tDM	tonnes Dry Matter
TEKO	Swedish Textile and Clothing Industries Association
THFA	Tetrahydrofurfuryl Alcohol
TP	Torrefaction and Pyrolysis
UCC	University College Cork
UCD	University College Dublin
WHITE	White Research SPRL
WP	Work Package
WR	Wageningen Research
wt	Wet tonnes

Executive Summary

This document constitutes the report on “Mapping of Regional Bio-based Value Chains” elaborated as a deliverable (D1.3) in the framework of the MainstreamBIO project. MainstreamBIO sets out to contribute towards supporting deployment of small-scale bio-based solutions into the mainstream across rural regions of Europe. The project establishes Multi-actor Innovation Platforms (MIPs) across diverse NUTS2 regions in 7 European countries, engaging and enhancing cooperation among key players (from farmers to local industry, tech providers, academia, public authorities and civil society). To support these MIPs, the MainstreamBIO project will co-develop innovation support services and digital tools to build awareness, understanding and capacity to uptake small-scale bio-based solutions in line with market demand and regional specificities. The partners will then deliver these tailored innovation support services in each of the MIP regions to accelerate the deployment of scientific and practical knowledge, introducing and developing theses bio-based solutions and their value chains in collaboration with regional multi-actor partnerships.

In this context, D1.3 “Mapping of Regional Bio-based Value Chains” is positioned within Work Package 1 of the project which focuses on the analysis of the current status of the 7 regions and set-up of regional multi-actor innovation platforms. Within this, Task 1.3 to which D1.3 relates, is focused on mapping of the available biomass feedstocks, waste and residue streams, actors, processes, resource flows, and bioeconomy value chains in the 7 MIP regions.

To achieve this a mixed approached is used which combines literature review within the focal regions conducted by MTU (IE) WR (NL), IUNG (PL), FBCD (DK), PROC (SE), AUP (BG) and INNV (ES), complemented by interviews with key experts, to collate important information regarding the selected value chains. To support this activity, MTU developed a structured methodology for data collection, in order to ensure a common approach was used between the regions, supported by a data collection template and structured interview template which was used by the regional partners.

To meet a KPI of 20 value chains to be covered, a target of 3 value chains per region was set. In total, 27 value chains were described across the 7 MIP regions, and these are described per country in Sections 4-10 of this report. Per country the breakdown of value chains included was Bulgaria (3), Denmark (3), Ireland (6), Netherlands (3), Poland (4), Spain (5) and Sweden (3). For each country, a background description is provided with relevant bioeconomy information (e.g., primary production, bioeconomy policy, key bioeconomy statistics and initiatives) along with an introduction to the national MIP regions, consisting of one or more NUTS2 region. Information collected for each feedstock has been developed into a dedicated subsection, with biomass arising and stakeholder maps generated, along with Sankey diagrams to display the flow of feedstock within the value chain

and region. Information regarding key innovation activities related to the value chain feedstock are described also. From the selected feedstocks from across the regions, a total of 172 million tonnes DM of biomass was included within the mapping exercise. While the feedstocks included are just a snapshot of total feedstocks within these regions, from the analysis of biomass flow, it appears that much of the feedstock is already serving some important function, which should be considered when planning for new value chains.

The mapping exercise on one hand helps stakeholders to understand the status quo of value chains, feedstocks and residues, which may be relevant for the MIP regions. This can help to identify opportunity areas for regional deployment of bio-based technologies, based on a better understanding of regional biomass arisings, and the current flows and price of that biomass (key biomass accessibility constraints identified by Attard et al. (2020). On the other hand, it also helps us to understand the common thematic areas of interest from across the MIP regions. The report has classified the selected related feedstocks using the biorefinery classification system developed by Lange et al. (2016) to broadly assess the types of common themes that are represented across the MIPs, with feedstocks associated green biorefinery and yellow biorefinery identified across multiple regions. This can provide an opportunity for knowledge and technology transfer, and other forms of collaboration between the relevant regions.

1. Introduction

The current document is D1.3 of MainstreamBIO entitled “Mapping of regional bio-based value chains”, which has received funding from European Union’s Framework Programme for Research and Innovation Horizon Europe under Grant Agreement No 101059420.

MainstreamBIO aims at contributing towards bringing small-scale bio-based solutions into the mainstream across rural Europe. To achieve this, the project aims to greatly enhance cooperation between key bioeconomy stakeholders, resulting in sustainable business model pathways for bio-based innovations in rural areas. Along these lines, the project follows an integrated methodology to establish regional multi-actor structures for demand-driven innovation, and deliver a combination of communication materials, training programmes, events, decision support systems and other practical digital tools within the MainstreamBIO Toolkit. More than 3000 farmers, producers, consumers and other agri-food bio-based stakeholders will be involved in testing, validating and ultimately benefitting from the business and technical support services of the MainstreamBIO Toolkit.

To deliver this ambition, the consortium of MainstreamBIO brings together a complementary and interdisciplinary group of 10 partners across 9 different countries within the EU and beyond, as presented in Table 1 below.

Table 1: MainstreamBIO Partners.

Partner Role*	Partner No	Partner Name	Partner Short Name	Country
CO	1	Q-PLAN INTERNATIONAL ADVISORS PC	Q-PLAN	Greece
CR	2	MUNSTER TECHNOLOGICAL UNIVERSITY	MTU	Ireland
CR	3	STICHTING WAGENINGEN RESEARCH	WR	Netherlands
CR	4	INSTYTUT UPRAWY NAWOZENIA I GLEBOZNAWSTWA, PANSTWOWY INSTYTUT BADAWCZY	IUNG	Poland
CR	5	RISE PROCESSUM AB	PROC	Sweden
CR	6	AGRAREN UNIVERSITET - PLOVDIV	AUP	Bulgaria
CR	7	FBCD AS	FBCD	Denmark
CR	8	EURIZON SL	INNV	Spain
CR	9	DRAXIS ENVIRONMENTAL SA	DRAXIS	Greece

CR	10	WHITE RESEARCH SPRL	WHITE	Belgium

* CO = Coordinator, CR = Contractor

In order to provide an overview of the current bioeconomy status of regions in different EU countries, D1.3. focuses on specific participating regions as outlined by the regional MainstreamBIO partners. In line with the Grant Agreement, and as outlined in D1.1. (D1.1. MainstreamBIO Multi-actor Innovation Platforms) MIPs have been established within the following regions and countries:

Bulgaria: South Central (NUTS2: BG42)

Denmark: Zealand NUTS2: (DK02) Mid Jutland (NUTS2: DK04), Northern Jutland (NUTS2: DK05)

The Netherlands: Friesland (NUTS2: NL12), Flevoland (NUTS2: NL23)

Ireland: Southern Ireland (NUTS2: IE05)

Poland: Lubelskie (NUTS2: PL81)

Spain: Catalonia (NUTS2: ES51) Navarre (NUTS2: ES22), Aragon (NUTS2: ES24)

Sweden: Middle Norrland (NUTS2: SE32), Upper Norland (NUTS2: SE33)

This current report aims to investigate regional value chains along with available biomass, waste and residue streams within these focal regions. This involves, the mapping of available biomass feedstocks, waste and residue streams, actors, processes, resource flows, and bioeconomy value chains in our focal regions. This includes an initial mapping of the existing value chains via desk research within all focal regions, by MTU (IE) WR (NL), IUNG (PL), FBCD (DK), PROC (SE), AUP (BG) and INNV (ES). In addition, further key information regarding the systems' characteristics shall be obtained by directly engaging local value chain actors via interviews (5 interviews are expected per region for a total of 35). The current deliverable sets out the approach for completing this work, along with the findings and analysis from each of the regions included.

The work provides key insights into current value chains and related information within these regions, helping MainstreamBIO MIP members to understand the biomass available in key sectors, existing flows and main actors, in an effort to provide further clarity on the status of these regions value chains, and opportunities for new value chain development and collaboration. In this respect, the information gathered within this report will be useful to further activities undertaken during **MainstreamBIO WP2 and WP3**, focused on the design and delivery of the MainstreamBIO toolbox, and innovation support services in the focal regions.

Key objectives of T1.3 include:

- Provide an overview of the local bio-based value chains in status quo.
- To understand the current biomass flows for relevant sectors in the participant regions.
- To understand the main bioeconomy actors participating on these value chains.
- To understand the value chain innovations (e.g., different research or technology approaches) currently active in the regions.
- To inform above with input from literature and interviews with key actors from the regions.

With the above in mind, this Deliverable 1.3 report **is structured in 14 distinct chapters**, as follows:

Chapter 1 provides introductory information about the project and Deliverable 1.3, its objectives and structure.

Chapter 2 presents a short literature review and context for the existing study taking into account the EU and regional bioeconomy context and existing and previous initiatives.

Chapter 3 describes the methodology that is applied to generate the Deliverable 1.3 results.

Chapter 4-10 provides an overview of the findings within each focal region with each chapter focusing on an individual region.

Chapter 11 provides a cross analysis of the findings from the different regional focus areas.

Chapter 12 provides concluding remarks.

Chapter 13 provides the list of references used within the report.

Chapter 14 contains the report annexes including (i) the interview template used (ii) biomass arising and flow tables per region.

2. Background Summary

The Updated EU Bioeconomy 2018 strategy recognises the important role that the bioeconomy can play in supporting regions across Europe to meet their sustainability objectives in a competitive manner, by creating new industries and jobs in urban, rural and coastal regions. Since European regions are diverse in their industries, and the primary sectors which underpin their agri-food, forestry and marine sectors, it is important to ensure that a regional and territorial approach is adopted to recognise this divergence when developing the bioeconomy across the EU. Since the 2018 strategy was launched, there has been a surge in the number of regions who are adopting their own strategies on a NUTS1, NUTS2 or NUTS3 level. A recent study from the EU Joint Research Centre found that 194 regions within EU-27 have a strategic framework for bioeconomy in place or are in the process of doing so. Overall, there are 359 bioeconomy-relevant strategies at a regional level in the EU. Of those, 334 frameworks are published in the form of documents such as strategies, action plans, roadmaps, and the rest are under development (Haarich and Kirhmayr-Novak, 2022).

Despite these developments, the majority of European regions are at the early stages of identifying and developing new bio-based value chains. A first step in this development, is creating an understanding of the current biomass arisings and flows within these regions, along with key actors and stakeholders, and activities taking place at research or commercial level which could be deployed to advance these new value chains. The importance of this task is also complicated by the fact that there are ecological boundaries within which the bioeconomy must operate. This has been highlighted within the Updated EU Bioeconomy Strategy 2018 and was further highlighted in the recent EU High-level Bioeconomy Conference 2022 (European Commission, 2018; Simon, 2022). Various trade-offs may occur when planning to divert biomass into new value chains or applications (European Commission, 2018; Heimann, 2019). An example of this complexity can be found in the potential of new bio-based value chains to impact on eco-system services and biodiversity, with a recent study suggesting that it will result in an increase in trade-offs (Mazziotta et al., 2022). Another example is the diversion of biomass feedstocks, such as straw from low economic value applications, such as in bedding or nutrient quality, into high value applications, such as bio-based chemicals. But inevitably this diversion has knock-on impacts, as these materials may need to be replaced with an alternative material in its current application. It is important therefore to understand not only what biomass, or by-products are produced, but also the current flows and applications of these sidestreams, as this will allow regions to make more sustainable and informed choices.

Taking into account these various trade-offs, we also need to consider what kinds of local value chains could be developed utilising biomass which can be sourced locally, thereby fulfilling the objective of developing regional bioeconomies. The Updated EU Bioeconomy Strategy notes the potential for deploying small-scale biorefineries to help primary producers such as farmers, foresters and fishermen to diversify their revenue sources and better manage market risks, all while achieving the goals of the Circular Economy (European Commission, 2018). These small-scale bio-based approaches can have benefits for regions, since they have a small capacity, and can be applied locally close to the source of biomass, requiring shorter transportation distances for feedstocks and the products they produce potentially can serve local markets (Bruins and Sanders, 2012). In addition, these small-scale approaches can be easier to implement locally since they generally have lower capital expenditure (CAPEX) requirements, something which is important since high CAPEX is recognised as a key barrier to bio-based economy implementation (BBP, 2017; Bruins and Sanders, 2012). Also, these approaches, which in addition to small-scale biorefineries may include local nutrient recycling opportunities, have the opportunity to create new jobs and revenues for the regions, and stakeholders including primary producers. A number of previous projects have been involved in assessing different types of feedstock-specific bio-based solutions, including Power4BIO, BE-Rural, AgriForValor, AgroFossilFree and Enabling. Meanwhile, a number of small-scale bio-based demonstration projects are bringing forward interesting results which have promise for regions across Europe.

In order to further develop these sustainable opportunities, it is also vital to identify the different regional stakeholders participating in different activities within the region. In order to achieve an effective switch from a fossil-based, linear economy to a sustainable, bio-based and circular economy there is need for change at a system level, involving all actors of the different chains and sectors (Costa and Donner, 2019). Lokesh et al. (2018) has highlighted the different value chain actors who need to be involved and engaged from feedstock production and procurement, through pre-treatment and conversion to consumption and end of life management. Understanding and engaging with these different actors, including primary producers, industries, research and academia, policy makers as well as actors from civil society, is an important step in developing new value chains, but also ensuring the broader successful implementation of a bioeconomy.

Building on above, the main objective of the current report is to investigate regional value chains along with available biomass, waste and residue streams. This includes the mapping of the available biomass feedstocks, waste and residue streams, actors, processes, resource flows, and bioeconomy value chains in the MainstreamBIO focal regions. The work undertaken will form a basis for understanding the potential new opportunities which could be developed within the region, taking into account the developments of tools and services from other work packages, including the MainstreamBIO toolbox, decision-support tool (WP2) and innovation services supports (WP3).

3. Methodology

The methodology for the current study is divided into 2 interlinked components:

1. At first, an inital mapping of the existing value chains is performed via desk research for all focal regions, by MTU (IE) WR (NL), IUNG (PL), FBCD (DK), PROC (SE), AUP (BG) and INNV (ES).
2. This information is validated and added to by directly engaging local value chain actors via interviews, based on questionnaires and guidance provided by MTU.

The mapping includes available biomass feedstocks, waste and residue streams, actors, processes, resource flows, and bioeconomy value chains in the focal regions. The approach is outlined in more detail in this section.

3.1 Selection of Regional Value Chains

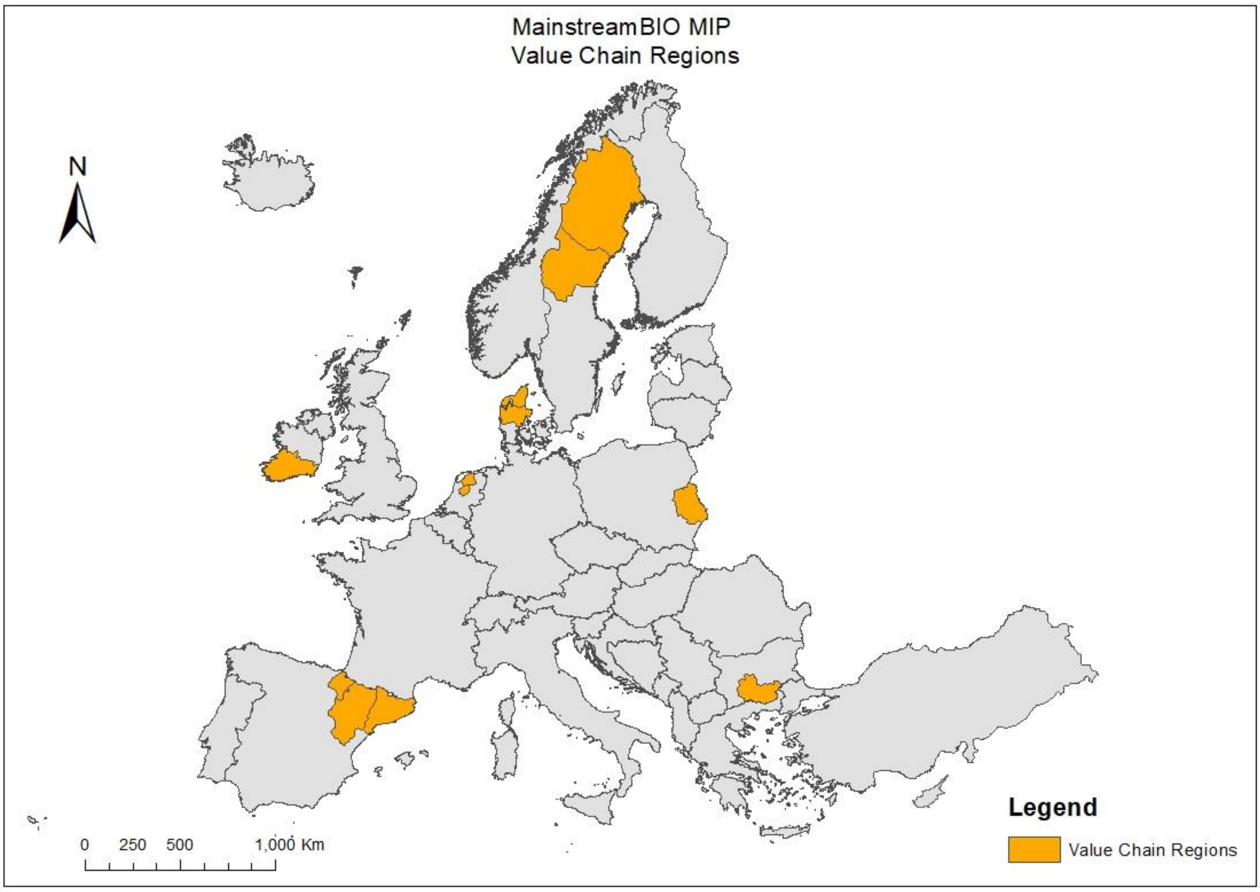
To begin the process, each MIP region was asked to select a region of focus along with specific value chain sectors to focus in on, corresponding as closely as possible with those areas mentioned within the GA. The selected country regions along with value chain feedstocks of focus are summarized in Table 2 below. In order to ensure that the KPI of 20 value chains mapped was achieved, a minimum of 3 value chains were selected per region. In total 27 value chains were focused on across the 7 MIP regions. This selection was based on feedstocks which were of interest from the perspective of regional partners and their MIP networks. A geographical representation of the MIP regions is provided in Figure 1 below.

Table 2. List of Country Regions and selected Value Chains per region.

Country	Region	Selected Value Chain Feedstocks
Bulgaria	South Central (NUTS2: BG42)	Forestry biomass, Greenhouse biomass residue, Local crop biomass
Denmark	Zealand NUTS2: (DK02) Mid Jutland (NUTS2: DK04), Northern Jutland (NUTS2: DK05)	Grass, Animal manures, Cereal straws

Ireland	Southern Ireland (NUTS2: IE05)	Grass, Animal manures, Cereal straws, Seaweed, Apple residues, Hemp,
Netherlands	Friesland (NUTS2: NL12) Flevoland (NUTS2: NL23)	Grass (roadside and nature), Animal manures, Pumpkin residues
Poland	Lubelskie (NUTS2: PL81)	Sugar beet residues, Berries residues, Corn residues, Rapeseed residues
Spain	Catalonia (NUTS2: ES51), Navarre (NUTS2: ES22), Aragon (NUTS2: ES24),	Pig slurry, Lucerne, Forest industry residues, Camelina, Brewers spent grain
Sweden	Middle Norrland (NUTS2: SE32), Upper Norland (NUTS2: SE33)	Forestry logging residues, Bio sludge, Fibre sludge

Figure 1. Location of the different MIP Regions Across Europe.



3.2 Data Collection Template for Desk-based Research on Value Chains.

To support in desk-based research for mapping of regional value chains, and to ensure as consistent an approach as possible was adopted across the 7 regions, a data collection template (included in Appendix 3) was developed by MTU to capture the main required information for each value chain. The template was designed to cover the components of T1.3 including the mapping of the biomass arisings and flows, actors, processes and innovations in our focal regions. The data collection template was composed of 5 tabs for completion by each regional partner plus 3 supporting tabs. The template tabs included;

1. Introduction tab: this tab explains the information and data requirements of the subsequent tabs. This allows the user to navigate the different tabs of the template, providing an explanation of each tab, along with the required information for each category, expected data amount and type.
2. High level introduction tab: this tab required some text providing a high-level introduction to the national bioeconomy for each region country – this information includes high-level information about the primary sector activities, activities and projects related to the bioeconomy, policies and strategies which are in place etc. Countries were selected via drop down menu.
3. Regional value chains: this tab requested the regional partners to explain the selected value chains per region, the related feedstock(s) which are the focus of the study and some justification for including this within in the study. For example, it may be a feedstock that is generated in large volume, or create a waste problem, or it may generate a residue which contains high value ingredients which may be of interest.
4. Regional value chain feedstock flows: this tab provided a template for collection of feedstock arisings and flow data within the regions and its subregions. The approach for this data collection is adapted from Attard et al. (2020). The template allows partners to input their overall quantity of feedstock generated within the region (e.g., NUTS2 Level data) in tonnes of dry matter (tDM), based on literature review and/or interviews, and then to allocate this to different subregion where such information is available (e.g., allocate from NUTS2 to NUTS3 county or provincial level). Where such information exists, this provides a more local context. This tab also allows team members to document the flows of the specific biomass or residue, by allocating a percentage fate towards the proportion of biomass or residue in a given use

or application (e.g., 50% may be left on the land, while another 50% may go to other subdivided applications). This above information will feed into the development of biomass arising maps and biomass flow Sankey diagrams which are detailed later. Estimated fates may be achieved based on literature or derived through interviews. Finally, an estimated price, where available, for sourcing this biomass is requested, as this may be interesting for potential value chain stakeholders. Both price and fate of biomass are examples of accessibility constraints for stakeholders wishing to develop new value chains (Attard et al., 2020). It should be noted that the collection of biomass data is based only on selected value chains of interest for the MIP region, and only represents a snapshot of the total biomass within these regions. A screenshot of this portion of the tab in the collection template is presented in Figure 2. Full detailed tables of biomass arising estimates and flows, along with data sources can be found in table form in Appendix 2.

Figure 2. Screenshot of Data Collection Template.

	GROT, logging residues (tDM)		
Region	Feedstock Value Chain 1		
Price per tonne	180 SEK		
Fate	Land	Combined Power and Heating Plant	Total
Fate %	99	1	100
Region (Middle Norrland, NUTS2: SE32 and upper Norrland, NUTS2: SE33, Sweden)	1763344	17812	1781156
Jämtland	492469.6	4974.4	497444
Västernorrland	409177.9	4133.1	413311
Västerbotten	473327.9	4781.1	478109
Norrbotten	388369.1	3922.9	392292

5. Regional value chain actors: this tab captures some of the key organisations and actors active within the related value chains, across a number of categories including primary producer, business, research and academia, policy and civil society. The location of the organisation and its coordinates is also included for mapping purposes. The list of value chain actors is again a snapshot based on the feedback of MIP partners and interviewees, as it is not possible to know every actor within the region.
6. Bio-based processes and services: this tab captures information relating to selected innovative processes and services which are taking place in the region focused on the selected value chains, along with information on its scale of deployment, sustainability benefits, market readiness, involved stakeholders and supplied products or service. The

purpose is to provide a snapshot of innovations which may be taking place within the selected value chain.

7. Guide to coordinates: this tab provides information regarding the format for obtaining the coordinates of organisations.
8. Back-up tab: this tab contains information on drop down arrows etc.

The template structure is presented in more detail in Appendix 3.

3.3 Interview Template for Value Chain Stakeholders

To complement this desk-based research, an interview template for value chain stakeholders was developed by MTU for use by regional partners. To avoid overlap with earlier questionnaires of MainstreamBIO Task 1.2, the questionnaire was adapted to support the successful completion of the data collection template regarding regional bio-based value chains. This would allow partners to validate the findings of the literature review, and support in collection of data, particularly addressing some of the data gaps that might exist. The target group for conducting interviews were key experts related to the identified value chains. Sector-specific experts were the most appropriate group to provide feedback on gaps related to the specific value chains and could be drawn from different categories, from researchers to advisory services, to companies who actively work on a specific value chain.

The interview template was semi-structured and can be used as appropriate to uncover different gaps that exist in relation to value chain information, at a regional level. It also contains some basic information about the respondent, such as type of organisation, job title, etc. The questions focus on technical aspects related to the biomass value chain, in line with the data collection template. The template can be viewed in Annex 1.

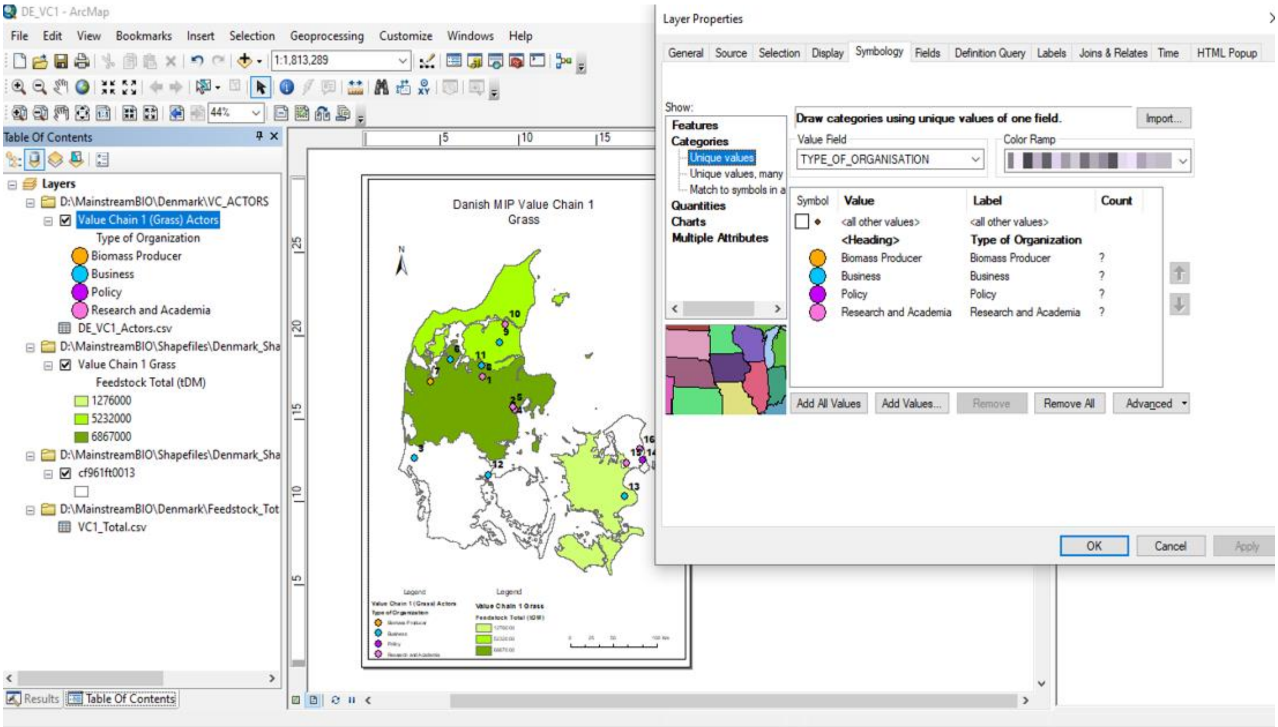
It should be noted that the privacy of the participants was assured at all stages of the interview study, according to the principles of GDPR. An information sheet and consent form was sent to participants prior to interviews. The interviews mainly took place via web communication tools such as zoom or teams along with phone. Following the interview, short transcriptions of the interviews were supplied to MTU by the regional partners, and information gathered could be added to regional sections. A total of 39 interviews were completed at this stage by the partners which included 4 primary producer actors, 10 business actors, 12 actors from research and academia, 1 civil society actor, 1 policy actor and 11 actors who were either other or covering multiple categories.

3.4 Creation of Regional Value Chain Maps

The data collected from the 7 MIP regions was then used to create regional value chain maps displaying biomass feedstock arisings and actors. For both the total feedstock arisings for each value chain of focus and the actors maps, Excel files were created with columns indicating the object ID, which value chain, type of feedstock and subregion. Additionally, the regional feedstock value chain files were given a column with the feedstock total (tDM), while the actors files were given additional files of organization names and type, location, coordinates, both latitude and longitude, and the projected X and Y coordinates. Due to each subregion having a unique projected coordinate system, the given coordinates had to be converted to the relevant X and Y co-ords using espg.io. All Excel files were then converted to *.cvs files to be used in the mapping software ArcMap and polygon shapefiles for each region and subregions were gathered. Within ArcMap, the data frame was converted to the relevant projected coordinate system and the subregion shapefiles were added. The value chain feedstock totals were then added and joined to the new shapefile through the subregions column. Through the symbology tab, the feedstock total column was selected to be displayed, and a unique colour was given to the different values to be displayed. For example, for grass feedstock arisings, different shades of green were given to the differentiate the total arisings of each subregion.

For the value chain actors, the X and Y coordinates were displayed. Under the symbology tab, the 'Type of Organization' column was displayed and a unique colour was given to each type of organization. Within the 'label features' tab, the 'Object ID' was selected to be displayed. A title, legend displaying feedstock totals and actors, scale and north arrow were then added to the map. These maps were then exported as jpeg. Where it was difficult to see multiple actor icons in one area, an insert layer was added. A new data frame was added to the map with the relevant subregions and actors displayed. A screenshot of the map generation is presented in Figure 3.

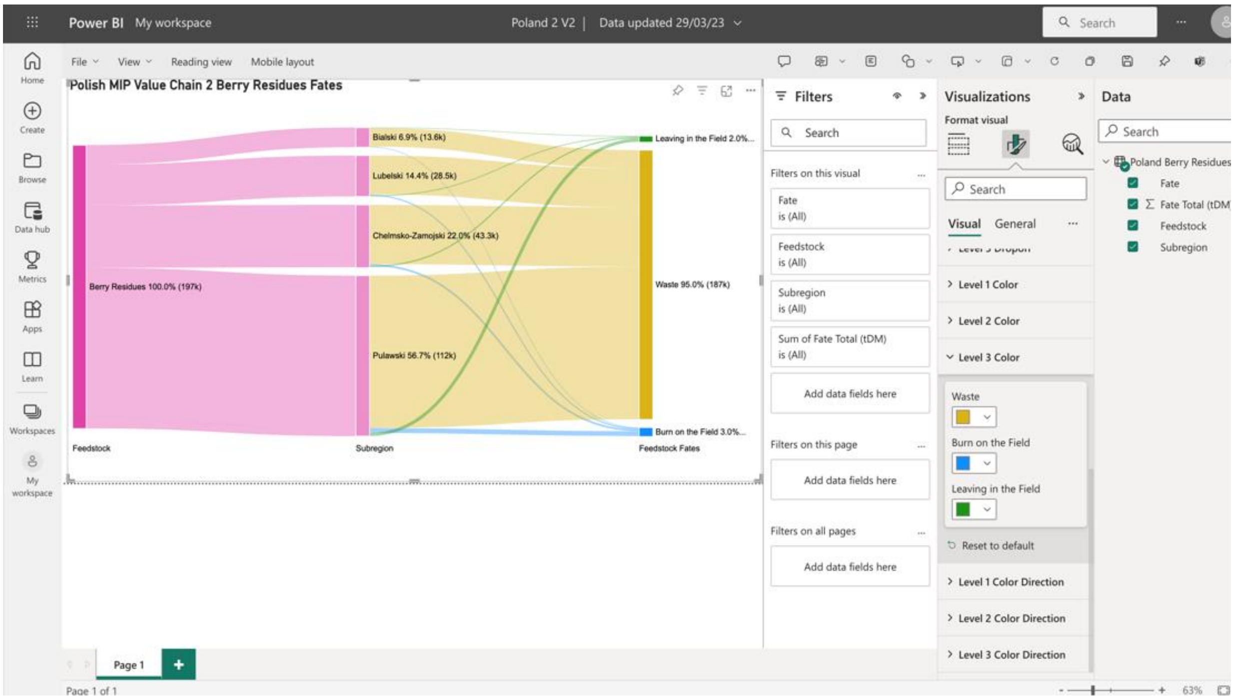
Figure 3. Screenshot of Maps Generation in ArcMap.



3.5 Development of Biomass Flow Sankey Diagrams

The feedstock value chain data gathered from each MIP region was used to create Sankey Flow Diagrams to represent the flow and fate (or end application) of each feedstock. From the data gathered, the type of feedstock, the region and subregion, the fate of the feedstock and the total amount of each fate (tDM) of the value chains were extracted to separate excel tables. To create the flow diagrams, each value chain table was added to the Power Bi software under the ‘Create’ tab. Once this data was added, the ‘Visualisation’ tab was selected within the software and the Sankey Diagram by Chart Expo was selected to represent the flow of data. The feedstock, region and subregion, and feedstock fate data were added to the ‘Category Data’ tab while the feedstock fate values (tDM) were added to the ‘Measure Data’ tab. Once the data had been added, each level of the diagram was labelled, such as feedstock and subregion. Level 1 represented the feedstock, level 2 represented the subregion and level 3 represented the fate of the feedstock. Each level was then given a unique colour, for example each feedstock was given a colour similar to the colour given to them in the value chain maps. Unique colours were also given to each feedstock fate for better visualization of the flow of the diagram. To ensure the diagram flowed correctly, the feedstock level was linked to the subregion on one level to flow to the right-hand side, while the feedstock fates were linked to the subregion on one level to flow to the left-hand side. The value and percentage of each section was labelled to show the amount of feedstock that fell under each fate category. A title was also given to each value chain Sankey diagram before they were exported to PowerPoint. An overview of the findings per region is presented next in Chapters 4-10. A screenshot of the Sankey flow diagram production using Power BI is presented in Figure 4.

Figure 4. Screenshot of Sanky Flow Production in Power Bi.



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4. Bulgarian MIP Region

Bulgaria is a promising country for bioeconomy development potential, rich in primary resources and with access to the Black Sea. With a population of almost 7 million, the country has a total area of 111,000 km² and a total coastline of 354 km. The majority of the land area is distributed between agricultural land (55%) and forestry land (33%). The agricultural area is essentially taken up by arable land (86.4 %) and permanent grass land and meadows (10.6 %), with arable land essentially dedicated to the production of cereals (1.8 million hectares (ha)) and industrial crops (1.1 million ha). Cattle are the dominant livestock animals (41%), followed by poultry (20%), pigs (15%) and sheep (12%).

The bioeconomy employed approximately 775,000 people in Bulgaria across its different sectors in 2019, while the value-added of the sector amounted to approximately €4 billion (Knowledge Centre for Bioeconomy, 2023). A 2021 study found that the main biomass types that could be mobilized for bio-based value chains nationally in Bulgaria include straw from different cereal crops, manures, pruning residues from permanent crops, vegetable and fruit processing residues, forestry residues and organic wastes (Elbersen and Voogt, 2021). Several Bulgarian entities are already engaged in EU and national level bioeconomy initiatives on a research and education level including Be-Rural, BioBec, BioCircularCities, MPowerBIO, BIOEASTsUP, CAP4BIOBG, CELEBio, AQUABIOPROFIT and COOPID. Through these International projects, along with nationally research e.g., through the Bulgaria National Scientific Program "Healthy Foods for a Strong Bioeconomy and Quality of Life" and other international projects, research is being conducted to determine the regional capacity for development of the bioeconomy. Meanwhile, some bioeconomy activities are active at the commercial level. According to the EU JRC data there are currently 28 commercial biorefinery facilities operational nationally, mainly focused on liquid biofuels and pulp and paper, with a smaller number focused on chemicals, sugar and starch and timber (JRC, 2022).

While the bioeconomy is already part of the sectoral strategies of the Ministry of Economy and the Ministry of Environment and Water, Bulgaria has yet to adopt a national bioeconomy and it is not sufficiently pronounced as a national priority. Bulgaria is a member of the BIOEAST Initiative which offers a shared strategic research and innovation framework for working towards sustainable bioeconomies in the Central and Eastern European (CEE) countries initiating cooperation through a multi-stakeholder network and cluster at European level to facilitate joint actions, including the development of a national circular and bioeconomy strategy. Even though there is no specific regional bio-based industry, there are several other strategic related documents, supporting it, including (CELEBio, 2021);

- CAP: Rural Development Programmes 2014-2020
- Bulgarian Rural Development Program for the period 2014-2020
- Strategy for Strengthening the Role of the Agricultural sector in the Bioeconomy
- Smart specialization strategy 2014-2020 (IS3)
- Energy from Renewable Sources Act
- National long-term program for promotion of the usage of biomass 2008-2020

The focus region of the Bulgarian MIP is the NUTS2 South Central Bulgaria region, comprising the NUTS3 regions (provinces) of Pazardzhik, Plovdiv, Haskovo, Smolyan and Kardzhali. The region is home to different types of primary production which generates potential biomass sources. This included over 145,000ha of cereals and around 10,000ha of oil crops. It is also a key fruit producing region accounting for 43% of apple production in the country, 37% of pears, 30%of plums and 29% of cherries. The region is also a key livestock territory, and Bulgaria's largest cattle farming region with 40,000 cattle, over 30,000 pigs and nearly 1.4 million chickens. A recent report indicated that the region has the best conditions for the construction of biogas plants due to the large cattle population. Within the region, a number of commercial bioeconomy activities are underway, including Mondi Stambolijski and Belovo Paper Mill within the pulp and paper industry and Essentica, one of the largest high-tech, state-of-the-art plants for the production of high-quality bioethanol, grain distillate and DDGS in the Balkans (CELEBio, 2021).

4.1 Forestry Value Chain

Bulgaria has considerable forest resources with forest occupying more than one third of the country's territory. South Central Bulgaria has a significant forest resource as a potential biomass source – with forest areas occupying more than a quarter of the land within the region. The sector is mostly dominated by state-owned enterprises, and it is therefore expected that the state will react quickly to develop the necessary regulatory framework to support the forestry sector in being part of the local bioeconomy developments. A recent report found that the total biomass potential, which consist of final fellings, thinnings, and associated logging residues, from forests within South Central Region is estimated at 1,200 Kton DM (CELEBio, 2021). The bio-waste amounts to up to 50% of the wood harvested in the forest holdings. Residual lignocellulosic biomass therefore represents a huge potential raw material source for industry and energy purposes given the size of the region.

4.1.1 *Biomass Arisings and Flows*

The flow of forestry biomass within the MIP region of South Region Bulgaria is presented in Figure 5 and a map of forestry biomass arisings across the MIP region and its subregions is provided in Figure 6. The total estimated amount of forestry biomass for the region is 722,280 tDM with Pazardjik seeing the largest arisings of 281,689 tDM, followed Smolyan with 196,821 tDM. The Plovdiv Region has total estimated biomass arisings of 119,176 tDM, with 83,062 tDM in the Kurdzhali region and 41,531tDM in Haskovo. The fate of the associated biomass is primarily focused on wood for the construction sector (505,596 tDM), which represents 70% of use, followed by chipboards (108,342 tDM), shredded paper (72,228 tDM), and cellulose production (36,114 tDM). A full overview of the arisings and flows of biomass for this value chain can be found in table form Appendix 2. The estimated price associated with purchasing forestry biomass is currently estimated at approximately €175–180 tDM in the case of round timber (50 cm diameter) to €50 – 55 tDM for small industrial timber.

Figure 5. Sankey diagram showing the arising and flows and fates of forestry biomass across different regions of the Bulgarian MIP.

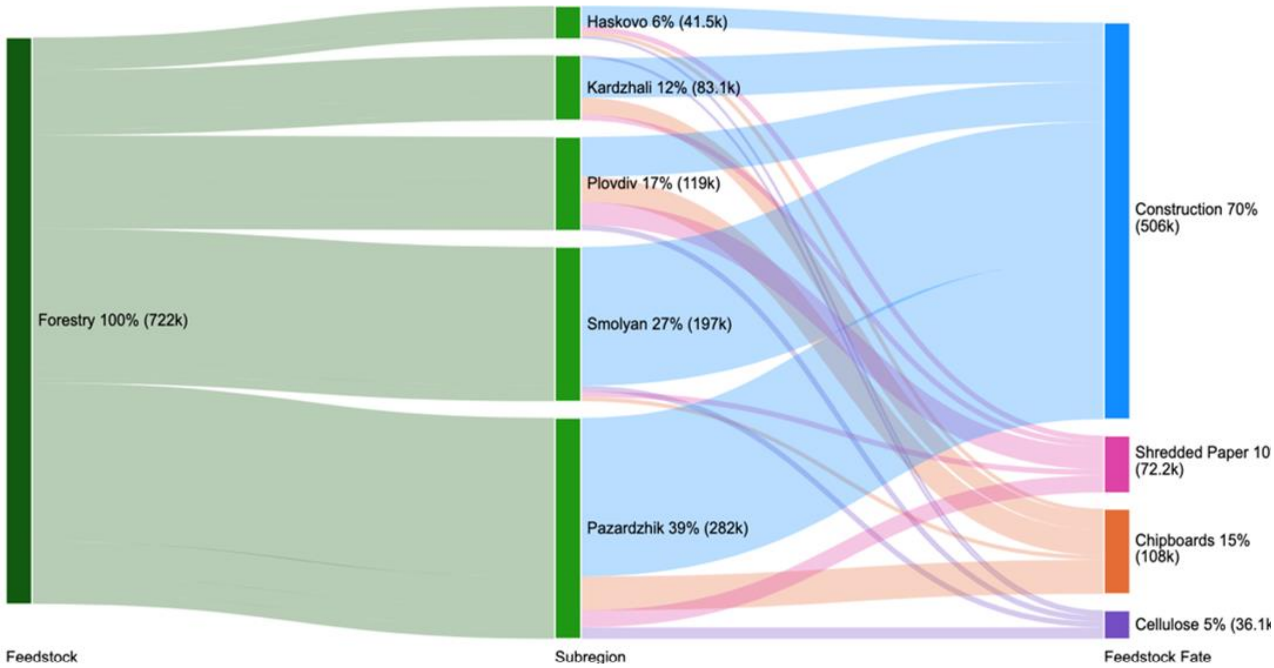

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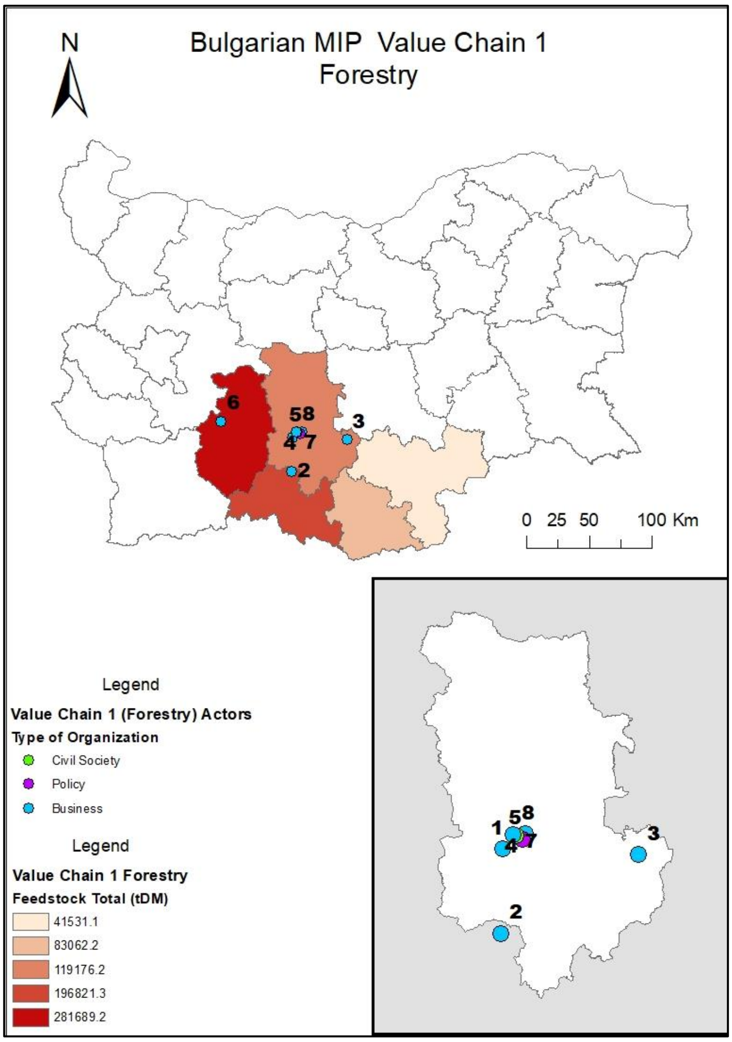
Figure 6. Map of arisings of forestry biomass and key stakeholders within the Bulgarian MIP region.



Business		**Civil Society**		**Policy**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*
1	MS Woodworking LtD	7	BGBIOM	5	Executive forest agency
2	South central enteprise				
3	GERMI				
4	Toplivo				
6	Belovo				
8	Andromeda 7				

4.1.2 *Biomass Value Chain Actors*

Key forestry value chain actors have been identified within the MIP region and are included in Figure 6. These include businesses in the region. The largest processors of wood and timber in the region are Mondi Stambolyiski, part of Kronoshpan Bulgaria Ltd. and Belovo Ltd. In addition, the Executive Forest Agency, operating under the Ministry of Agriculture, is a relevant actor for the development of policy which supports the development of the bioeconomy within the region. The accredited analytical laboratory at the Energy Agency of Plovdiv can help on the research and analytical side as they test and investigate the chemical composition of solid biofuels, biogas substrates, by-products and residual products, sewage sludge ashes, filtration dusts and biowaste in order to assess the possibilities for use of the various biomasses.

4.1.3 *New Biomass Value Chain Opportunities and Examples*

While the forestry biomass potential of the region is large, most companies are still lagging behind in bio-based R&D and the connection between them and the research institutes and universities is not well established. However, there are innovative examples within the region such as MS Woodworking who are looking towards the use of forestry residual materials as a feedstock for producing energy pellets and mulch. The high calorific value of the pellets produced (4700-5200 kcal/kg (5 kW/h for 1 kg), guarantees efficient and low-cost heating, while the mulch retains moisture in the topsoil and thus reduces irrigation and weed spraying costs. Another relevant initiative is the Horizon 2020 BioRES project which aimed at introducing an innovative concept of Biomass Logistic and Trade Centres (BLTCs) in Serbia, Croatia, and Bulgaria based on cooperation with technology leaders from Austria, Slovenia, Germany, and Finland. This approach helps in increasing the demand for woody bioenergy products (processed firewood, wood chips, wood pellets, and wood briquettes) in these countries and contributing to the achievement of EU targets set out in the renewable energy directive. Internationally, R&D efforts show great potential for forestry biomass to be utilized for extraction of high value compounds such as bioactives and food additives like xylitol and vanilla (Kilpelainen et al., 2020; Osorio-González et al., 2019; Strizincova et al., 2021), or for conversion to high value materials like cellulose nano crystals, (Aryapratama and Janssen, 2017; Moriana et al., 2016).

Figure 7. MS Woodworking Production site producing biomass pallets and mulch in Plovdiv (source: https://pelletify.com/).

4.2 Greenhouse biomass Value Chain

In South Central Bulgaria, agriculture is generating 5% of GDP in the regional economy. In rural areas it is the only business activity, which provides livelihood for the residents and provides raw materials for related industries. The rural population employed in the agriculture sector operates mainly in small-sized farms and they constitute a significant source of income for their owners. Subsidizing these farms determines the annual employment rate in rural areas. The total area of greenhouses in the South Central Region is 898 ha, which is 81% of the area of greenhouses nationwide. The main crops grown in greenhouses are tomatoes which account for 116.4 thousand tons and cucumbers which makes up 51.4 thousand tons per year (Ministry of Agriculture and Forests, 2022).

4.2.1 *Biomass Arisings and Flows*

The flow of greenhouse residual biomass arising within the Bulgarian MIP region is presented in Figure 8, while a map of arisings across the MIP region and subregions is provided in Figure 9. The total amount of residual biomass for the region from this sector is significant and estimated at

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1,020,062 tDM. Pazardjik is the largest producer of this biomass with 428,4266 tDM, followed by Plovdiv with 387,624 tDM. The Kurdzhali Region produces an estimated102,006 tDM, with 71,404 tDM coming from the Haskovo region and 30,602 tDM in Smolyan Region. The majority of this residual biomass, over 700,000 tDM, is understood to be used to produce biogas and several biogas plants are operational in the region, with the main other end use being as fertilizer or compost. A data table of the arisings and flows of biomass from this value chain can be found in Appendix 2. The estimated price associated with purchasing greenhouse residual biomass is currently €15.50 per tDM.

Figure 8. Sankey diagram showing the arisings and flows and fates of greenhouse biomass across different regions of the Bulgarian MIP.

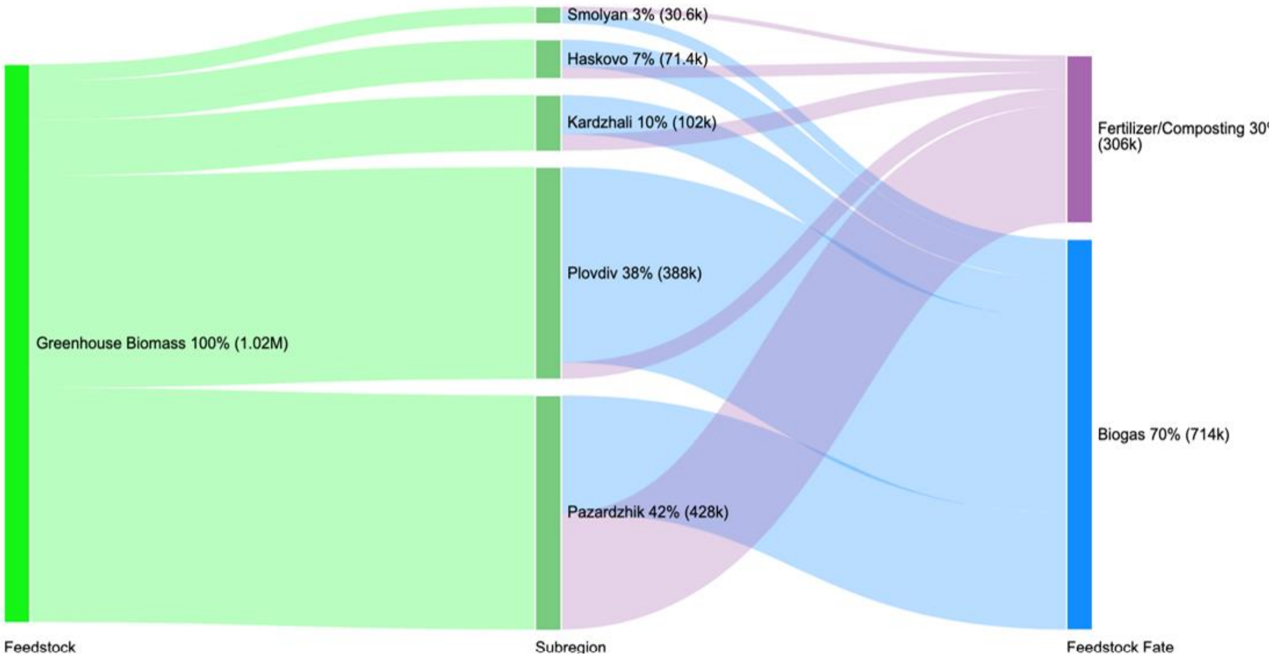

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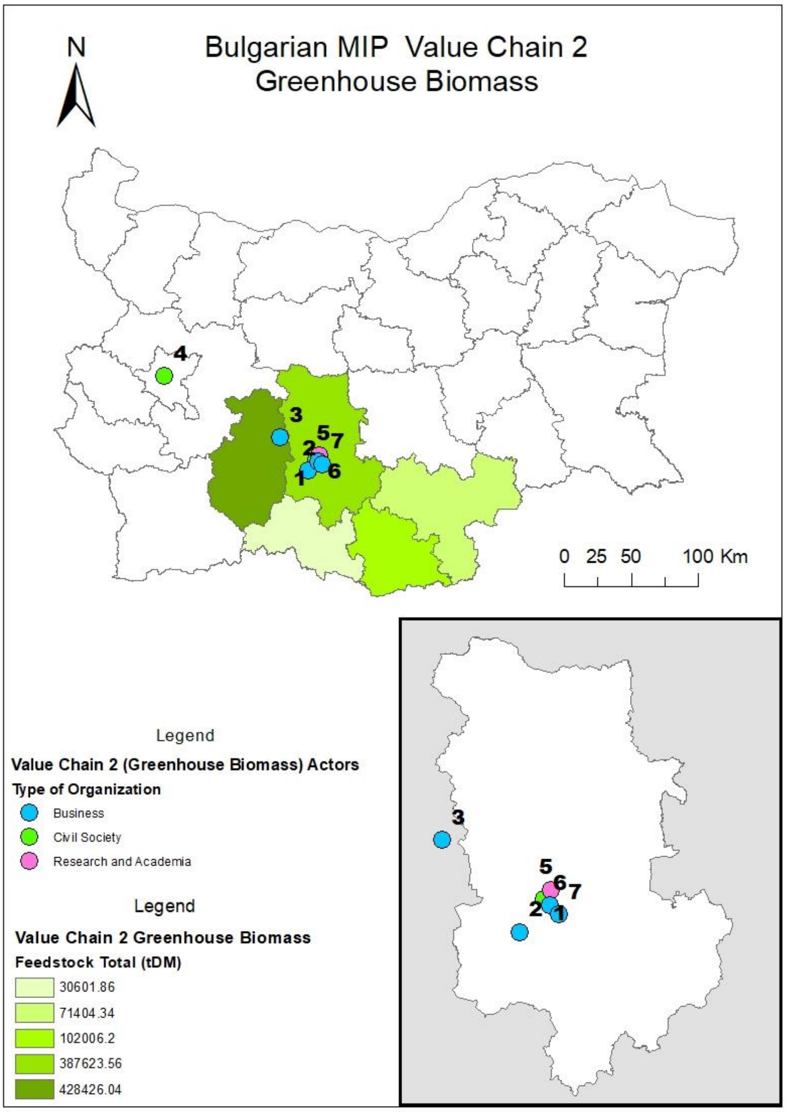
Figure 9. Map of arisings of greenhouse biomass and key stakeholders within the Bulgarian MIP region.



Business		Civil Society		Research & Academia	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*
2	Mushroom Farm	1	Bulgarian Greenhouse Producers Association	5	(MVCRI) Maritsa Vegetable Crops Research Institute
3	Bulkomp	4	Koren Fondation		
6	Lumbreco				
7	CUPFFEE				

4.2.2 *Biomass Value Chain Actors*

Key greenhouse biomass value chain actors within the MIP region have been included in Figure 9. These stakeholders include the Bulgarian Greenhouse Growers association representing the regional producers, as well as business organizations such as Bulkomp, Lumbreco and CUPFFEE who add value across the value chain in food and material applications. The Maritsa Vegetable Crops Research Institute based in Plovdiv, is a leading research partner to this sector and is the national research center for scientific, scientific-applied activities and extension services in the field of the vegetable crops and potato breeding, and technologies for vegetable crops growing. On the research side, also, the Institute of Plant Genetic Resources near Plovdiv is developing technology for pelleting residues from agricultural crops like sesame and tobacco.

4.2.3 *New Biomass Value Chain Opportunities and Examples*

A number of local companies along with research institutes are already active in adding value to the biomass produced. Several farms in the region have already adopted anaerobic digestion to produce biogas from these residues. At commercial level, Lumbreco Ltd. for example, based in Plovdiv, have developed a liquid organic fertiliser which has a high content of amino acids of vegetable origin obtained by hydrolysis of vegetable manures. The product contains biologically active substances - actinomycetes, gram positive bacteria that are producers of natural antibiotics, which increases the resistance of plants. Lumbreco can reduce the application of chemically active substances to soil and groundwater that negatively affect human health. Crops which have been fertilized with Lumbreco have a 20% higher yield and are visibly greener, healthier and more resistant to adverse meteorological conditions. The higher yield of the crop reflects on the higher level of revenue and income from the cultivation of the respective crop. CUPFFEE, based in Plovdiv, on the other hand, are working to recycle residual biomass for use in compostable drinking cups. At the pilot level, Maritsa Vegetable Crops Research Institute, are working to develop a blended juice product from tomato plant residues which may otherwise be discarded. In this way the carbon footprint of agriculture is reduced. Tomato juice is rich in betacarotene and vitamins, which are extremely important immunostimulants and the juice can be included in the diet of children and adults with compromised immunity. Internationally, research through projects such as BioBoost shows the potential of valorizing tomato stem residues into fibres for paper and cardboard production.

Figure 10. Edible cups from CUPFFEE based in Plovdiv, Bulgaria (source: https://cupffee.me/).

4.3 Local crop residues

Other local crops residues also play an important role in Bulgaria, both from a production and a tourism perspective, and these could also be a potential contributor to its emerging bioeconomy. The Bulgarian rose oil industry is a key national industry and a factor of national pride. Being a unique activity characterizing the country, the rose oil industry and its products are famous not only in Bulgaria, but also exported to many countries. A relatively small number of companies are engaged in the chain of the rose production due to the specific geographic area where the roses grow, which is associated with the region of the Bulgarian MIP. These companies are not only a motor for industrial growth, but also help national tourism making Bulgaria famous in the world.

Another important crop from a Bulgarian MIP perspective is walnuts, due to the favorable conditions that exist for the development of a relatively large number of species. This sector is important for feeding the local population, as fruit is an integral part of a balanced diet. Demand for products from the sector is consistent because of the importance they have in the daily diet of the local population.

4.3.1 *Biomass Arisings and Flows*

The most suitable production area for the oilseed rose is the relatively small area between Stara Planina and Sredna Gora - from Strelcha in the west to Zimnitsa in the east. The main production centres are the municipalities of Karlovo, Pavel Banya and Kazanlak. Accordingly, the districts of Plovdiv and Stara Zagora concentrate 90% of the total area and 80% of the number of holdings (CELEBio, 2021). The flow of oilseed in the MIP region is presented in Figure 11, while a map of total arisings is provided in Figure 12a. 4161 tDM is produced only in Karlovo, with most of this going towards rose blossom, with a small amount (0.02%) going towards rose oil. The current price for rose blossom is €1000 and rising to €5,500kgDM for rose oil.

In the case of walnut, walnut oil for use in culinary applications can be produced as a high value co-product along with the walnut. The total production of walnut across the region is included in Figure 12b and amounts to 4750 tDM, with Haskovo being the largest producer in the region (3,183 tDM), followed by Plovdiv (1,118 tDM) and Kurdzhali (310 tDM). Small amounts are produced in Smolyan (100 tDM) and Pazardjik (40 tDM). The flow of this value chain can be seen in Figure 11. The main component of walnut goes towards nut production (3,800 tDM), with about 15% going towards oil production and the remaining being shells. The current price for walnut oil is estimated at €1500 tDM. A data table related to biomass arisings and flows of biomass can be found for both of these value chains in Appendix 2.

Figure 11. Sankey diagram showing the arisings and flows and fates of local crop (rose oil and walnut) biomass across different regions of the Bulgarian MIP.

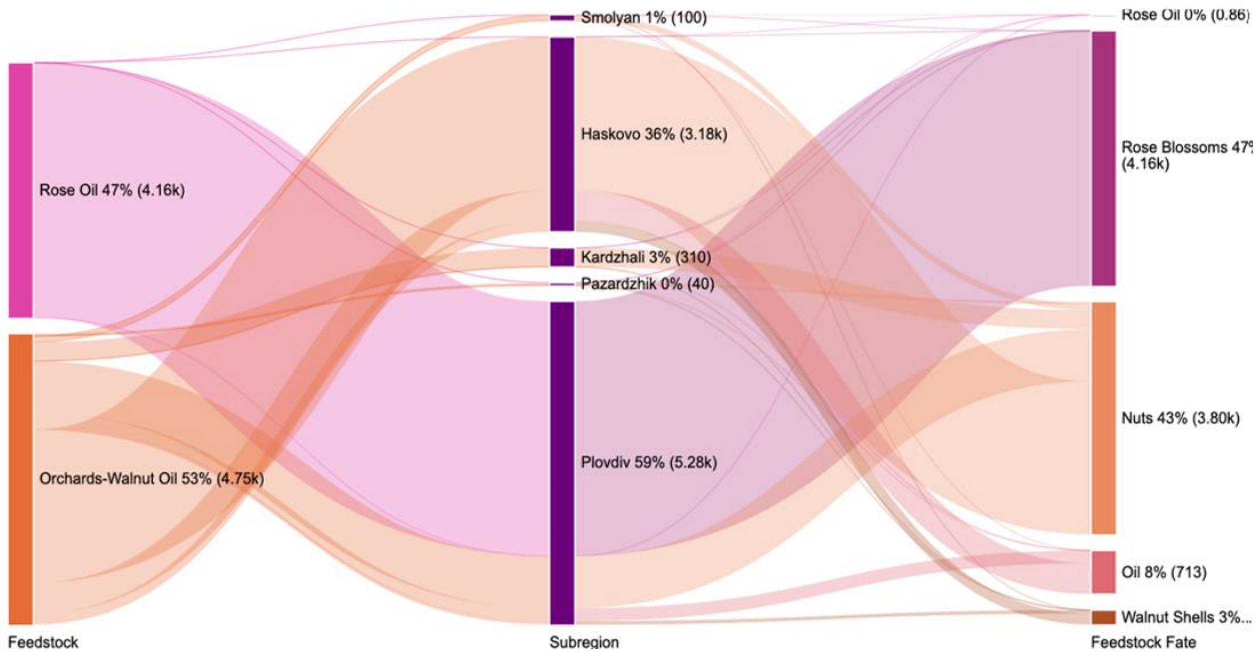
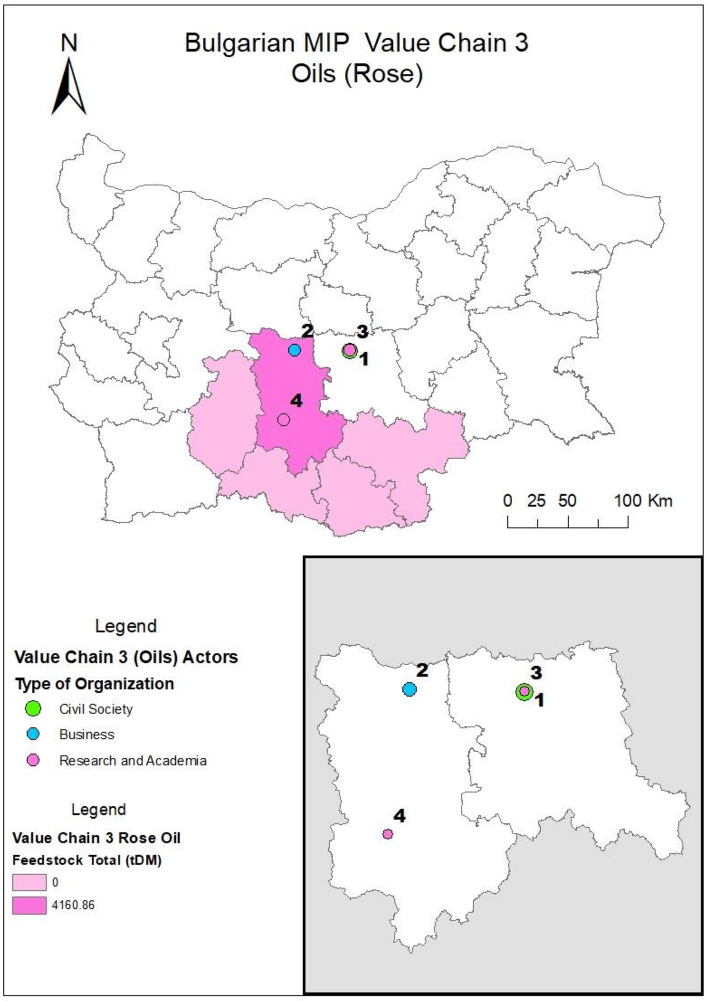
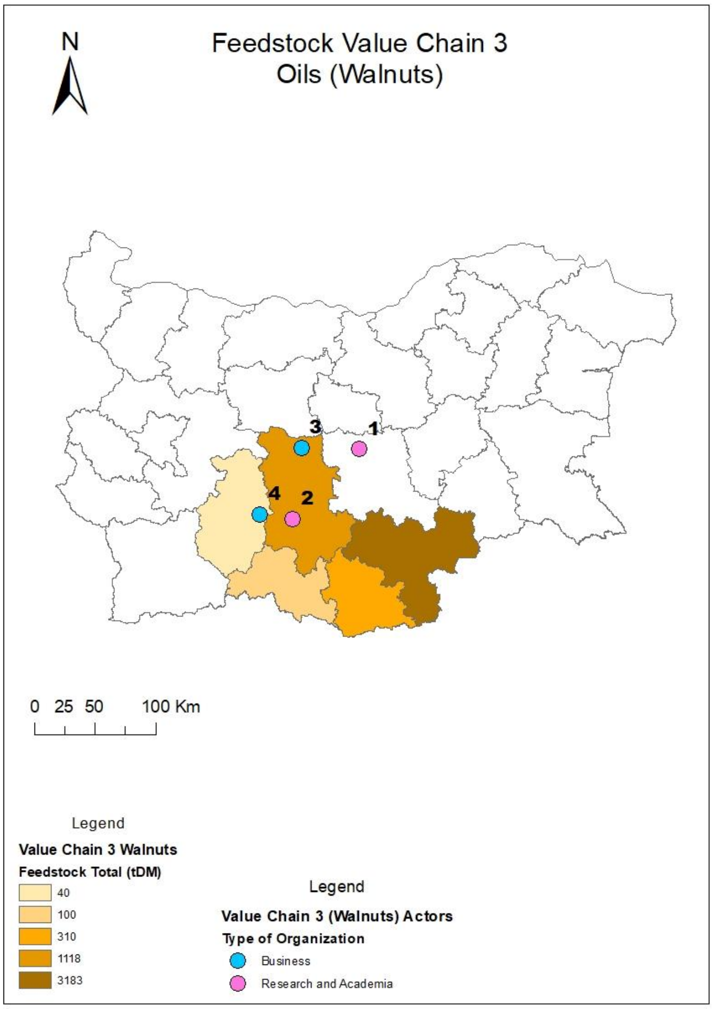


Figure 12. Map of arisings of local crop (rose oil (a) and walnut(b)) biomass and key stakeholders within the Bulgarian MIP region.



Business		**Civil Society**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*
2	Bulgarian Rose	1	Professional Association of Rose Growers	3	Institute of Rose, Essential and Medical Cultures
				4	Fruit Growing Institute Plovdiv



Business		Research & Academia	
ID	*Organization*	*ID*	*Organization*
3	Gourmoli Ltd	1	Institute of Rose, Essential and Medical Cultures
4	Balcho Ltd	2	Fruit Growing Institute Plovdiv

4.3.2 *Biomass Value Chain Actors*

A number of important stakeholders from the rose oil and walnut value chains are included within Figure 12a and 12b respectively. The Professional Association of Rose growers is a union of rose growers in the MIP region. The association provides help for the farmers who are the rose growers and the prime producers of rose blossoms. They are providers of raw material for rose oil distilleries, mainly in the region of Kazanluk and Karlovo. Other key business actors include, Alba Group Ltd., a leading producer of rose oil in South Central Bulgaria, producing rose water and other essential oils; Bulgarian Rose Damascena Ltd which is a part of the Terraland Group, founded to manufacture and distribute essential oils and waters, cosmetics and probiotics containing Lactobacillus bulgaricus and rose oil. The company Bulgarska Rosa – Karlovo AD are a producer of rose oil in the city of Karlovo, who produce rose water and other essential oils. Meanwhile, on the research side, the Institute of Rose and Essential Oil Crops in Kazanlak are involved in supporting research related to the crop production and developing technology for essential oil and medical plants and providing licensed testing labs for analyses and certificate issuing for oils, drugs, plant extracts, sowing seeds, cosmetics and pharmaceuticals.

Key actors within the walnut value chain include within research and academia, such as the Institute of Rose and Essential and the Medical Cultures, and the Fruit Growing Institute in Plovdiv. Meanwhile companies focused on walnut oil production within the region include Gourmoli Ltd. and Balcho Ltd.

4.3.3 *New Biomass Value Chain Opportunities and Examples*

In addition to the high value products already generated from these local crops there is some potential to add value to the residual stream also, which can be seen in the region. ZP Stanislav Stoyanov based in Dimitrovgrad have developed a process to produce abrasive paste from walnut shells as a more sustainable alternative to silicon carbide, aluminum oxide, alumina zirconia and ceramic oxide, typical abrasive elements commonly used. In addition, a variety of research has been conducted to investigate the production of fuels and materials, such as pyrolysis oil and biochar from walnut shells (Griffin et al., 2017; Rasool et al., 2018). Various other treatments have been applied, including acidic pre-treatment, hydrothermal treatments such as organosolv and hydrothermal carbonization (Morales et al., 2021; Naderi and Vesali-Naseh, 2021; Tan et al., 2019). Morales et al. (2021) found that the organosolv treatment of autohydrolysed solid walnut shells permitted high lignin removal and the delignified solid was suitable for cellulose nanocrystal production. In addition to the development of new products from these local materials, it is also noteworthy that these sectors can also generate revenue through eco-tourism, in which biomass provides not only a product but a service for the local economy. For example, in the MIP region, there are many service providers providing tours of rose oil plantations for interested tourists.

5. Danish MIP Region

Located in Northern Europe, Denmark spans an area of 42,943 km^2 and with a population of just over 5 million inhabitants. With over 7,000 km of coastline, it is a country rich in marine resources in addition to terrestrial resources. In 2018 primary land use in Denmark was largely dedicated to agriculture (64%) with a smaller forestry sector of about 14% (Eurostat, 2021b). The main crops in Denmark are small grains, mainly wheat and barley, covering more than half of the agricultural area. Fodder crops, mainly grass and maize for silage, amounts to 780,000 ha, but Denmark is also an important producer of sales crops such as rapeseed, sugar beets and grass seeds of various types (EIT Food, 2022). In terms of livestock, the dominating animals among livestock farms are pigs and cattle, but also to a smaller extent poultry, horses and sheep (Statistics Denmark, 2022b). Danish farmers own and control the main processing and marketing industries for food products in the country, as farmer-owned cooperative dairies and slaughterhouses have a market share of more than 90 per cent of the annual production (EIT Food, 2022).

The Danish bioeconomy employed almost 170,000 people across its various sectors in 2019 (Knowledge Centre for Bioeconomy, 2023). The combined added value of all bioeconomy sectors stood at almost €17 billion in 2019 (Knowledge Centre for Bioeconomy, 2023). It is also developing a number of bio-based industries across different sectors. There are 61 bio-based industry facilities located in Denmark, of which 82% are commercial facilities and the remaining are pilot or demo facilities. The majority of these are centred on biomethane, timber and liquid biofuels, with a smaller number focused on chemicals, sugar and starch, composites and pulp and paper (JRC, 2022).

In Denmark, there is great potential in utilizing bioresources from agriculture, forestry and fishing to produce renewable and sustainable materials. Effective utilization of biomass can have a major impact on both the national climate account, the pressure on natural resources - including biodiversity - and the economy. However, framework conditions that promote biological resources, including residues, waste and side streams, are important factors. The utilization of green biomass is a key focus area in Denmark and needs to be increased both for the use in the energy sector (to replace natural gas) and the agri-food industry (feed and food), utilising all fraction of the biomass.

The Ministry of the Environment is deeply committed in promoting a sustainable and circular development of the bioeconomy. Hence, the Environmental Technology Development and Demonstration Program (MUDP) as well as the Green Development and Demonstration Program (GUDP), are providing annual grants for development, testing and demonstration of new environmental technology that will pave the way for a sustainable society and create growth and employment. The work to promote bioeconomic solutions extends across ministries, as The Ministry of the Environment collaborates with the Ministry of Food, Agriculture and Fisheries, the Ministry of Business and the Ministry of Education and Research to jointly create a greener and more sustainable society. The Ministry of the Environment is also part of the inter-ministerial secretariat that services the National Bioeconomy Panel, which has been established to provide recommendations for the Danish government.

The focus regions of the Danish MIP are NUTS2 regions of Mid Jutland (Midtjylland), Northern Jutland (Nordjylland) and Zealand (Sjælland). The selected regions contain a total farm area of just over 2 million ha, of which approximately 1.7 million ha is utilised agricultural land serving a variety of primary sectors and generating different types of biomass and residue streams. (EuroStat, 2022).

Within this MIP region there are several key industry actors, in addition to R&D activities and infrastructure. For example, at Aarhus University (Foulum, Mid Jutland), there are a range of processing facilities focused on various biomass types including:

- Green biorefinery for production of protein enriched animal feed from green clover/grass.
- Biogas pilot plant including biogas to synthetic natural gas (SNG) upgrading.
- Lipid extraction and conversion to functional lipids and fuels.
- Hydrothermal Liquefaction (HTL) conversion pilot plant.

In Aalborg University, (Northern Jutland), there is a facility for Continuous HTL pilot plant for multiple organic input streams (e.g., lignocellulosics, grasses, organic residual streams). Innovative commercial companies active in the region include AquaGreen, an engineering company producing facilities for dehydration by steam drying and pyrolysis ovens for producing biochar from wastewater sludge. They have facilities installed in Fårevejle wastewater treatment, in Odsherred municipality of the Zealand Region and this plant handles all the sludge from the municipality’s 50,000 households. Another example is Danish Marine Protein, who produce protein from different marine sources such as starfish, fish-offcuts, shrimp shells and even terrestrial biomass like grass. The biomass is mainly sourced from the Limfjord in the North-west area. The Limfjord extends from Thyborøn Channel on the North Sea to Hals on the Kattegat. It is approximately 180 kilometres long, and has an irregular shape with numerous bays, narrowings, and islands. Other interesting initiatives include the development of an energy island in Mid Jutland, which is in the early process of establishment, while at Vordingborg harbour (Region Zealand) initiatives to produce jet fuel using straw are in progress.

5.1 Grass Value Chain

Currently Denmark holds about 300,000ha of grassland, which is mainly dedicated to cattle farming, particularly dairying. Just over half of the permanent grassland is located in the selected Danish MIP regions, amounting to 69,520 ha in Mid Jutland, 48,630 ha in Northern Jutland and 28,370 ha in Zealand. Denmark has a well-established selection programme for grass and clover; a programme that has provided mainly cattle farms with high-yielding varieties for decades (Termansen et al., 2016). In recent years, it has been highlighted in Denmark that converting land towards green biomass production, could result in environmental benefits for the Danish agricultural sector. Permanent soil cover, which can be achieved by growing green biomasses, has positive environmental effects; it extends the growing season, and it allows for the establishment of a permanent root system (Termansen et al., 2016). Studies have demonstrated that converting to grassland can increase the efficiency of nutrient use and reduce nitrogen leaching on farms. In addition, the developments of new research in the field of green biorefineries, are showing the additional benefit that can be achieved by maximizing the protein potential of grass, which can displace imported soya feed ingredients for animals.

5.1.1 *Biomass Arisings and Flows*

The total grass production in the Danish MIP regions is estimated to be approximately 13,375,000 tDM biomass, broken down by Mid Jutland (6,867,000 tDM), Northern Jutland (5,232,000 tDM) and Zealand (1,276,000 tDM). The majority of this is going towards the production of silage for forage for cattle, along with a feedstock for Denmark's large biogas industry. The flow of grass across the MIP region is provided in Figure 13, while a map of total grass arisings is given in Figure 14. A small amount is estimated to go towards protein extraction (for pig and poultry feed) using green biorefineries, as this is an emerging sector for the region, with some plants recently coming onstream. In that case the fibre fraction and the brown juice is going into biogas (where it can be classified as a second-generation feedstock), and some of the fibre is also used for feeding cattle, though mainly at a research level. A full overview of the arisings and flows of grass biomass in Denmark can be found in table form in Appendix 2. Price estimates for accessing grass in Denmark vary between €29 to up to €100 per tonne DM.

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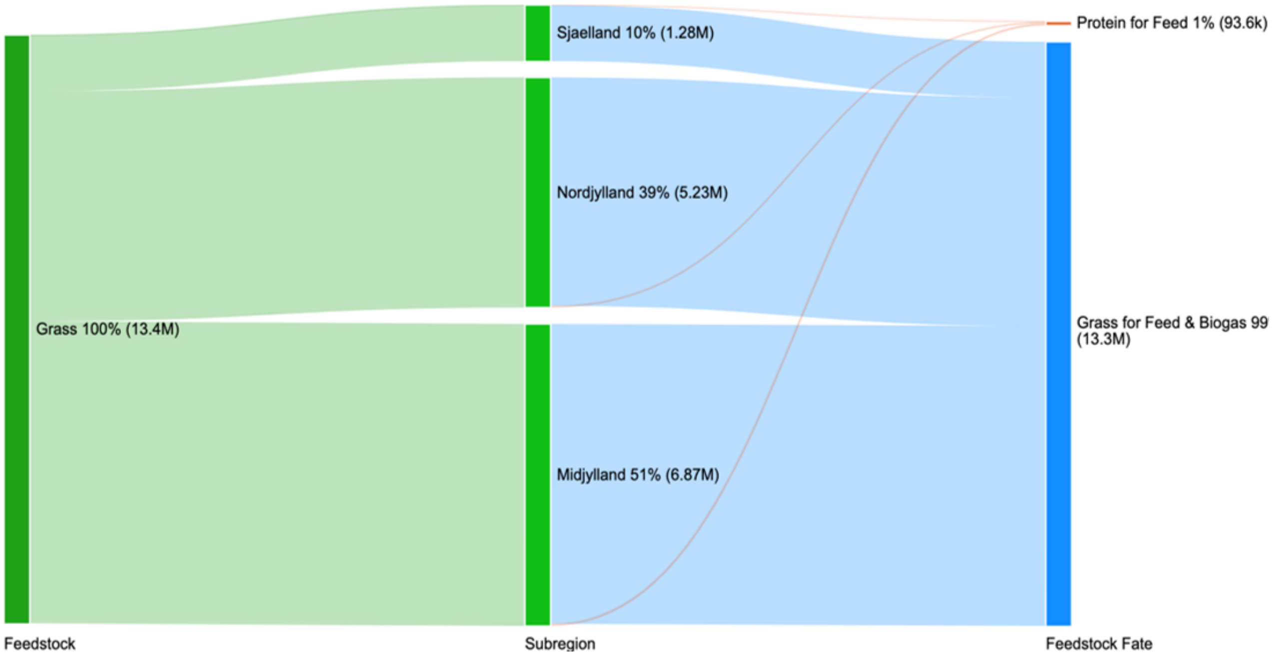
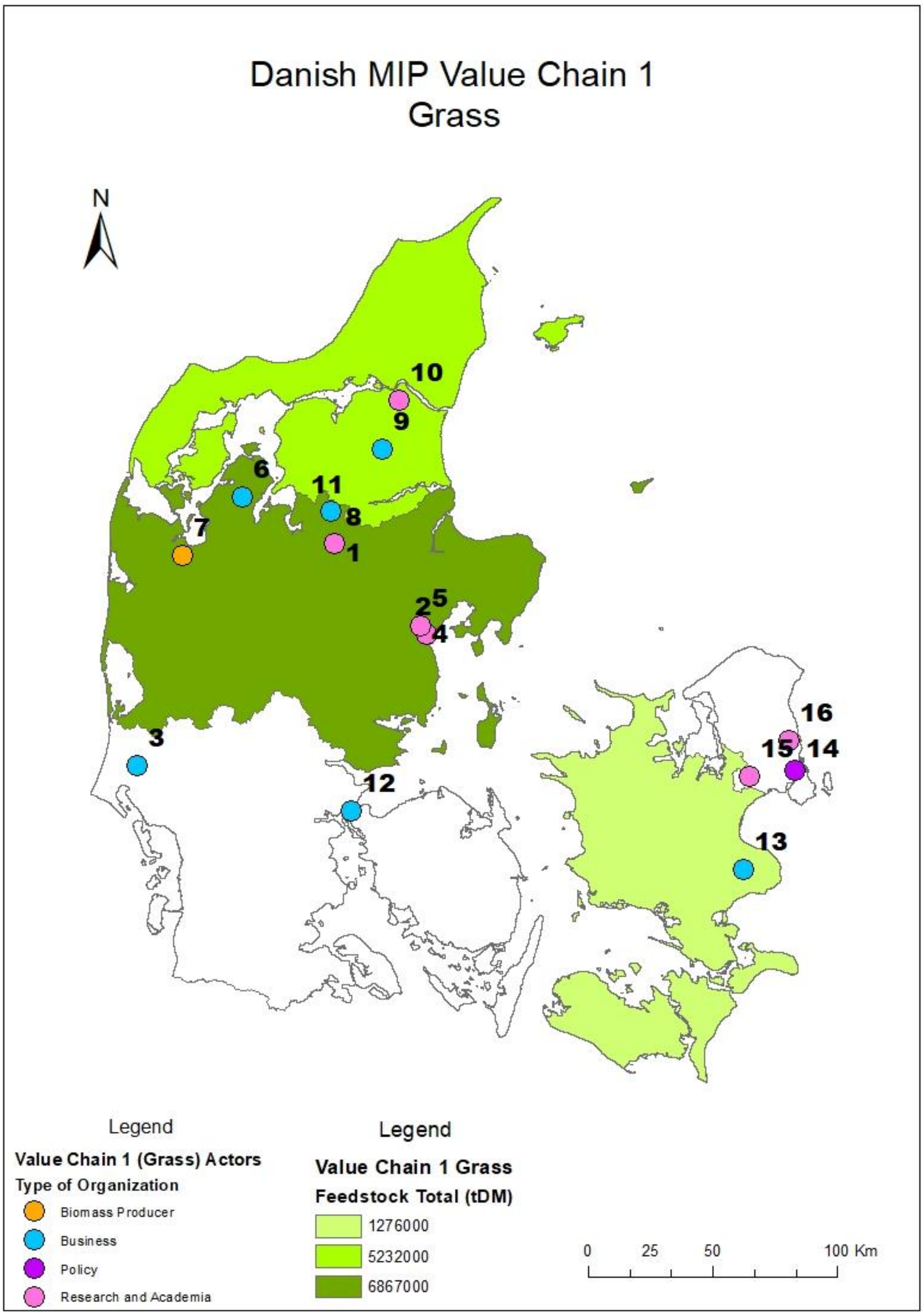
Figure 13. Sankey diagram showing the arisings and flows and fates of grass biomass across different regions of the Danish MIP.



Funded by the European Union

Figure 14. Map of arisings of grass biomass and key stakeholders within the Danish MIP region.



Biomass Producers		**Business**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
7	Ausumgaard	3	Biorefine Denmark A/S	14	Danish Agricultural Agency	1	Aarhus university, Department of Agroecology

		6	Danish Marine Protein			2	Aarhus university, Department og Biological and Chemical Engineering
		9	Plan Energi			4	SEGES Innovation
		11	FBCD A/S			5	ICOEL, Innovation centre for organic farming
		12	DLG - Danish co-operative company owned by Danish farmers			8	ICROFS, International Centre for Research in Organic Food Systems
		13	Danish Agro			10	AFRY
						15	Danish Technological Institute
						16	Technical University of Denmark

5.1.2 *Biomass Value Chain Actors*

There are a variety of key value chain actors identified within the MIP regions. Several universities and research centres are conducting research related to grass including sustainable agriculture and bio-based value chain opportunities. These include Aarhus University, Danish Technological Institute and the Technical University of Denmark, who have facilities to support companies investigating these opportunities. Food and Bio Cluster Denmark AS (FBCD) are Denmark's national cluster for small and large companies, knowledge institutions and other organizations within the food and bioresources sector. Businesses such as DLG, a Danish co-operative company owned by Danish farmers, and Biorefine Denmark A/S are working towards scale up opportunities in the area of green biorefining. The Danish Agricultural Agency is an agency under the Ministry of Food, Agriculture and Fisheries of Denmark which is working to support conditions for sustainable growth and green transformation in the field of agriculture.

5.1.3 *New Biomass Value Chain Opportunities and Examples*

Denmark is already a key European play in the development of new biomass value chain opportunities from grass. Its work through universities such as Aarhus University to demonstrate such initiatives is well established. The university is home to a green biorefinery demonstration facility for the extraction of protein from fresh grass and other green biomasses. The plant came online in 2019, with building costs amounting to approx. 15 million DKK (€2 million), and the establishment of the plant was facilitated via funding from various foundations and companies, including Arla, Danish Crown, DLG, DLF, GUDP, the Central Denmark Region and Aarhus University. The plant is conducting research on a variety of products related to green biorefinery including feeds for cows, pigs and chickens, and to date has produced very positive results (Damborg et al., 2019; Stødkilde et al., 2021; Stødkilde et al., 2020). The university is also partner on the EU Horizon 2020 GO-GRASS project investigating the potential of circular grass-based models along with FBCD and other European partners. At a commercial level, green biorefinery technology is being scaled through BioRefine, a Danish company formed by the three agricultural companies DLG, Danish Agro and DLF. The company has developed a new method to extract protein from grass and alfalfa. They have recently scaled the process to commercial level. The overall goal is a total production of approx. 4,000 tons of protein and 25,000 tons of dry matter fibre (DLF, 2020; NIRAS, 2022).

Figure 15. Aarhus University green biorefinery demonstration plant based in Foulum, Denmark (source: https://bce.au.dk/).

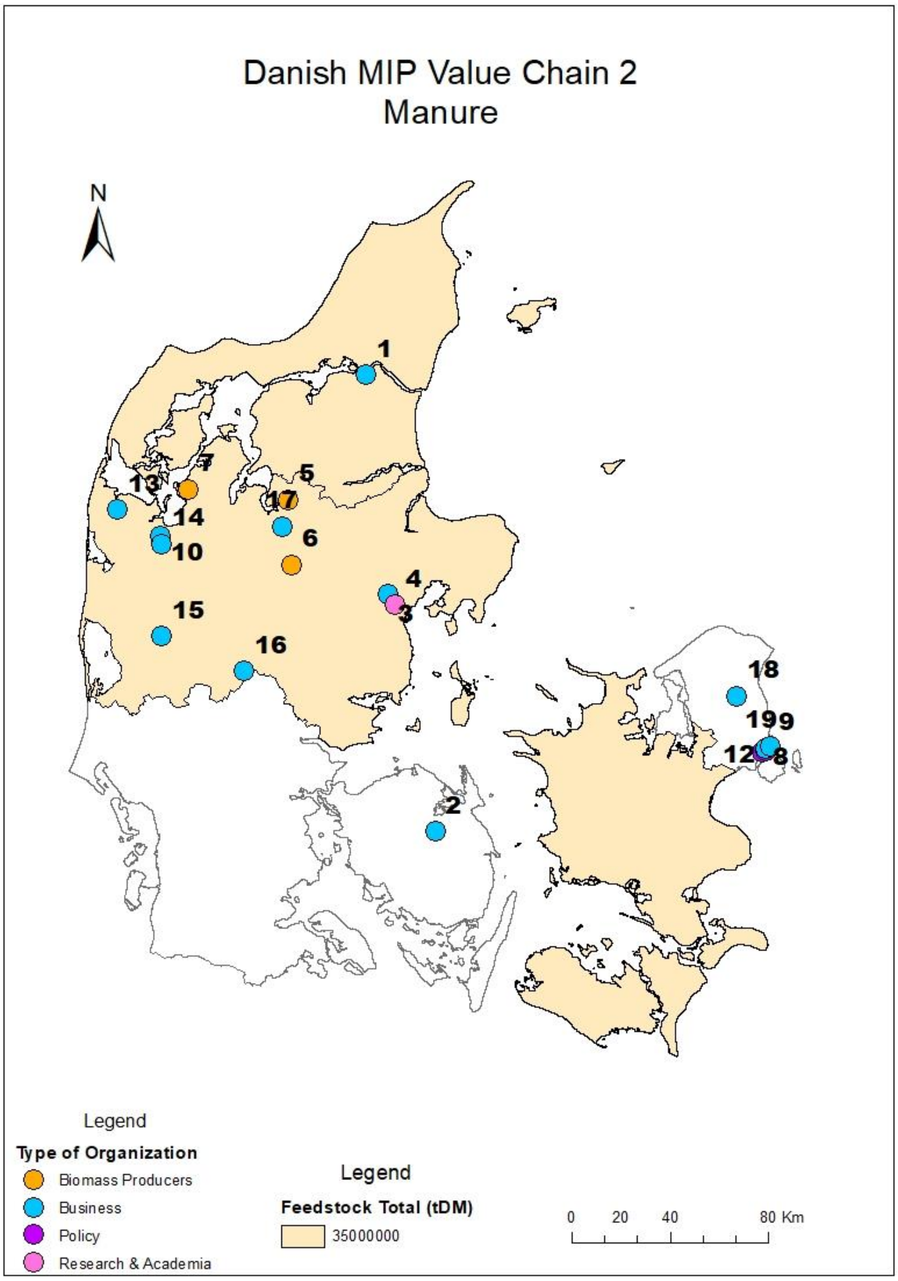
5.2 Animal Manure Value Chain

Livestock is an important component of Danish agriculture, with around a quarter of Danish farms specializing in this area, mainly in cattle and pigs. The number of cows in Denmark in Q4 of 2022 stood at 1,466,400 while the pig count at the same time was 11,541,000. Poultry, horses and sheep play a smaller but still significant role in the livestock sector. In MIP region the majority of these cows are in Mid Jutland (444,244) and Northern Jutland (347,889) respectively, with a smaller amount in Zealand (66,175). In relation to pigs Mid Jutland again has the largest herd count (4,765,276) followed by Northern Jutland (2,950,496) respectively, with a smaller amount in Zealand region (1,308,338).

5.2.1 *Biomass Arisings and Flows*

Within the MIP region it is estimated that the arisings of animal manures from the different livestock sectors (cattle, pigs, poultry, sheep and horses), constitutes approximately 35,000,000 tDM. Approximately 35% of this is estimated to go for the production of biogas through anaerobic digestion, with the remainder being used as fertiliser. The price of slurry fluctuates but is often €0. The reason is that many farmers exchange manure with degassed manure or digestate which results from biogas production, and which often is of a better quality, easier to allocate, and is often delivered in buffer tanks in the fields rather than at the farm. Thus, the farmer saves money on transport and logistics. Separately, SEGES Innovation suggests that manure can attract a price of between €1.30 – 2.60 per tDM if farmers were to sell this to produce biogas due to the current demand.

Figure 16. Map of arisings of manure biomass and key stakeholders within the Danish MIP region.



Biomass Producers		**Business**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
5	Stakildgaard	1	Energy Cluster Denmark	8	Frej - Think tank (NGO)	4	SEGES Innovation
6	Kuhr Hedegaard	2	Nature Energy	9	Concito - Denmarks green think tank (NGO)		

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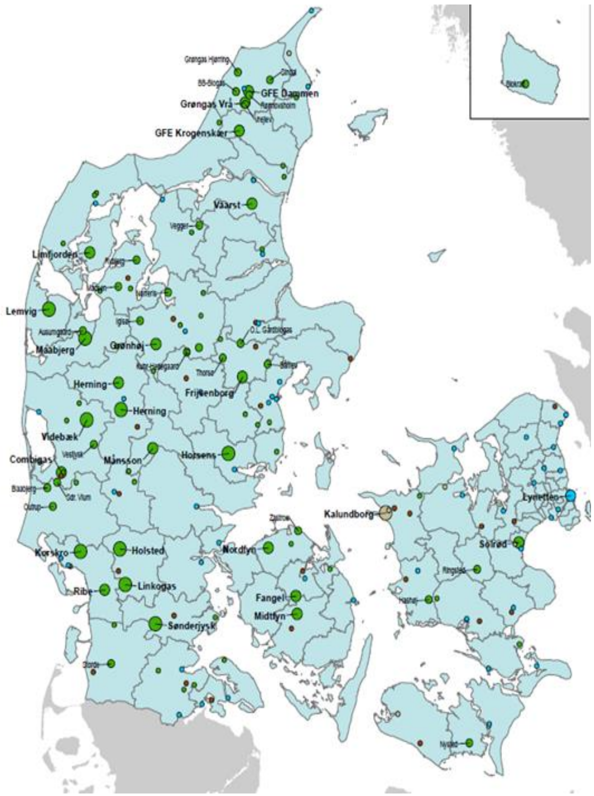
7	Tranemarken Agro	3	HedeDanmark	11	Danish Energy Agency		
		10	Ausumgaard Biogas				
		12	Biogas Danmark - association				
		13	Lemvig Biogas				
		14	Maabjerg Bioenergy Drift A/S				
		15	Nature Energy - Videbæk				
		16	Månsson Biogas				
		17	Evida - National gas distribution company				
		18	NIRAS A/S - engineering consultant service				
		19	Biocirc				

5.2.2 *Biomass Value Chain Actors*

Key actors in the manure value chain in the Danish MIP region include business actors focused on the production of renewable energy such as biogas. Among others, these include Ausumgaard Biogas, Månsson Biogas, Nature Energy and Lemvig Biogas. On the supplier side are primary producer organisations such as Tranemarken Agro, Kuhr Hedegaard and Stakildgaard. On the policy side there is the Danish Energy Agency which is responsible for handling national and international agreements, tasks linked to production, supply and consumption of energy, and efforts to reduce greenhouse gas emissions. It oversees the legal and political frameworks for reliable, affordable and clean supply of energy in Denmark. Other NGOs include the sustainability Think Thank – Frej and Denmark's Green Think Thank called Concito.

5.2.3 *New Biomass Value Chain Opportunities and Examples*

Anaerobic digestion to produce biogas is a growing application for animal manures produced on Danish farms, with production of biogas rapidly increasing in Denmark, with subsidies in place for its use. The widespread nature of biogas production facilities in Denmark can be seen in Figure 17 (Danish Energy Agency, 2018). The different support schemes for biogas include the following uses:



- Production of electricity
- Upgraded biogas delivered to the natural gas grid or cleaned biogas delivered to a town gas grid
- Use of biogas for process purposes in the industry
- Use of biogas as a transport fuel
- Use of biogas for heating purposes (Danish Energy Agency, 2020)

Figure 17. Map of Biogas Plants in Denmark.

The Maabjerg BioEnergy biogas plant is a well-established Danish biogas example and one of world's largest plants. It was designed primarily to treat animal slurries and eventually to form part of a biorefinery concept. The plant processes up to 800,000 tons of biomass annually about 500,000 tons of which are liquid and solid manure, supplied by the local farming community. Along with manure, the plant co-digests wastewater sludge, dairy waste and food waste, producing 18 million Nm^3 biogas for use in district heating and electricity generation, as well as digestate for use as fertilizer and fibres (IEA Bioenergy Task 37, 2014). A challenge is that many biogas companies are owned by larger consortia with available capital funds, and therefore biogas is becoming a big business or industry instead of a bio-based solutions for farmers. Also, the competition for biomass makes production of and establishment of new plants at farms difficult.

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Figure 18. Maabjerg BioEnergy biogas plant based in Holstebro Denmark (source: https://bigadan.com/).

5.3 Local Crops Value Chain

The main crops in Denmark are small grains, mainly wheat and barley, covering more than half of the agricultural area in the country. The breakdown of wheat and barley production, respectively among the MIP regions is Zealand (125,482 ha and 113,415 ha), Mid Jutland (130,519 ha and 205,781 ha) and Northern Jutland (81,832 ha and 100,705 ha). Feed is the dominant use of the domestic crop. Small amounts of rye, oats and maize are produced in all regions (Statistics Denmark, 2022a). From the harvest, straw is produced on the farm as a by-product of cereal production which has several potential applications in a bio-based economy.

5.3.1 *Biomass Arisings and Flows*

An overview of the estimated flow of straw biomass, and arisings in the region is presented in Figure 19 and 20 respectively. The total straw production from various sources combined within the MIP region is estimated at 3,483,000 tDM, with the largest arisings in Mid Jutland (1,519,000 tDM), Zealand (1,086,000 tDM) and Northern Jutland (878,000 tDM) respectively. In terms of the current end use of straw it is estimated that about 32% of the MIPs straw (1,114,560 tDM) goes towards animal feeding and bedding, with about 27.2% (947,376 tDM) used for heating, 0.8% (27,864 tDM) used for biogas and the remainder 40% (1,393,200 tDM) left unsalvaged. This represents a potentially valuable resource if it can be harvested and collected sustainably. The estimated price for straw currently stands at approximately €80/tDM. An overview of the flow and arisings of straw biomass is presented in table form in Appendix 2.

Figure 19. Sankey diagram showing the arisings and flows and fates of cereal straw across different regions of the Danish MIP.

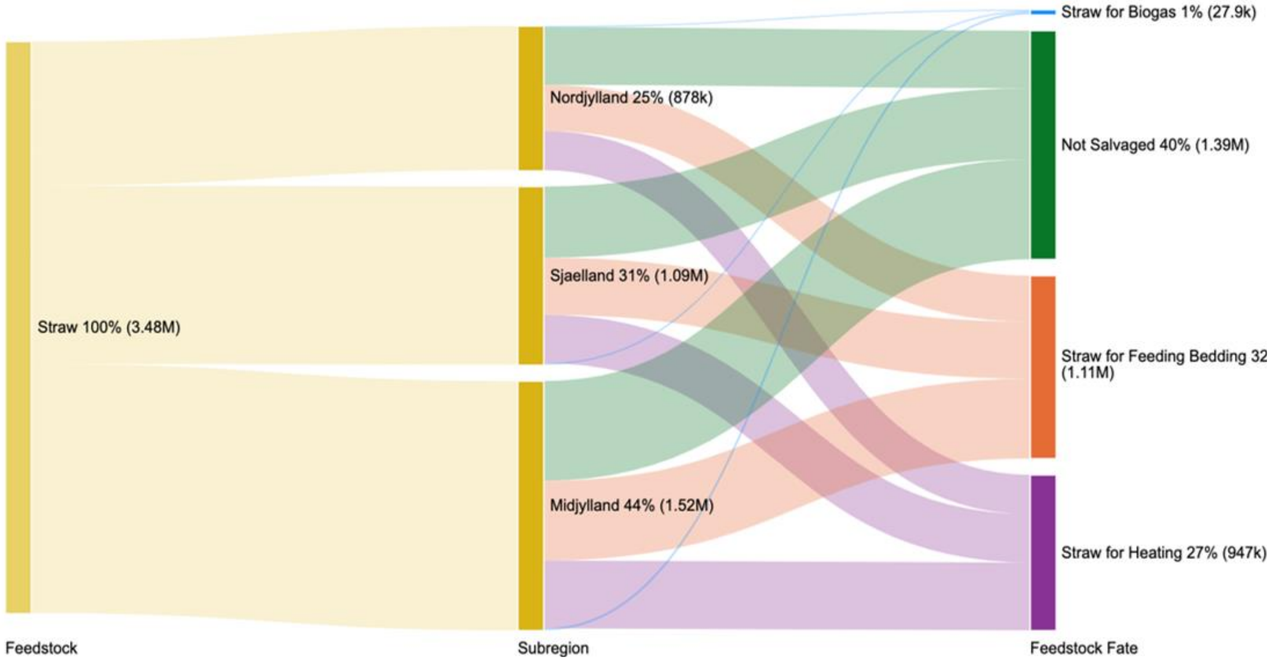

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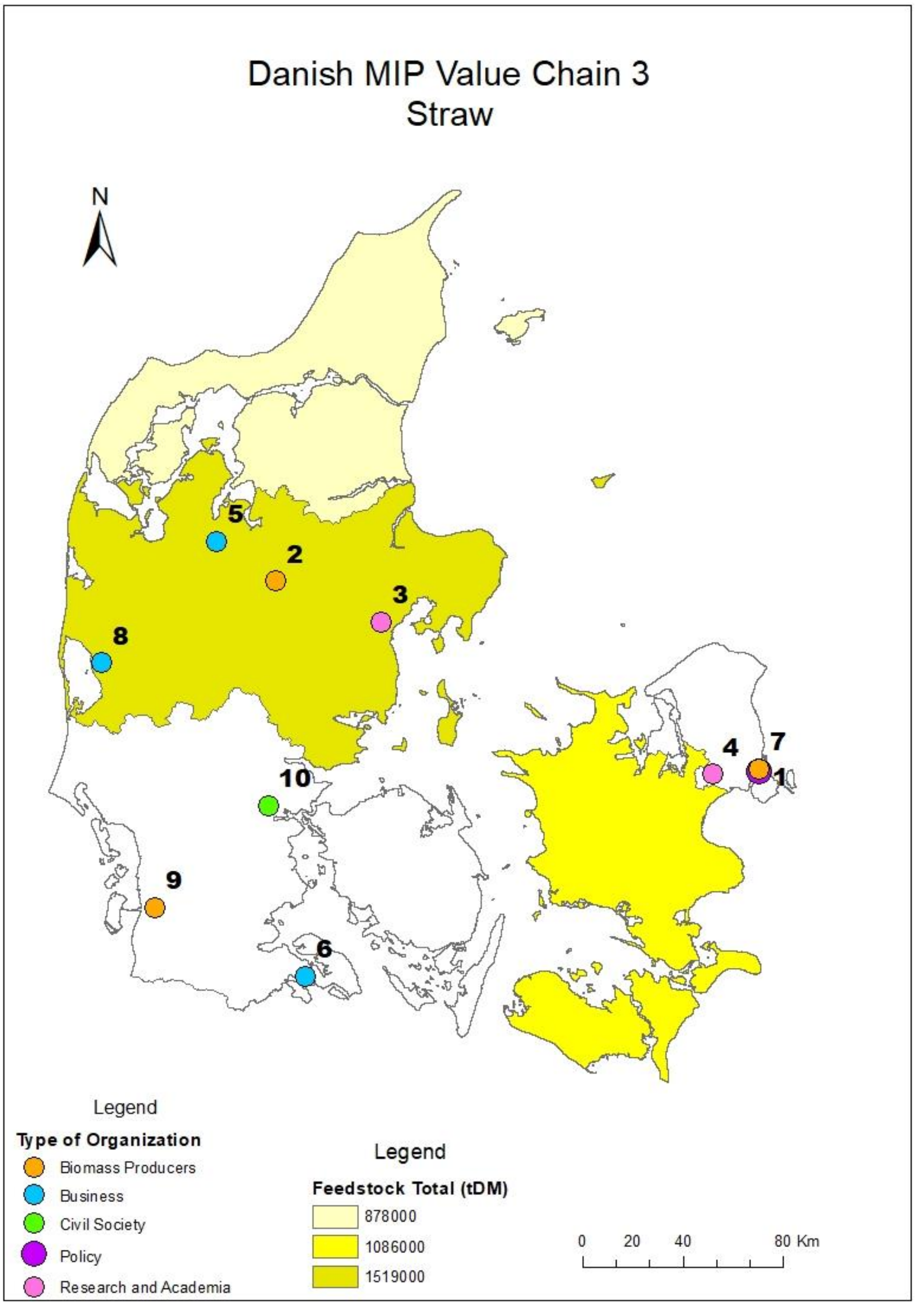
Figure 20. Map of arisings of straw and key stakeholders within the Danish MIP region.



Biomass Producers		Business		Civil Society		Policy		Research & Academia	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
2	Kuhr Hedegaard	5	Halm Danmark	10	Danish District Heating Association	1	Danish Energy Agency	3	SEGES Innovation

7	Dansk Halm - Supplier Association	6	Maskinfabrikken Cormall A/S					4	Danish Technological Institute
9	Halmselskabet - Straw Association	8	Linka Energy A/S						

5.3.2 *Biomass Value Chain Actors*

Several stakeholders within the MIP region have been identified as key to the straw value chain covering a range of groups. This includes the straw association Halmselskabet, and other producer groups such Kuhr Hedegaard and Dansk Halm. There are also businesses and entities linked to the production of energy from straw, such as Linka Energy A/S and the Danish District Heating Association (Civil Society). Research and Academia who are active in looking at the potential of straw include the Danish Technological Institute and SEGES Innovation, while the Danish Energy Agency is active in understanding and supporting the development of new opportunities from straw.

5.3.3 *New Biomass Value Chain Opportunities and Examples*

Straw holds great potential to be used as a renewable energy source, and as can be seen above, one of the main applications for straw currently is for the production of energy in district heating settings. In this case farmers producing straw deliver it to different district heating boilers. Dansk Halm is an example of an association of producers of straw for district heating and biogas. The association buys and sells straw for farmers to district heating plants as well as biogas plants. They are an independent association with a secretariat at the Department of Agriculture and Food in Axelborg, that protect and strengthen the interests of the straw suppliers. The association works to ensure good conditions for straw suppliers and utilization of straw for energy purposes and help create better opportunities and better political understanding for the use of straw for e.g., energy purposes, non-food, etc. by maintaining good contact with buyers of biomass, the political system, agencies etc. Straw as biomass has always been used for different applications, especially feeding and bedding, but as natural gas is desired to be phased out, the use of straw for biogas plants has gained increased interest. As the demand has increased, so to, the price for straw has also increased, creating an additional source of revenue for farmers. Since straw is rich in carbohydrates and lignin there is also potential to valorize these materials further, after pre-treating. Examples of efforts to further process these materials include Dong Energy A/S Inbicon’s second generation ethanol plant at Kalundborg, Denmark. The plant was inaugurated in 2009, with a process which converts 30,000 tDM of straw into 5.4 million litres of ethanol, 13,100 t of lignin pellets and 11,250t C5 molasses (Persson, 2010). Recent research from the Technical University of Denmark (DTU) indicates that the use of straw to produce liquid biofuels for heavy transport is a more economically and environmentally sustainable route than using it as a solid fuel for district heating (Venturini et al., 2019). At a research level, the focus has also been on understanding the potential use of straw, not only for energy production, but also to produce high value materials. The BIOVALUE project for example has investigated the use of straw in the production of ingredients for pharmaceuticals, cosmetics and textiles. It is important that any straw for new value chains is sustainably harvested since straw plays an important role in adding carbon and organic matter to the soil. It offers advantages in relation to the root development of the crop, the water-holding capacity of the soil and better structure in the soil, among other benefits. This creates some sustainability concerns of harvesting straw for biogas or new applications.

6. Irish MIP Region

Ireland is Europe's third largest Island and is composed of the Republic of Ireland and Northern Ireland. The Republic of Ireland has an area of 70,273 km^2, which is rich in terrestrial land and marine resources. Approximately 64%, is suitable for agriculture, with 11% of total land used for forestry. The country has a much larger maritime area than its land area at 488,762 km^2 (Central Statistics Office, 2021). All of these resources make Ireland a potential destination for bioeconomy development. The Republic of Ireland contains 3 NUTS2 regions (Northern and Western region, Eastern and Midlands region and Southern region), along with 8 NUTS3 regions and 26 counties. Its main areas of primary production include grassland production at over 80% of total agricultural land (mainly beef and dairy), production of livestock (mainly dairy, beef, pigs, poultry, sheep), and a smaller tillage sector (mainly barley, wheat, oats). While Ireland’s food sector is a large contributor to Ireland’s exports and rural economy, a challenge exists due to the high share of national greenhouse gas emissions (33%) which can be attributed to the agriculture sector (Department of Communications, 2017). In response to this, Ireland has introduced a Climate Action Plan in 2021 with the aim of reducing greenhouse gas emissions by 51% by 2030 and achieving climate neutrality by 2050 (Dept. of Environment, 2021). To help achieve this, sector emission ceilings have been introduced, including a 25% reduction in agricultural emissions by 2030 as compared to 2018 levels. These factors, along with market sensitivities, emphasized by Brexit, have supported investment into Ireland’s bioeconomy which is seen as an avenue for defossilization, increased competitiveness and market diversification.

The bioeconomy sector in Ireland employed almost 180,000 people across its various sectors in 2019, while the combined value-added from these sectors reaching almost €17 million (Knowledge Centre for Bioeconomy, 2023). Ireland has 14 bio-based industry facilities, with 11 being commercial plants and remainder being R&D and demo plants. These are mainly focused on chemicals and liquid biofuels (JRC, 2022). Ireland has had a National Bioeconomy Policy Statement in place since 2018 and has established a Bioeconomy Implementation Group, which is jointly chaired by the Department of the Environment, Climate and Communications and the Department of Agriculture, Food and the Marine, has a mandate to oversee the development of the bioeconomy in Ireland (Dept of An Taoiseach, 2018). In 2021, the Irish government established a National Bioeconomy Forum to provide a voice for a broad range of stakeholders, including industry, community groups, NGOs and relevant state bodies. In addition, the government expects to publish a first National Bioeconomy Action Plan in 2023 for implementation during the 2023-2025 period.

Ireland's MIP region, the NUTS2 Southern Region of Ireland is comprised of three NUTS3 regions and 10 local government areas (Mid-west; Clare, Tipperary, Limerick; South-East; Carlow, Kilkenny; Wexford; Waterford; South-West; Kerry, Cork). This region comprises some of Ireland's richest agricultural land, with many of the country's largest agriculture co-operatives based within the region. In particular, the region comprises some of Ireland's best grasslands, and it is also home to Ireland's traditional cereal production areas along the Eastern Countries. It is also home to many smaller industries in areas such as livestock and fruit production. While the region does not have a dedicated regional bioeconomy strategy, an objective of Ireland's Climate Action Plan is to support regional assemblies to identify areas of potential growth in the bioeconomy. The Southern Regional Assembly of Ireland are currently participants on the Horizon Europe ROBIN project, which is aiming to identify and co-develop good governance practices for regional bioeconomy development. In 2016, parts of the Southern Region, were awarded the status of Model Demonstrator Region for Sustainable Chemical Production, centred around a National Bioeconomy Campus at Lisheen in Co. Tipperary. The development of the campus is led by the Irish Bioeconomy Foundation, a national cluster, comprised of large and small companies, public sector bodies and academic partners. The campus is home to the Bio-based Industries Joint Undertaking Flagship initiative called AgriChemWhey, aiming to produce bio-based chemicals and co-products from whey permeate. Another clustering initiative Circular Bioeconomy Cluster South-West, based in Tralee, Co. Kerry, is also supporting education and outreach to companies in the South-West Region. Several universities, centres and groups are active in various aspects of bioeconomy research, with much of these involving collaborations with industry. An overview of some relevant value chains in the region is provided below.

6.1 Grass Value Chain

Out of a total of 4.9 million ha of Agricultural Area Used (AAU), grassland comprises almost 4.1 million ha making it the most abundant forms of terrestrial biomass in the country (Central Statistics Office, 2016). Ireland is the only country in Europe with over 50% of its total land area as grassland, (57% of total area) (Eurostat, 2021a). Yields of grass in Ireland are comparatively high at 12.7 to 15.0 tDM/ha (O'Donovan et al., 2022). The main purpose of grassland in Ireland currently is to provide grazing and forage for livestock animals, particularly beef and dairy cows. However, livestock-based farming is a key contributor to Ireland's national greenhouse gas emission profile, with rumen methane from cows, forming over 50% of the total emission contribution from agriculture (Department of Communications, 2017). Consideration must therefore be given to reducing animal stocks and potential alternative land uses, which may provide new bioeconomy opportunities.

6.1.1 *Biomass Arisings and Flows*

In Ireland productive grassland can be roughly divided between grass that is intensively managed (includes grazing and silage) and grass that is only used for silage harvesting. A breakdown of the total grass flows and arisings considering both types of grassland and is included in Figure 21 and 22 below, with a total production of just over 40 million tDM. Counties Cork (2,308,555 tDM from silage only grassland, and 8,293,652 tDM from intensive land) followed by Tipperary (1,312,678 tDM from silage only land, and 5,412,481 tDM from intensive land) are the largest producer regions for grass. All counties produced a large volume of grass in both categories. In terms of the flow of grass, grass harvested from silage only land is used as ruminant feed only, while from intensive land 70% of the grass estimated to be used for grazing with the remaining 30% harvest for silage as winter forage for ruminants (Figure 21 below). A small amount may be used in anaerobic digestion, but this is currently considered to be very small. A more detailed summary of the availability and flow of grass can be found in table format in Appendix 2. Grass is estimated to have a market value of €121 per tDM and up to €204/ tDM for 1st cut grass silage.

Figure 21. Sankey diagram showing the arisings and flows and fates of grassland biomass across different regions of the Irish MIP region.

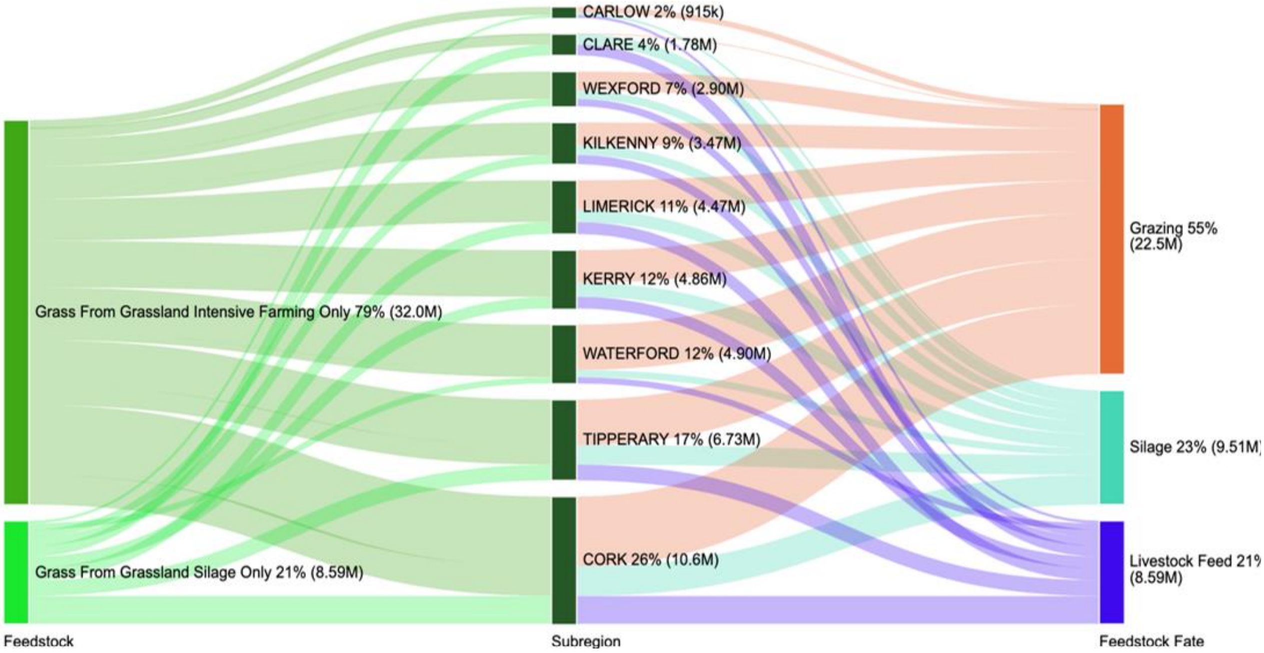


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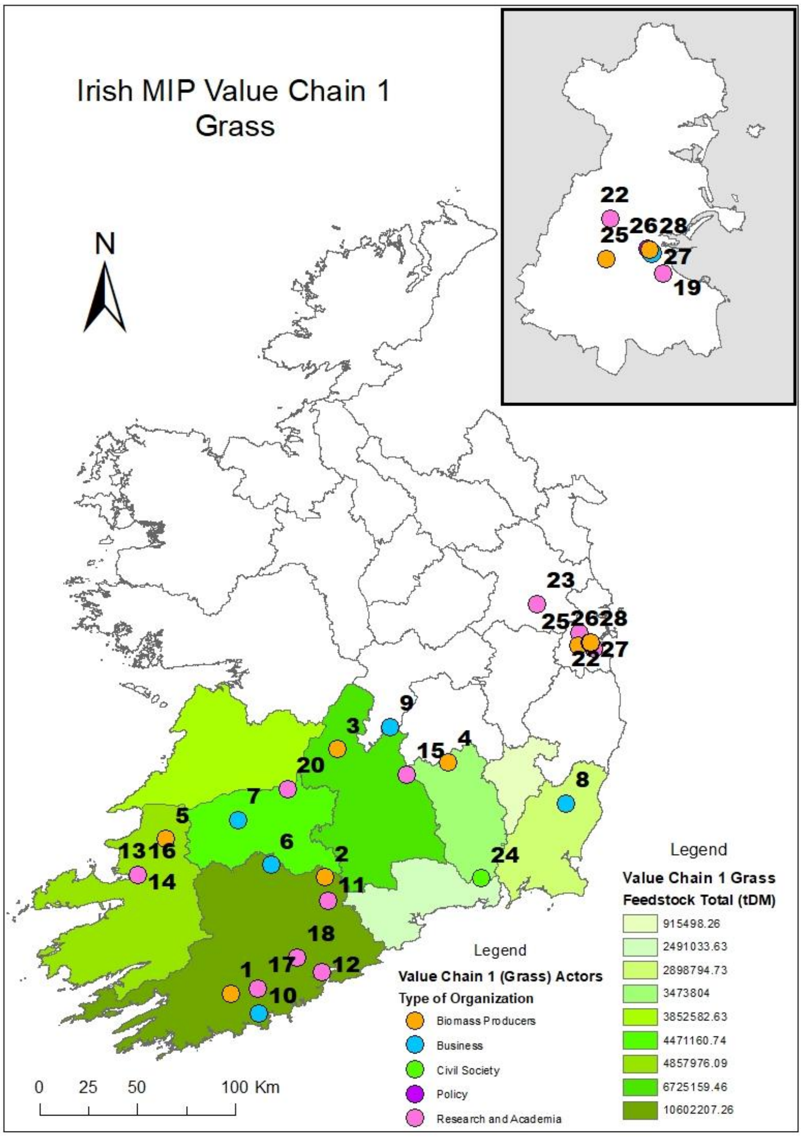
Figure 22. Map of arisings of grassland biomass and key stakeholders within the Irish MIP region.



Biomass Producers		**Business**		**Civil Society**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
1	Carbery	6	Dawn Meats	24	Southern Regional Assembly	26	Dept of Agriculture	11	Teagasc Moorepark
2	Dairygold	7	ABP Food Group					12	MarEI
3	Arrabawn	8	Irish County Meats					13	CircBio Group

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4	Glanbia	9	Ashboune Meats					14	Shannon Applied Biotechnology Centre
5	Kerry Group	10	Barryroe Co-operative					15	AgriChemWhey
25	Irish Farmers Association	27	Dairy Industry Ireland					16	Biorefinery Glas
28	Irish Cooperative Organisation Society							17	Farm Zero C
								18	NEWTRIENTS
								19	BiOrbic
								20	DPTC
								22	Meat Techology Ireland
								23	Teagasc Grange

6.1.2 *Biomass Value Chain Actors*

A summary of some key identified grass value chain actors and their stakeholder role can be seen on Figure 22. In Ireland Dairy production is dominated by cooperatives, many of whom have an international presence, such as Carbery, Glanbia and Dairygold. The beef sector is more fragmented with individual farmers supplying a number of regionally located factories. Various universities and research centres such as DPTC, BiOrbic, CircBio, BiOrbic, MarEI, Shannon ABC and Teagasc Moorepark are active in providing support to research in these sectors.

6.1.3 *New Biomass Value Chain Opportunities and Examples*

In Ireland research is already underway, to consider alternative approaches to grassland management. This includes on the input side, to consider how grass may be produced more sustainably through inclusion of clover and multispecies swards (Moloney et al., 2020; Sheridan et al., 2022), to the development of bio-based fertilisers and biostimulants as alternatives to traditional fertilisers (Quille et al., 2022). A flagship project in Ireland called "Farm Zero C" is using a holistic approach, combining multiple strategies with the aim of developing a net zero emissions model for the dairy sector. The approach involves addressing management practices, including grass and soil management, reducing input emissions, testing low emission diets including anti-methanogenic feed additives, and looking for opportunities to displace emissions off farm, e.g., through production of on-farm energy, and biorefinery products. In recent years, Ireland has become active in the research and development of green biorefineries for the processing of grass and other green leafy biomass. The EIP-Agri Biorefinery Glas project, has been a flagship project, led by Munster Technological University, Carbery and others for the development of farm-based biorefineries, producing low emission feed products for ruminants and pigs, displacing soybean meal imports, extracting prebiotic sugars and co-producing bioenergy through anaerobic digestion. The results have shown good potential for the development of green biorefineries in Ireland (Ravindran et al., 2022; Ravindran et al., 2021; Serra et al., 2022). In February 2022, the Irish Department of Agriculture announced a €3 million infrastructure investment granted to MTU and University College Dublin to develop an integrated green biorefinery and anaerobic digestion plant in collaboration with Carbery in Cork, Ireland. Another green biorefinery project funded through the EU LIFE Programme called Farm4More is also looking to produce feed products along with biochar from grass. Other approaches such the GRAZE project, is looking at develop a community-based anaerobic digestion programme which includes grass as part of the supply chain. Looking at the broader, grassland value chain, several models exist which focus on extracting value from dairy residues. These include the Carbery Dairy model, based at Balineen Co. Cork, which produces whey protein, second generation bioethanol and biogas from residues to cheese production. Another large co-operative, Glanbia, lead the BBI JU AgriChemWhey project which is aiming to produce lactic acid, fertiliser and high value ingredients from dairy processing sidestreams.

Figure 23. The Biorefinery Glas grass biorefinery initiative based in Cork and Kerry, Ireland (Source: https://biorefineryglas.eu/).

6.2 Manure Value Chain

Due to the high herd count particularly in the cattle sector, significant amounts of cattle slurries and manures are produced on an annual basis in Ireland. A previous report suggested that over 37 million tDM of animal slurry are stored in Ireland annually (Ni Ruanaigh and McGrory, 2011). The slurry is primarily stored and landspread to supply nutrients for soil. However, both the storing and spreading of animal slurry is key source of greenhouse gas emissions in Ireland. Manure management accounts for almost 10% of national emissions (Department of Communications, 2017). Aside from the greenhouse gas emissions challenges there are also challenges around water and air quality which are associated with slurry and manure management. These feedstocks could be potentially processed to bio-based fertilisers or energy sources. A recent study has found that using a combination of slurry, manure and grass silage feedstocks, biogas or biomethane could potentially contribute to 28% of Ireland's annual gas supply by 2025 (SEAI, 2018). The government has recently increased its biomethane production ambition with a target of 5.7TWh of biomethane production in Ireland by 2030.

6.2.1 *Biomass Arisings and Flows*

Given that the Southern Region of Ireland is a key location for beef and particularly intensive dairy production, a large volume of slurry biomass arisings is estimated within the region, approximately 29.4 million tDM. Figures 24 and 25, respectively, provide an overview of the regional breakdown and flow and arisings of manure biomass across the regions and combines slurry and manure feedstocks dairy and beef cattle, sheep, pig and poultry sectors.

It is assumed that 100% of the biomass is supplied back to the land directly or stored and then applied to the land (Figure 24 below). A small amount is used for anaerobic digestion; however this is currently considered very minor and no precise figures are available. A more detailed summary of the availability and flow of biomass per county can be found in Appendix 2. Generally animal manure is not linked to a specific price in Ireland.

Figure 24. Sankey diagram showing the arisings and flows and fates of livestock manure across different regions of the Irish MIP region.

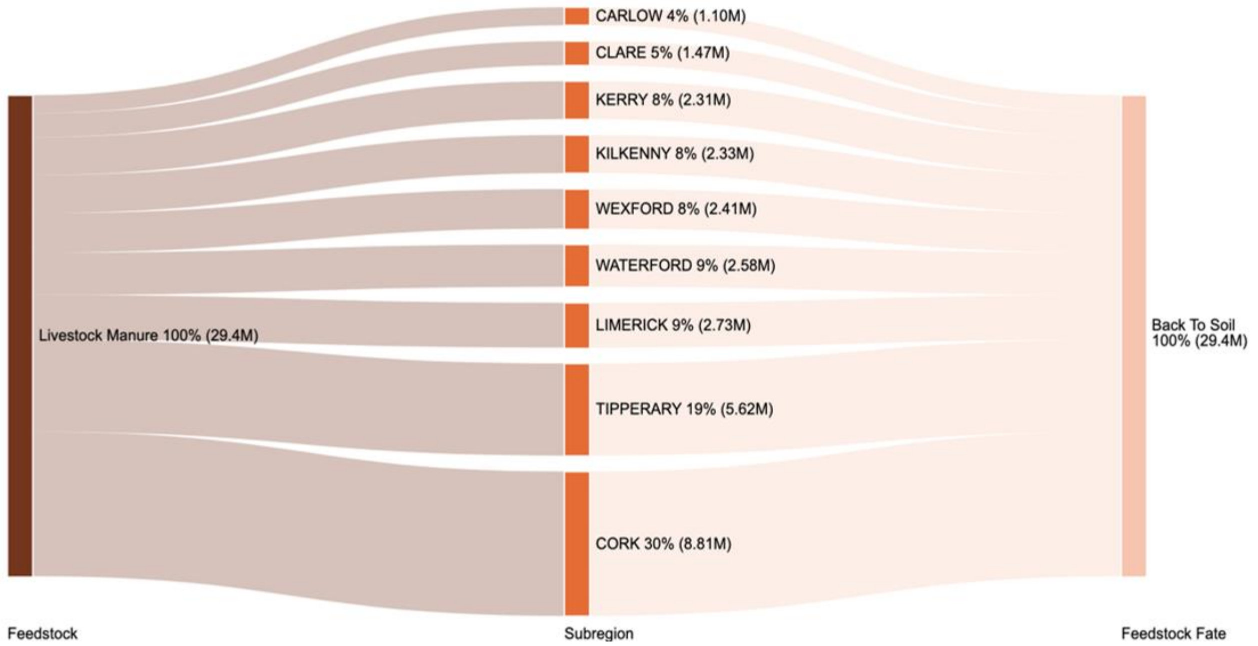

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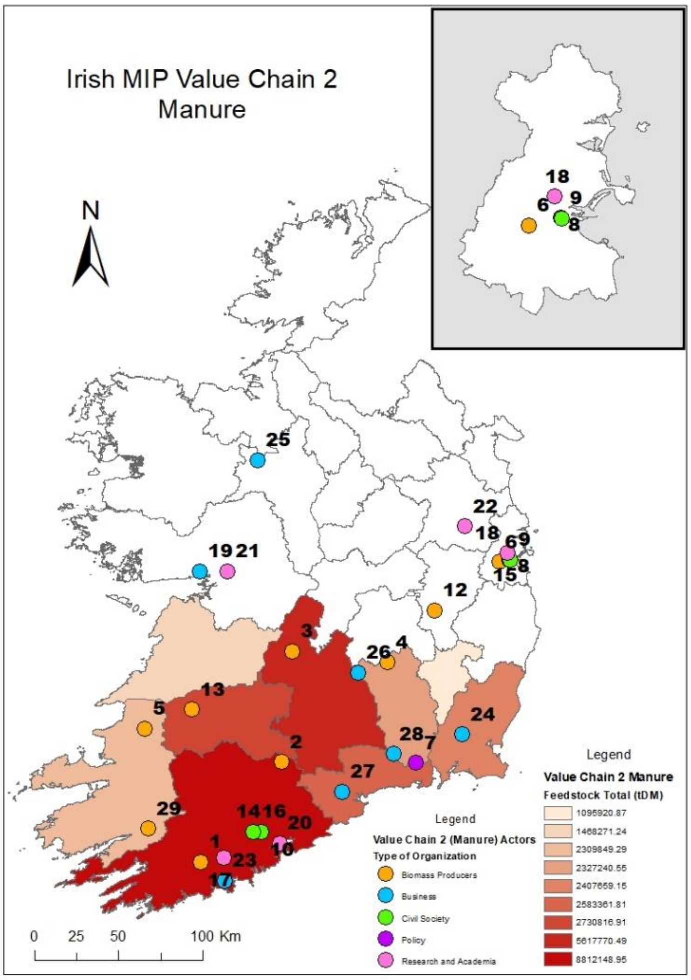
Figure 25. Map of arisings of animal manure biomass and key stakeholders within the Irish MIP region.



Biomass Producers		**Business**		**Civil Society**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
1	Carbery	10	Gas Networks Ireland	9	Irish Cooperative Organisation Society	7	Southern Regional Assembly	17	Farm Zero C
2	Dairygold	19	NVP Energy	14	Renewable Gas Forum	8	Dept of Agriculture	18	Small biogas demonstration programmme
3	Arrabawn	23	Timoleague AgriGen	15	Irish Bioenergy Association			20	MarEI
4	Glanbia	24	Biogreen Energy Products Ltd	16	Fertilizer Association of Ireland			21	Fleet Project

5	Kerry Group	25	BioCore Environmental					22	Teagasc, Grange
6	Irish Farmers Association	26	BEOFS Biodigester						
12	Green Generation	27	Ashleigh Environmental						
13	Green Gas	28	Ormonde Organics						
29	Roughty Valley Cooperative								

6.2.2 *Biomass Value Chain Actors*

As slurry is generally produced on farms, it is managed by the farmers. Some of these farmers operate within cooperatives, particularly within the dairy sector. However, many farmers operate independently, within the beef, poultry and pig sectors. As there is much interest in the renewable energy development from slurries, some of the key actors have also been highlighted such as Gas Networks Ireland, the organisation that own and operate the natural gas network in Ireland. Existing biogas plants such as Green Generation, Timoleague AgriGen and Green Gas, projects such the GRAZE project, and associations such as the Renewable Gas Forum and the Irish Bioenergy Association, are also key actors within the sector and region.

6.2.3 *New Biomass Value Chain Opportunities and Examples*

As slurry management is a major contributor to agri-related emissions, various approaches to slurry management are being considered. Low Emission Slurry Spreading and the use of protected urea are commonly promoted as good practice steps for adoption on farms in Ireland. At research level novel solutions for slurry management are being developed. Irish company GlasportBio developed an additive applied to slurry in storage which has proven highly effective at reducing methane, hydrogen sulphide, ammonia and other gaseous emissions associated with slurry management. In addition, by preventing loss of valuable nutrients this enhances the value of manure and slurry for onward uses, such as anaerobic digestion. A recent study found that this reduced gaseous emissions by cattle slurry by up to 90% with additive-treated slurry providing a richer feedstock for anaerobic digestion, increasing methane output by 17% (Thorn et al., 2022). Various research, and demonstration projects are underway to support biogas production at different scales, including at farm scale (e.g., through the EIP-Agri Small Biogas Demonstration Programme) and at larger scale (e.g., through the GRAZE project which will construct a central grid injection (CGI) facility in Mitchelstown, Co. Cork. Projects such as ReNU2Farm are investigating the potential and marketability of recycling derived fertilisers from farm residues such as slurries. Teagasc have commissioned an anaerobic digestion plant (1,625 m3 digester capacity) at their Grange research facility which will test the co-digestion of different sources including pig and cattle slurry and grass silage.

Figure 26. Teagasc Grange Biogas Plant at Grange, Ireland (Source: https://www.teagasc.ie/).

6.3 Cereal residue Value Chain

While Ireland's tillage sector has declined in recent years, due in part to dairy expansion, it is still a significant component of agriculture nationally. Cereals comprise the largest component of the tillage sector, with approximately 280,000 ha and an annual crop output of around 2.3 million tonnes DM (Wallace, 2020). A recent study showed that tillage farms have the lowest carbon footprint at 2.5 t/ha, compared to the other main farming enterprises such as dairy production with 9.5 t/ha (Teagasc, 2021). The Southern Region of Ireland contains most of the areas which hold a strong tradition of producing cereals, and other crops like sugar beet, particularly around the East Coast. Cereals, mainly wheat, barley and oats, are used for the production of oats, whiskey, beer and other products across Ireland, generating by-products at the factory (e.g., brewers spent grain) and in the field. On the field, straw is a key by-product of the cereals sector. Recent studies show that the sector generates an estimated 750,000-1 million tDM of by-products annually on a national level (Attard et al., 2020; BioEire, 2017). The straw by-products are currently used in relatively low economic value applications such as animal bedding and land application but could potentially be used for the generation of biochemicals, biomaterials and bioenergy.

6.3.1 *Biomass Arisings and Flows*

The total straw biomass (derived from barley, oats and wheat combined) within the Southern Region of Ireland is estimated at just over half a million tDM. The bulk of this is derived from barley, followed by wheat and oats. The flow of this biomass is presented in Figure 27, while total arisings at a county level is presented in Figure 28. Cork and Wexford are the largest producer counties (in excess of 100,000 tDM each), with significant volumes also being produced in Carlow, Kilkenny and Tipperary. A breakdown of the straw types within these regions is included within Appendix 2. Figure 27 shows the flow of straw into different applications across the MIP region. For all straw types, the main applications are in animal feeding and bedding, with a small amount applied to land. In the case of wheat straw, a proportion of this also goes towards mushroom composting. Mushroom compost is manufactured from wheaten straw and poultry manure, with the addition of water and gypsum. Ireland introduced a Straw Incorporation Measure in 2022 with the purpose of encouraging tillage farmers to increase soil organic carbon levels by chopping and incorporating straw from cereal and oilseed crops. The aim is to sequester carbon in tillage soils, thereby reducing greenhouse gas emissions.

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Figure 27. Sankey diagram showing the arisings and flows and fates of cereal straws across different regions of the Irish MIP region.

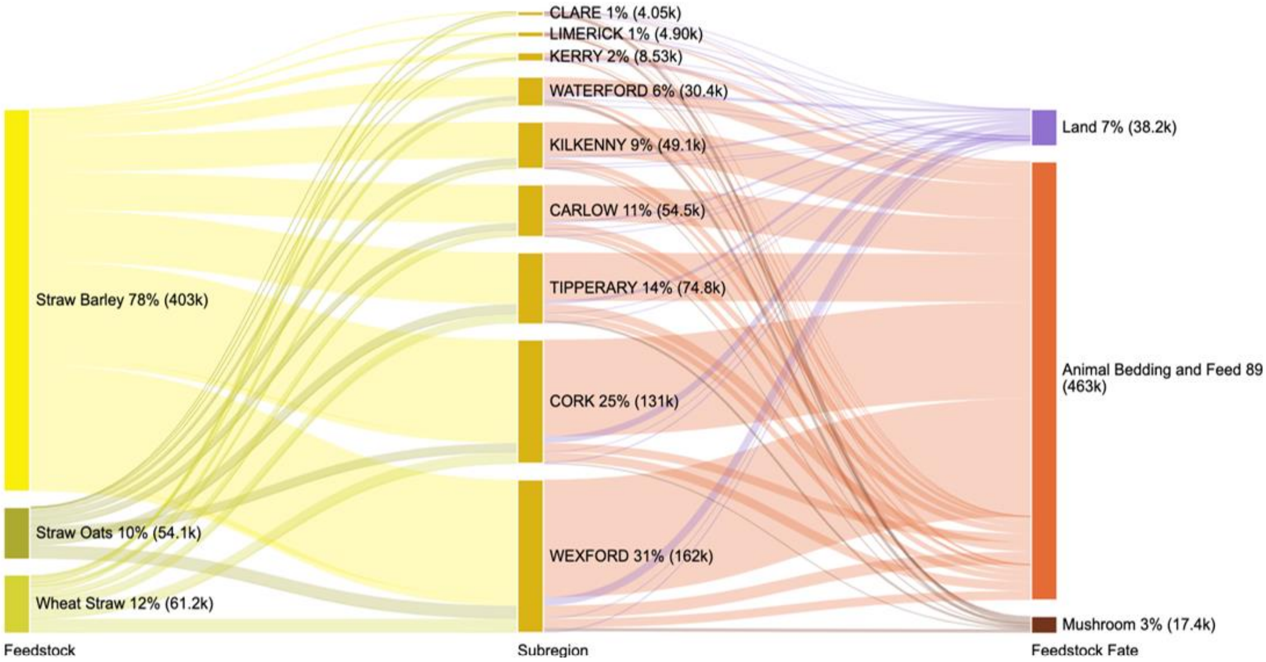
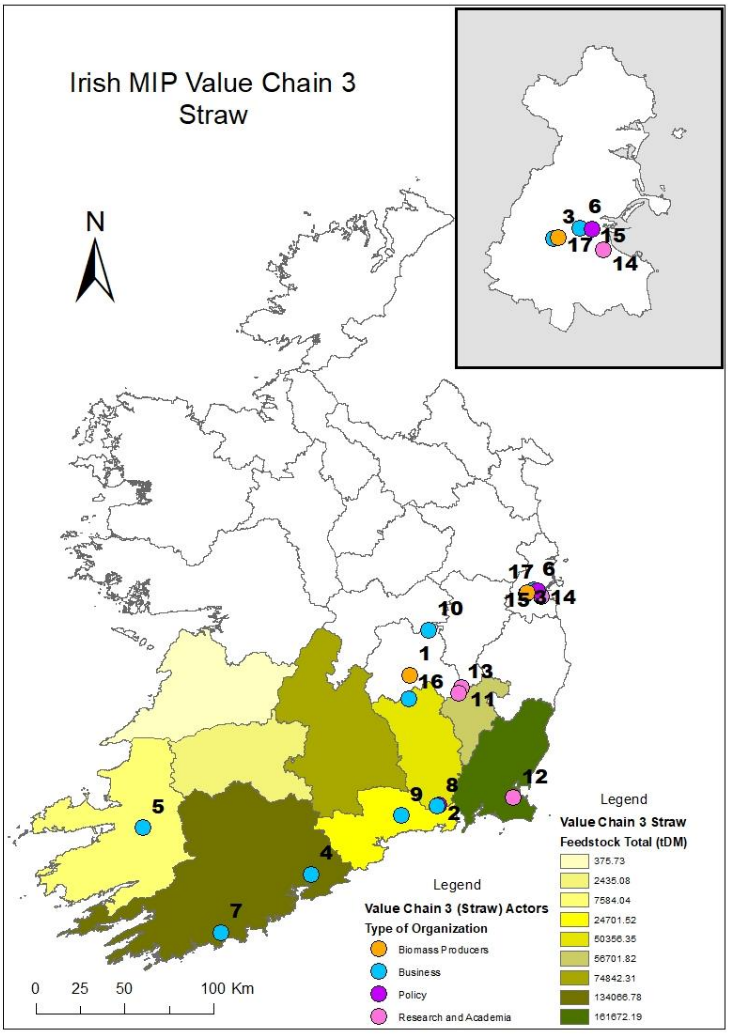


Figure 28. Map of arisings of cereal straw biomass and key stakeholders within the Irish MIP region.



Biomass Producers		**Business**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
1	Irish Grain Growers Association	3	Irish Distillers	2	Southern Regional Assembly	11	Teagasc Oakpark
17	Irish Farmers Association	4	Jameson Distillery	15	Department of Agriculture Food and the Marine	12	Teagasc Johnstown Castle
		5	Torc Brewery			13	South East Technological University (Carlow)
		6	Diageo/Guinness			14	UCD, School of Agriculture

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		7	Clonakilty Brewing				
		8	Metalman Brewing				
		9	Flahavans				
		10	Odlums				
		16	Tirlan (formerly Glanbia)				

6.3.2 *Biomass Value Chain Actors*

Straw production is mainly overseen by individual farmers who are managing the crop. These are mainly represented by the Irish Farmers Association and Irish Grain Growers Association. Other actors in the value chain include those actors currently using the crops produced such as food producers like Flahavans and Odlums, and brewing and distilling companies such as Diageo and Irish Distillers. Compound feed companies also form part of this user group. Various research entities are involved in research related to crops, with Teagasc Crops Centre at Oakpark being a central research body in the development of cereal crops.

6.3.3 *New Biomass Value Chain Opportunities and Examples*

Various research and demonstration activity is being conducted within the region which has the potential to increase the sustainability, and lead to new value chain opportunities from straw. On the input side work is under way to evaluate the potential of biostimulants to replace mineral fertilisers in order to enhance cereal crop production (Goñi et al., 2021). Various studies have been conducted evaluating the potential of biofuels such as bioethanol and pyrolysis oil from different kinds of straws (Butler et al., 2013; Murphy and Power, 2008; Spicer et al., 2012). In Ireland, the Grow Green Burn Blue project is investigating the co-production of pyrolysis oil and other energy carriers from straw and other biomass sources using a continuous pyrolysis process. The process will be integrated within a districted heating scheme, while the project is also exploring the different value-added products which may be used from the process. Previous attempts have been made to develop commercial projects based on straw and other cereal-based residues in Ireland including as an energy source, and for the production of chemical building blocks (Plastics Today, 2013; Renewables Now, 2013). Internationally several projects are underway to explore the use of straw in advanced applications. One example is the Optisochem project which focuses on the conversion of wheat straw to bio-isobutene, a chemical building block with applications in the energy, materials and cosmetics sectors.

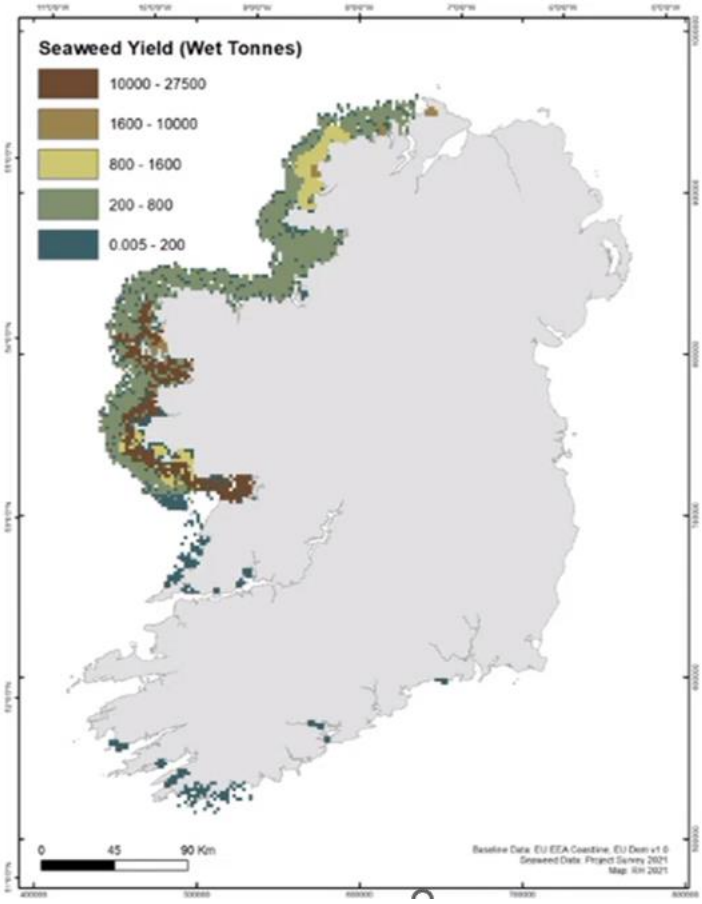
6.4 Seaweed Value Chain

With a large coastline, Ireland is home to a large maritime sector, in particular for food applications. A declared landing of 322,785 wet tonnes of fish were landed in Ireland in 2021(Sea Fisheries Protection Authority, 2022). The main sources of pelagic fish include Boarfish, Mackerel, Horse mackerel and Albacore tuna, with Whitefish sources mainly including Haddock, Whiting and White Pollock (Bord Bia, 2017). Shellfish and crustacean sources include Brown crab, Velvet crab, Prawns, Lobster, Pink shrimp, Whelks, Scallop and Periwinkle, while the main aquaculture sources include Organic salmon, Organic mussels and Oysters (Bord Bia, 2017). Ireland also has an emerging sector focused on the harvesting and landing of seaweeds for various applications including food ingredient, health products and cosmetic products. Primary sources include dulse, carrageen moss, and various kelps and wracks. The seaweed sector is still relatively small-scale and largely untapped, but with enormous potential for developing value-added materials.

6.4.1 *Biomass Arisings and Flows*

Approximately 40,000 wet tonnes of seaweed is harvested in Ireland each year with over 95% naturally grown (Bord Bia, 2021). While the actual regional breakdown of seaweed feedstocks exists, a new study has mapped the seaweed arisings as coastal locations in Ireland, with the main production areas along the North-Western, and Western Coastlines, with smaller production areas of the South-Western Coastal areas of Cork and Kerry. Ascophilum nodosum (not represented in the south, represents 98% of the seaweed harvested in Ireland) is used to produce intermediary ingredients (for valorising) and lower value products for agricultural/amenity horticulture use. The price of Ascophilum nodosum is approximately 60 €/wt. Nationally the main other species (excluding Ascophilum nodosum) of seaweed harvested include Saccharina latissimi, Pelvetia canaliculate, Palmaria palmata, Nori, Laminaria digitata, Himanthalia elongate, Fucus serratus, Chrondrus crispus and Alaria esculenta, amounting to a total of approximately 33,000 wet tonnes, ranging in price from 800-1500 €/wt. Regardless of the species, it is estimated that in the South of Ireland from 0.005 to 200 wt per 2 km of beach is harvested per year. Traditionally the destination of the seaweed has been agriculture (soil amendment) and animal feed but there is currently an expansion of seaweed for human use in cosmetics, nutraceuticals, or food, growing over time. A map of the main yields of seaweed (wet tonnes) in different coastal regions of Ireland is provided in Figure 29.

Figure 29. Map displaying the main yields of seaweed in different coastal regions of Ireland (source: Gibson, C. 2023).



6.4.2 *Biomass Value Chain Actors*

Over 40% of the seaweed processors are in the South of Ireland. The primary processing is primarily located in the Northern part of the country while the valorisation process is mainly located in the South. Some key processing actors include Nutramara, Brandon Scientific and Bioatlantis on the South-Western coast, and Marigot on the Southern coast. Key research organisations and centres active in the area of seaweed research include Munster Technological University (CircBio and Shannon ABC), BiOrbic, Bantry Marine Research Station, the Marine Research Institute and MarEI. Bord Iascaigh Mhara, the agency of the Irish state with responsibility for developing the Irish marine fishing and aquaculture industries, is another important stakeholder.

6.4.3 *New Biomass Value Chain Opportunities and Examples*

Due to the large number of innovative processors and research entities active within the region, there are many examples of innovative projects and companies focusing on the valorisation of seaweed. Recent studies have shown the potential for seaweed-based bio-stimulants (Ascophilum nodosum) to reduce the nitrogen input requirements of various crops while maintaining yield of these crops (Goñi et al., 2021; Quille et al., 2022). Some of these biostimulants may also be used to support plant production in regions prone to drought (Goñi et al., 2018). Research is also underway among Irish research entities to investigate the extraction of polyphenols, laminarin, protein, and other bioactive and antioxidant compounds for use in food, nutraceutical and feed applications (Kadam et al., 2017; Kadam et al., 2015b; Ummat et al., 2020). Other applications in high value biomaterials and cosmetics also hold potential (Kadam et al., 2015a; Kadam et al., 2015c). Due to the high-level emissions attributed to livestock production, a recent interest in the potential of seaweed additives as methane-abating feed additives is also being investigated. A recent project called Sea Solutions has been established to evaluate ingredients to reduce enteric methane emissions from pasture-based sheep, cattle and dairy cows. Regional companies such as Bioatlantis and Nutramara are developing technologies and bringing products to market across a range of products from biostimulants, nutraceutical and cosmetic products.

Figure 30. Facilities of BioAtlantis in Kerry, Ireland (Source: https://www.bioatlantis.com/).

6.5 Apple residue Value Chain

Irish apples have been grown commercially for over a century and considered a lucrative crop in suitable areas. A decline in production began in 1973 upon entry to the EU and lifting of tariffs on imported apples. The total apple production area in 2017 was 713 ha (Teagasc, 2020a). There are three types of apples produced commercially in Ireland: dessert apples (eating apples); culinary (cooking) apples; and cider apples. Dessert apples are the most common type found in retail sales in Ireland, while Cider apple production consists of about a third of the acreage being grown with special varieties. The out-graded apples from both dessert and culinary apple production are used to make cider (Teagasc, 2020a). The recent trend towards smaller craft cider production, has led to some increased demand for apples to meet this market.

6.5.1 *Biomass Arisings and Flows*

The total amount of damaged apples going for cider production in Ireland is estimated at 1,362 tDM, with Carlow identified as the main production area for these apples. The main production zones are highlighted in Figure 32. The flows of this biomass across regions and fates are indicated in Figure 31 below, with over 60% going for cider production, and around 16% produced as a pulp from cider process which is often landfilled. A small amount of pruning residues is also produced. Apples vary in price between 750 €/ton for dessert and culinary apples to 185-266 €/ton for cider apples. A more detailed breakdown of biomass arisings and flows is included in Appendix 2.

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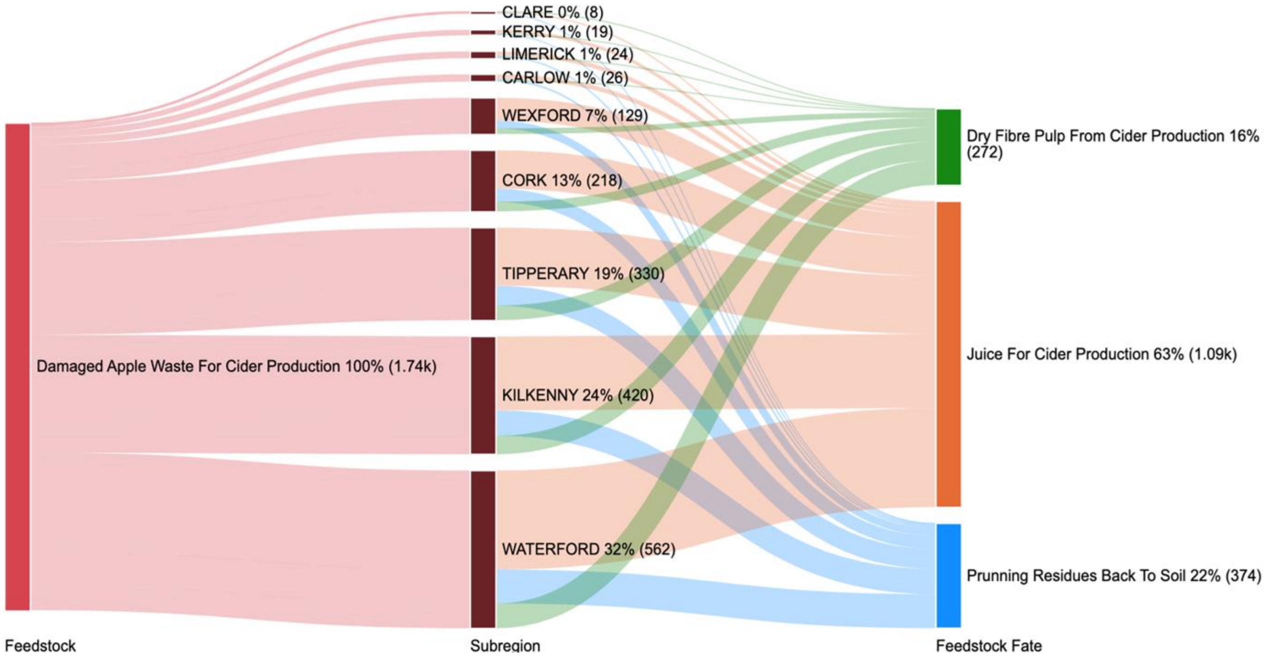
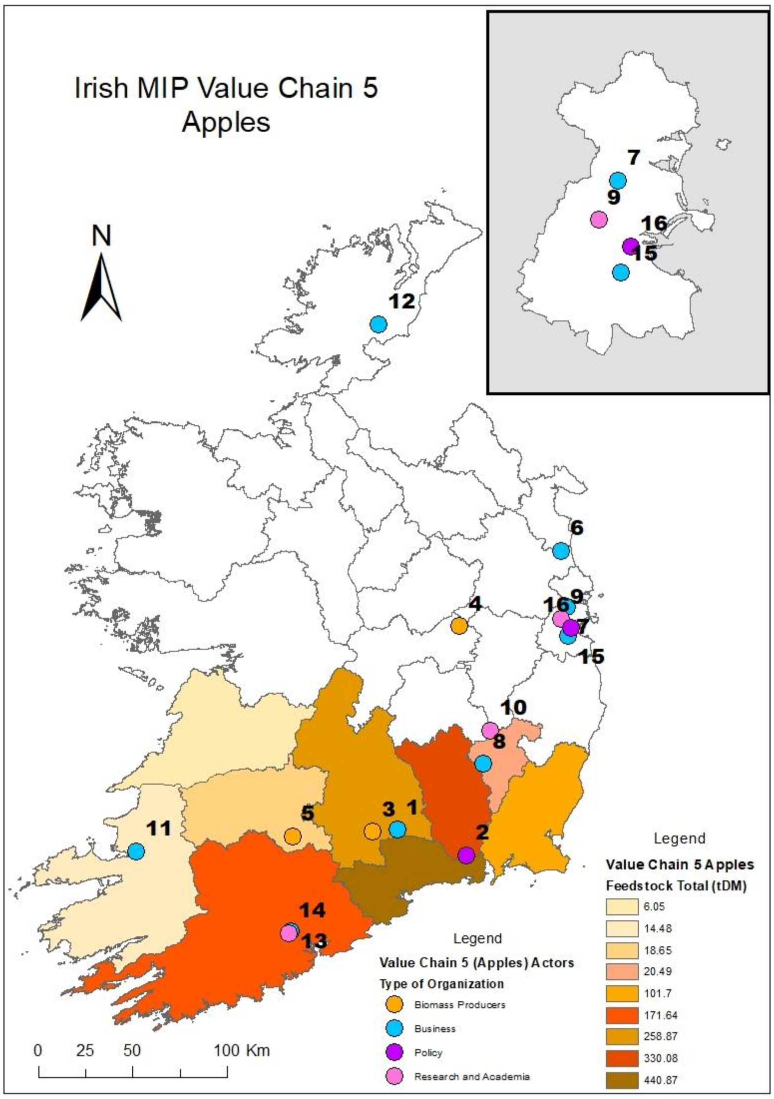
Figure 31. Sankey diagram showing the arisings and flows and fates of damaged apples across different regions of the Irish MIP region.



Funded by the European Union

Figure 32. Map of arisings of apple residual biomass and key stakeholders within the Irish MIP region.



Biomass Producers		**Business**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
3	Apple Farm, Tipperary	1	Bulmers	2	Southern Regional Assembly	9	Teagasc Ashtown
4	Apple Farm, Offaly	6	Dan Kelly's Cider	16	Department of Agriculture Food and the Marine	10	Teagasc Oakpark
5	Apple Farm, Limerick	7	Keelings			14	UCC

		8	Falling apple cider				
		11	Total Produce				
		12	Mulrines				
		13	Heineken Cork (producing Orchard Thieves Cider)				
		15	Vitners Association of Ireland				

6.5.2 *Biomass Value Chain Actors*

Bulmers Ltd. based within the Southern Region of Ireland (at Clonmel, Tipperary) is Ireland's largest cider producer and the main consumer of apples for cider production. Smaller breweries for Cider production include Falling Apple Cider, Dan Kelly's Cider, along with Heineken in Cork, which produces Orchard Thieves Cider. A number of juice producers also exist including Ballybryan Farm and Mulrines. There are about 40 full-time commercial apple growers in Ireland, and a number of additional smaller-scale operatives, growing approx. 15,000tDM of apples on an annual basis (Irish Apple Growers Association, 2020).

6.5.3 *New Biomass Value Chain Opportunities and Examples*

Although the volume of apple processing residues is relatively small compared to other sectors, this material has a high sugar content which may be suitable for use in higher value added processes. To date only a relatively small amount of research regarding these residual streams appears to have been undertaken. Wijngaard and Brunton (2009) investigated the optimization of extraction of antioxidants from apple pomace using pressurized liquids. Reis et al. (2014) investigated apple pomace as a potential ingredient for the development of new functional foods, finding that the inclusion did not compromise the food negatively, but increased fibre and phenolic content, along with antioxidant capacity of the project. Other studies internationally have investigated the use of apple processing residues in applications including biofuels, bio-based chemicals and materials (González-García et al., 2018; Gulhane et al., 2015; Gustafsson et al., 2019).

6.6 Hemp Value Chain

Over the last decade there has been a growing interest in Ireland in the development of a hemp industry. The interest in hemp comes from its potential application both for medicinal and material products. Hemp is an excellent break crop as its extensive root system improves soil structure. Subsequent crops have less weed pressure, and yield increases of 10–20% have been shown in winter wheat crops grown after hemp (Finnan and Styles, 2013). It has been demonstrated that hemp can produce high annual yields of biomass of approx.12.5 t/ha in Ireland with no agrochemical input and with modest fertilizer input. In addition, there is a growing interest in the potential of hemp to contribute to Ireland's plan for defossilization. The estimated sequestration rates from hemp production are between 10 to 22 t of carbon dioxide (CO_2) emissions per hectare (Madden et al., 2022).

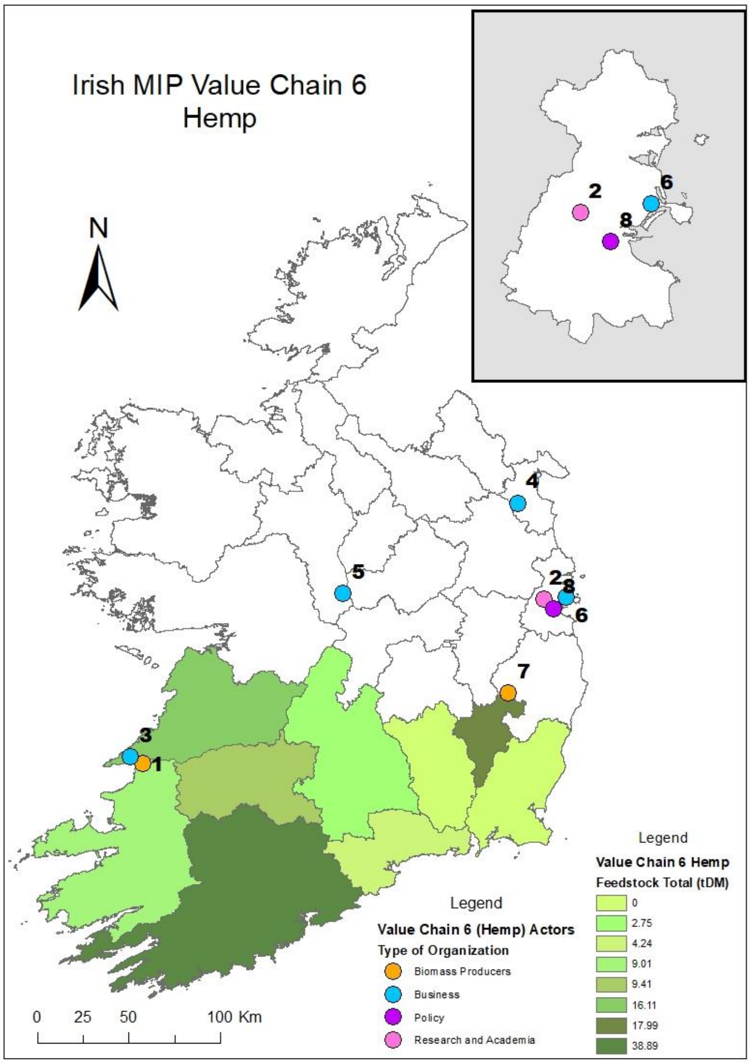
Hemp can potentially be fractionated into different streams for further added value including stalk (into fibre and hurd), seeds (into hemp oil and seed meal), or flower (into CBD products) (Teagasc, 2020b). Hemp can be used in the construction, car manufacturing, paper, food, animal bedding, clothing, drinks, health, pharmaceutical, biofuel and cosmetics industries. Hemp oil is used in health supplements, personal care, cooking and also in industrial applications such as linseed oil in paints (Department of Agriculture, 2022).

Current legislation in Ireland does not allow for the growing of hemp unless a specific license has been granted by the Health Products Regulatory Authority (HPRA) which operates under the auspices of the Department of Health (Department of Agriculture, 2022). Hemp farmers must under current legislation destroy the hemp flower, as cannabinoids are produced in the flower head (Teagasc, 2020b). The current legislative framework is described as being prohibitive for growers and researchers.

6.6.1 *Biomass Arisings and Flows*

There was an increase in the area of hemp sown in Ireland between 2016 and 2019. However, there was a 77% decrease in area sown between 2019 and 2022 from 316 ha to 72 ha (Department of Agriculture, 2022). While there is a lot of interest in the development of a hemp industry in Ireland, the production level is still low at only approximately 100 tDM based on official figures. There is interest in scaling the industry, but this will require some legislative support, and the deployment of infrastructure for pre-processing of hemp. Some indicative prices for hemp co-products were 200-800 €/tDM for hemp stalk and up to €1500 t/DM of seed (Hemp Cooperative Ireland 2023).

Figure 33. Map of arisings of hemp biomass and key stakeholders within the Irish MIP region.



Biomass Producers		**Business**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
1	Hemp Cooperative Ireland	3	Wild Atlantic Hemp	8	Health Products Regulatory Authority	2	Teagasc Ashtown
7	Hemp Farmer	4	Celtic Wind				

		5	deDanú Limited				
		6	Hemp Heros				

6.6.2 *Biomass Value Chain Actors*

Key actors in the hemp value chain include the producers, mainly represented by Hemp Cooperative Ireland, a national association of hemp producers and other stakeholders. A number of companies are also developing products from hemp feedstock including deDanú and Wild Atlantic Hemp with a primary focus on Cannabidiol as an ingredient in various health products. Research on production and valorsiation of hemp is supported by a number of institutes nationally including Teagasc, Munster Technological University, and Technological University of Shannon, Midlands and Midwest.

6.6.3 *New Biomass Value Chain Opportunities and Examples*

Despite the current, relatively low production of hemp, the interest that has been developed in its potential to bring environmental and commercial benefits (e.g., through biorefining), with interested growers across the country, indicates that this a potential development area for Ireland. Hemp Cooperative Ireland is already actively engaged in a number of research projects with national collaborators on topics including, the design of a hemp harvester which can cut and separate the stalk and seed of the hemp crop. Another ongoing collaboration exists within Shannon ABC, aimed at standardizing cannabinoid extraction in Ireland. A separate initiative called Hemp4Soil investigates the role of hemp in soil biodiversity and carbon storage on dairy farms. Other projects have focused on the potential of hemp and its by-products in various food and material applications including, the extraction of protein for food applications (Cabral et al., 2022) and the use of hemp lime bio-composite as a building material in Irish construction (Daly et al., 2012). At Cloughjordan Eco-village in Co. Tipperary, a first lime-hemp house was developed in 2011 as one of many sustainability initiatives within the village. Cloughjordan is renowned as the village with the lowest carbon footprint in Ireland, and its sustainability ethos has generated an interest from eco-tourists wanting to visit and stay at some of the village's accommodations. To support the development of Ireland's hemp sector, further research is required to develop integrated processing to ensure valorisation of the different hemp fractions (e.g., seeds, stalk or flower). Interesting international projects, such as MULTIHEMP have already shown the potential for hemp co-products to be developed into a spectrum of bio-based materials such as cosmetics (from hemp oil) and insulation and composites (from fibres).

7. Netherlands MIP Regions

Located in Northern Western Europe, Netherlands spans a total area of 41,850 km^2 and contains a population of 17.8 million inhabitants. The country has a coastline of 451km providing direct access to maritime resources in addition to its terrestrial resources. In 2018 primary land use in the Netherlands was mainly focused on agriculture (54%) with a relatively small forestry use (8%) (Eurostat, 2021b). Agriculture is a very important component of the Netherland's rural economy, and overall economy. After the United States, the Netherlands is the biggest exporter of agricultural produce in the world, exporting some €65 billion of agricultural produce annually, which accounts for 17.5% of total Dutch exports (Government of the Netherlands, 2021). The Dutch agricultural sector mainly produces cereal, particularly wheat and feed crops (such as fodder maize) and potatoes (Government of the Netherlands, 2021). The livestock sector is also a significant sector. According to the 2021 Netherlands agriculture census, the total pig population was approximately 11.4 million pigs, the national cattle herd was just under 4 million, the poultry herd was almost 100 million, while the dairy goat herd was 482,000 (CBS, 2021). The horticultural sector focuses on vegetables and flower bulbs with Dutch greenhouses producing mostly vegetables and flowers like sweet peppers and roses (Government of the Netherlands, 2021).

The Netherlands bioeconomy employed over 400,000 people across its different sectors in 2019, with a combined added value from all bioeconomy sectors of almost €33 billion (Knowledge Centre for Bioeconomy, 2023). It is also developing a number of bio-based industries across different sectors. There are 113 bio-based industry facilities based in the Netherlands, 102 of which are classified as commercial plants, with 7 pilot and demo plants and 4 R&D plants. These are mostly related to bio-based chemicals, biomethane, liquid biofuels and pulp and paper, with a minority focused on bio-composites and fibres, sugar and starch and timber (JRC, 2022). Bioeconomy development in The Netherlands is politically guided by the "Framework Memorandum on the Bio-based Economy" (2012). The framework paper complements the innovation contract on the biobased economy, "Groene Groei: Van biomassa naar business" (2012). This bio-based business strategy is a result of the government's 2011 innovation strategy which identified the bioeconomy as a common theme across several top sectors (German Bioeconomy Council, 2015). Other key documents include the "Strategic Biomass Vision for the Netherlands towards 2030" published in 2016, aimed at understanding how the Netherlands can best use its biomass resources to achieve its 2030 policy targets across key areas such as food, energy, climate, mobility and bio-based economy. More recently a comprehensive review has been made of all available bio-based raw materials (feedstocks) which can be used in the bioeconomy now and in the near future, which products can be made now and in the near future and the way to go to increase the production of biomaterials, bioproducts and energy. This report by Corbey & Van Asselt, 2022 was a result of the discussions of the government with many stakeholders on the way for reducing climate impact and the climate pact of the Netherlands. Also, more recently Voncken (2022) published a report commissioned by the ministry of agriculture regarding a microeconomy survey of the bio-based economy in the Netherlands. Voncken (2022) also provides concrete recommendations for further development. These are in line with the report of Corbey & van Asselt, but are sometimes even more specific, namely making bio-based raw materials a spearhead policy and, in addition to residual flows, also focusing on large-scale cultivation of dedicated bio-based crops for the purpose of cost price reduction and sufficient market size for processing. In this report it is stated that it is always essential to enable valuation via CO_2 credits so that revenue models can be created.

Netherlands has long been home to key research and development in the area of bio-based economy through institutes such as Wageningen University, through Wageningen Food and Bio-based Research and the Application Centre for Renewable Resources (ACRRES) and Delft University of Technology, and companies such as Corbion, Royal Cosun, Avantium, BTG, GRASSA and many more. Many research results are in the Groene Grondstoffenreeks (2023).

The focus regions of the Netherlands MIP are the NUTS2 regions of Friesland (NL12) based in North Netherlands and Flevoland (NL23) based in East Netherlands. These regions contain a total farm area of just over 300,000 ha, of which almost 95% is utilised agricultural land serving a variety of primary sectors and generating different types of biomass and residue streams. (EuroStat, 2022). In terms of breakdown of farm area per NUTS2 region of the MIP, it is mainly in Friesland (235,730), with a smaller amount in Flevoland (92,760) (EuroStat, 2022). While the majority of policy frameworks related to the bioeconomy are led by the central government, regional governments of the Netherland's are also supporting these initiatives e.g., through public procurement programmes. In addition, activities in rural areas, such as in Flevoland (Jutte et al., 2018) and Friesland (Vereniging circulair Friesland, 2023) promote the support of farmers in the context of the circular economy with the aim of developing several biobased opportunities. Examples of such actions are the creation of the platforms ACRRES and "Vereniging circulair Friesland". Meanwhile, Horizon Flevoland is the regional development agency in Flevoland which supports Flevoland entrepreneurs who want to grow and support social and environmental challenges. They recently released a multiple year strategic vision and plan for 2023-2027 (Horizon, 2023). There are three pillars: transitions in food production, raw materials and energy. A special focus area mentioned will be bio-based construction. By using bio-based materials in applications a focus in on the sequestering of biogenic carbon in buildings which should be kept for at least several decades. It should also be an additional source of income for farmers for paid CO_2 credits. Horizon Flevoland support this by networking and connecting entrepreneurs and searching and initiating for adequate subsidies with support from students and other stakeholders.

7.1 Value Chain 1 - Manure

In the Netherlands, intensive livestock farming means that there is an excess of manure produced in some regions which cannot be used sustainably by the livestock sector, and this can generate negative impacts on the ecological system. For land application of animal manure, the Netherlands is bound by the annual limit of 170 kg nitrogen as stated in the EU's Nitrates Directive, and the excess of manure places pressure to meet these targets. Dutch manure policy focuses on both the production and the application of manure and fertilizers. The main goal is to prevent or limit nutrient dispersion in the environment by regulating manure application (Leenstra et al., 2019). This manure which cannot be applied directly on the land also presents an opportunity to scale new bio-based industries in the Netherlands. The production of manure at a national level is estimated at 62.2 million tDM in the case of cattle, 10 million tDM in the case of pigs and 1.4 tDM in the case of poultry (Leenstra et al., 2019). Dutch manure exports amount about 3 million tonnes/annum (Netherlands Enterprise Agency, 2022).

7.1.1 *Biomass Arisings and Flows*

Within the MIP region of Netherlands, it is estimated that the arisings of animal manures from the different livestock sectors (cattle, pigs, poultry, sheep and horses), constitutes approximately 12,309,000 tDM allocated by Friesland with 10,911,000 tDM and Flevoland with 1,398,000 tDM. As in the national case, the regional manure is mainly coming from cattle, followed by pigs and poultry. Most of this is estimated to go either for direct land application or for use in anaerobic digestion. However, no precise breakdown was identified. Manure is considered to have a negative price value in the Netherlands of -€10 to – €15 per tonne. The breakdown of slurry by region is provided in Figure 34. A full summary of the arising per region data is included in Appendix 2.

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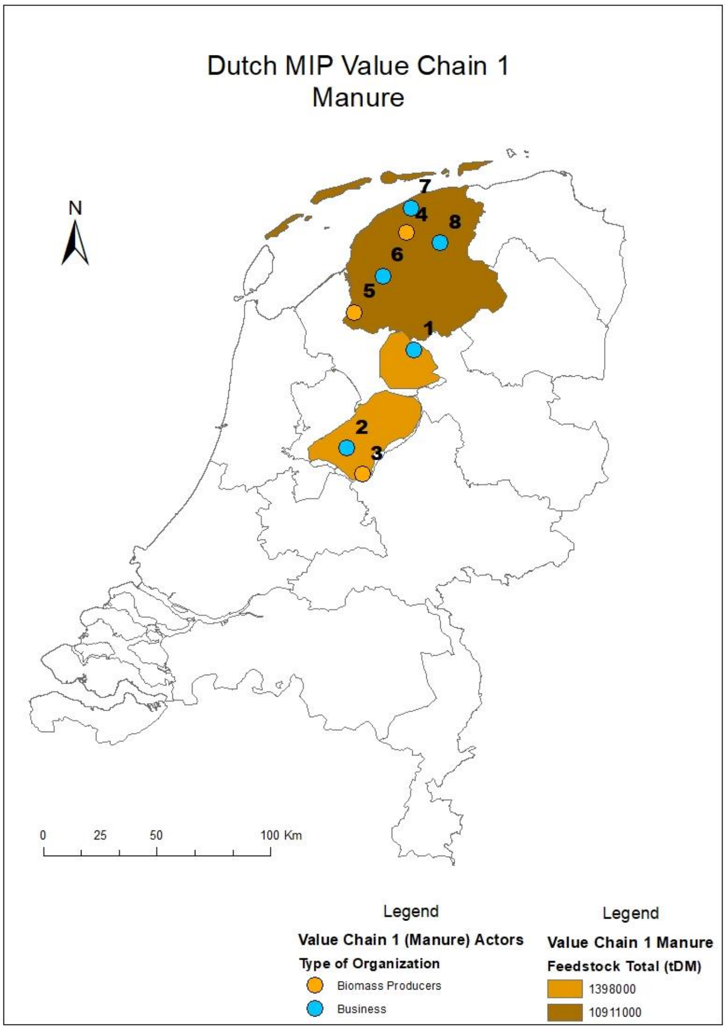
Figure 34. Map of arisings of animal manure biomass and key stakeholders within the Dutch MIP region.



Biomass Producers		**Business**	
ID	*Organization*	*ID*	*Organization*
3	Biogas Plant, Zeewolde	1	Biogas Plant, Luttelgeest
4	Biogas Plant, Jelsum	2	Biogas Plant, Zeewolde
5	Biogas Plant, Koudum	6	Biogas Plant, Tirns
		7	Biogas Plant, Marrum
		8	Biogas Plant, Burgum

7.1.2 *Biomass Value Chain Actors*

Some of the key actors associated with the manure value chain within the Netherlands MIP region are highlighted in Figure 34 above. These mainly include biomass producer and business stakeholders who interact for purposes of using manure for biogas generation. Examples of such stakeholders are located in both regions of the MIP.

7.1.3 *New Biomass Value Chain Opportunities and Examples*

Due to its high nutrient value, there is potential to use manures efficiently to create new value chains. One the main areas that illustrate this is in the anaerobic digestion of manures to produce biogas. The biogas policies in The Netherlands are relatively stable in the sense that subsidies for biogas plants have continued from the earlier SDE regulation, into the current SDE++. But in that time, there has been a significant shift in focus on agricultural biogas installations from co-fermentation of manure towards mono-fermentation of manure (Winquist et al., 2021). The agricultural biogas production has grown considerably since 2011, but since then, the number of co-fermentation plants decreased with subsidies somewhat decreased for this mode, and feedstock prices increasing.

Mono-fermentation of manure is less demanding in terms of management because no off-farm inputs need to be purchased. Furthermore, new mono-fermentation installations have been developed and implemented that better suit the different scales of farms. In the Netherlands, the large dairy cooperative, FrieslandCampina, has been a driving force behind mono-fermentation at farm scale in the so-called Jumpstart-program (Winquist et al., 2021). In 2020, there was considerable enthusiasm among dairy farmers to participate in the mono-fermentation project. One of the aspects of the approach is for farmers to lease the installation from the cooperative instead of having to entirely buy it themselves. In recent years, therefore, a shift can be observed from co-fermentation to mono-fermentation of manure on farms (Winquist et al., 2021). Initially the biogas produced on farms was used to produce electricity via CHP, however, in recent years, more of this biogas is being upgraded to natural gas quality and delivered to the gas grid. Due to rising gas prices this has becomes more economically viable.

Other initiatives in the Netherlands' focus on the sustainable utilisation of nutrient value of slurries. The Dutch company Byosis for example has developed a system for better managing slurries and digestates, creating systems for pasteurisation, drying and ammonia stripping of these feedstocks. The ammonia stripping technology traps the ammonia in acid, such as sulphuric acid, and can thereby reduce the nitrogen content of the biomass where required for further use (Sanders et al., 2020). Other research in the Netherlands is investigating the potential of vermicomposting of manures. These ingredients can be potentially converted to feed and vermicompost by earthworms, such as Eisenia fetida and Dendrobaena veneta, thereby producing alternative protein sources for feed and alternatives for artificial fertilizer (Groeneveld et al., 2023). Other applications, including the production of black soldier fly larvae, are also being investigated (Parodi et al., 2021).

Figure 35. Farm-scale biogas production via Friesland Campina's Jumpstart project (Source: https://www.frieslandcampina.com/).

7.2 Value Chain 2 - Grass

In the Netherlands, grassland is one of the primary land uses, accounting for 772,410 ha (EuroStat, 2022). In the MIP region, grassland is mainly located in Friesland (164,300 ha) with a smaller amount arising in Flevoland (5,590 ha). While grass is often in demand for silage production for Netherland's large dairy system, grass from roadsides and nature grass is a large stream that is often not used to its full potential. Nature grass has a low nutritional value and is not usually suitable to feed to cattle.

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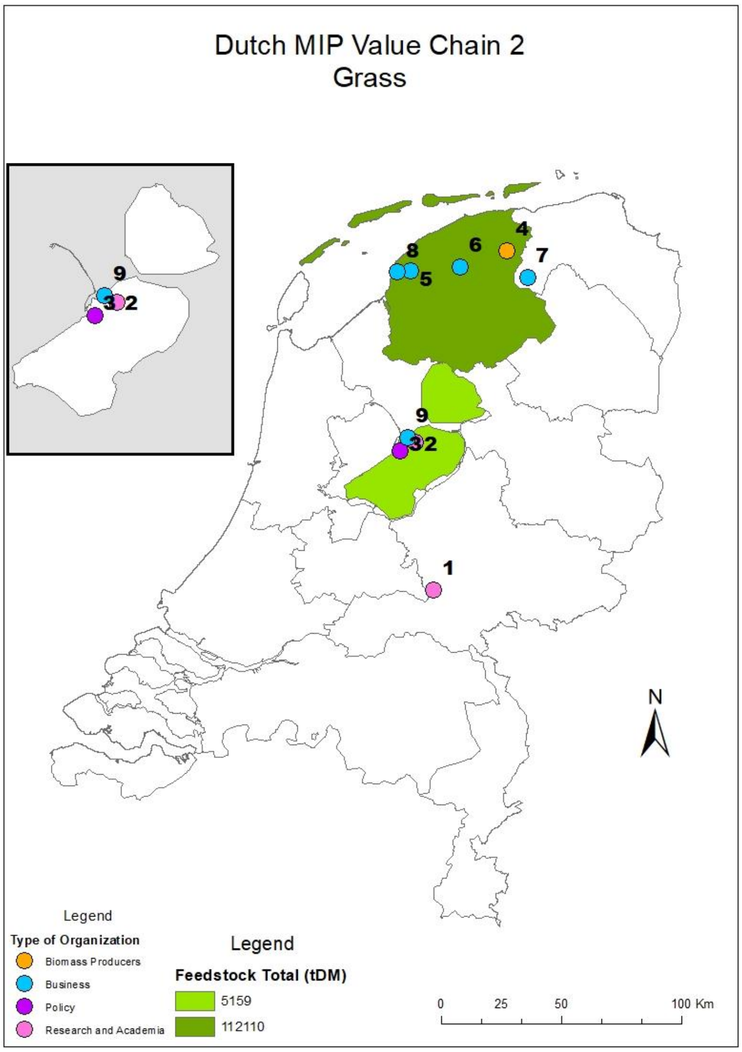
Roadside grass is often polluted with litter or sand. Both can be composted but are often left in situ. Where this material can be harvested, multiple applications are possible with this grass, such as e.g., thermal insulation material.

7.2.1 *Biomass Arisings and Flows*

Within the MIP region of the Netherlands, it is estimated that the arisings of nature and roadside grass constitutes approximately 117,269 tDM. The largest amount is available in the Friesland region with 103,000 tDM nature grass and 9110 tDM roadside grass, with smaller amounts available in Flevoland (1278 tDM nature grass and 3881 tDM roadside grass). Some of the nature grass is used for feeding purposes, but some would be available for other uses. Approximately 80% of the roadside grass is estimated to be used for composting with the remaining 20% which is harvested estimated to go for biogas production. While the price of feedstock depends on the quality, roadside grass often has a negative price, as it costs money to process it. Nature grass is also sold depending on the quality and more often has a positive value of around €10-20 per tonne, although this is significantly lower than the price of high-quality silage grass, which costs approximately €50-60 per ton. The distribution of stakeholders and grass arisings across the MIP region is presented in Figure 36.

Figure 36. Map of arisings of nature and roadside grass biomass and key stakeholders within the Dutch MIP region.



Biomass Producers		Business		Policy		Research & Academia	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
4	Nordlike Fryske Walden	5	Huhtamaki Fiber Packaging Nederland	3	Provincie Flevoland	1	Wageningen Research
		6	Huhtamaki Fiber Technology B.V.			2	ACRRES (part of WR)
		7	Huhtamaki Paper Recycling B.V.				
		8	Westra Groenrecycling				

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		9	Orgaworld Vergisting Biocel				

7.2.2 *Biomass Value Chain Actors*

Key value chain actors have been identified in the Netherlands MIP region related to innovations in the grass value chain. These include those on the production side, such as Nordlike Fryske Walden, an association of 800 members, farmers and private individuals, who ensure the preservation of the landscape and farmland birds through nature and landscape management. Businesses involved in the management and utilisation of this material have also been identified, such as Hutamaki, a major packaging producer with an interest in grass fibres and Westra Groenrecycling who help to manage green waste. Relevant policy actors include Provincie Flevoland, while research active stakeholders include Wageningen Research and ACRRES.

7.2.3 *New Biomass Value Chain Opportunities and Examples*

As indicated above, some of this underutilised grass already goes for use in applications such as composting and biogas production, however additional value-added opportunities are also being investigated. Researchers at Wageningen Research have investigated the thermal conversion of these materials to produce bioenergy (Elbersen et al., 2015). Other research initiatives focus on conversion into material products. The GO-GRASS project, for example which involves the participation of Dutch actors Wageningen Research and its initiative ACRRES is one of the pilot regions to test new bio-based business models from grass bioeconomy (using green biorefineries). In the case of the Netherlands, GO-GRASS partners are developing a process to extract fibres from roadside and nature grass to produce high-quality packaging and paper, in combination with Schut Papier, Nordlike Fryske Walden and others. On a demonstration level, the company NEWFOSS has also been active in the Netherlands in demonstrating the production of paper and packaging materials from roadside grass and nature grass. A green biorefinery demonstration plant is operated by NEWFOSS in Uden, with up to 10 tons of fibre material produced daily. Separately, the Interreg Grassification project involving partners from the Netherlands, Belgium and UK, has also investigated the potential for roadside grass to be used for the production of bio-based materials, including prototype products such as geotextiles products and structural materials.

Figure 37. Bioresource and renewables research infrastructure at ACRRES, Netherlands (Source: https://www.acrres.nl/en/home-2/).

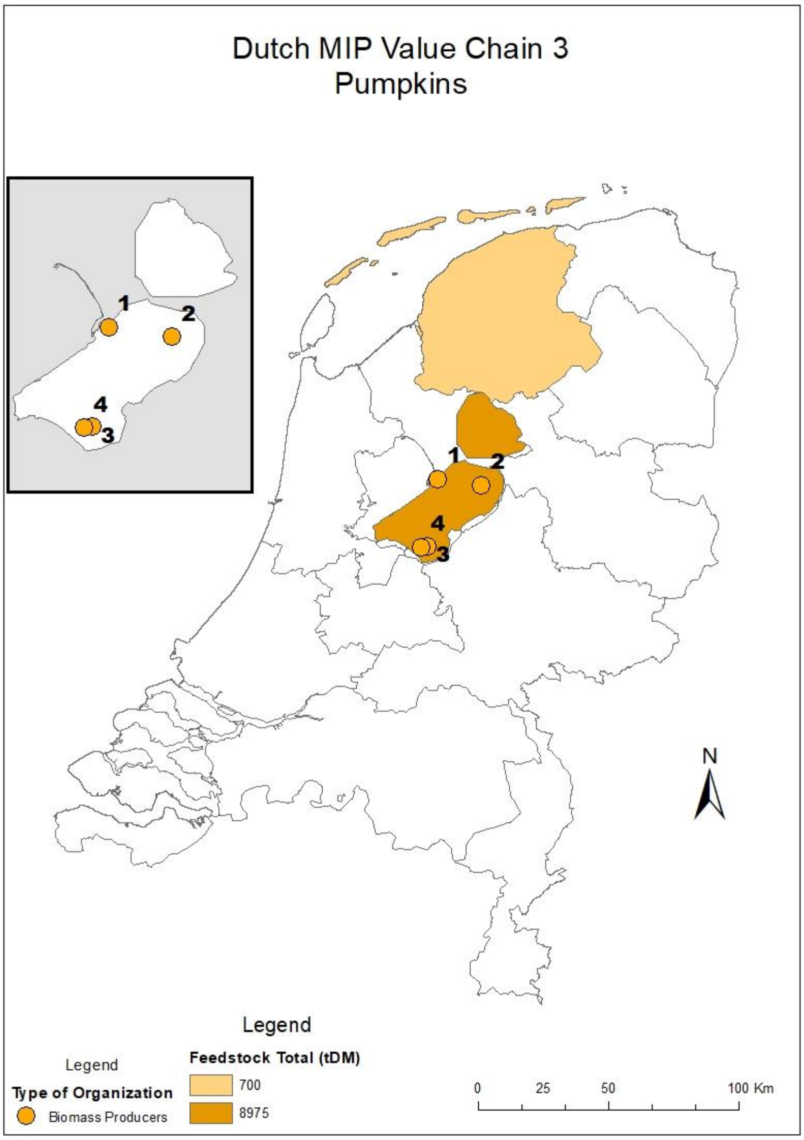
7.3 Pumpkin Value Chain

There are 754 ha of Dutch agricultural land which contain pumpkin patches, with the largest producing province being Flevoland. One quarter of the growing space is located in Flevoland (194 ha) with a smaller amount in Friesland (24 ha) (CBS, 2018). 60 percent of the total area for pumpkin cultivation is organic agriculture. On these farms, some of the pumpkins are harvested with spots that are not desired by retailers and are either used to feed the pigs, or as a feedstock for the digester to produce biogas. These applications are of low value, so there could be better alternatives for these relatively clean feedstock.

7.3.1 *Biomass Arisings and Flows*

Since Flevoland is the region with the largest pumpkin growing area, as expected, most of the pumpkin output of the MIP comes from this region with an estimated 8,975 tDM compared to Friesland Campina's 700 tDM. This distribution is highlighted in Figure 38 below. This produce mainly goes towards the food market, with the residual streams mainly going towards pig feed or bioenergy applications. The price depends on the use of the pumpkin.

Figure 38. Map of arisings of pumpkin biomass and key stakeholders within the Dutch MIP region.



Biomass Producers	
ID	*Organization*
1	Pumpkin Farmer, Lelystad
2	Pumpkin Farmer, Dronten
3	Pumpkin Farmer, Zeewolde
4	Pumpkin Farmer, Zeewolde

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7.3.2 *Biomass Value Chain Actors*

Some of the key actors within the value chain for the MIP region have been identified in Figure 38. Since most pumpkin production is done on farm and sold directly to the supermarket, the key stakeholders are in the primary producer category, and these are located in Flevoland. Some of these producers grow multiple crops alongside pumpkins, and have a focus on sustainability, including the use of anaerobic digestion to covert by-products and residues produced on farm into energy and fertiliser.

7.3.3 *New Biomass Value Chain Opportunities and Examples*

While the majority of underutilised pumpkins within the MIP goes for pig feed, and a proportion into bioenergy, there are potential alternative options for adding value to these materials. One of the pumpkin producers, based in Lelystad, for example, is looking towards the production of pumpkin beer, to reduce and valorise the residue streams of the farm. Other interesting applications may be possible in future however, as pumpkin is also an interesting feedstock for the extraction of natural phytochemicals such as carotenoids, phenolics, vitamins, minerals, polysaccharides, pectins, fibres, tocopherols, phytosterols, essential oils, proteins, peptides and amino acids (Hussain et al., 2022a). These ingredients are involved in several pharmacological and biological activities including antimicrobial, anticancer, antioxidant, cardioprotective, antiaging, anti-inflammatory and prebiotic activities. Various recent studies have explored the production and use of many of these interesting ingredients which can be extracted from pumpkins (Hussain et al., 2022a; Hussain et al., 2022b; Montesano et al., 2018).

8. Polish MIP Region

Poland is a country in Central and Eastern Europe which covers an area of 312,696 km^2 and is home to a population of over 38 million inhabitants. The country has a coastline of over 770 km to the north which provides access to the Baltic Sea. In 2018 primary land use in Poland was 85% dedicated to either agriculture (50%) or forestry (35%) (Eurostat, 2021b). There was a total of 16.5 million ha of farmland area in Poland in 2019, over 14.7 million ha of which was utilised agricultural land area (EuroStat, 2022). Within the Polish agricultural sector, the most important crops are grains, of which the highest yields come from wheat, triticale, barley, rye and oats. Other major crops are potatoes, sugar beets, fodder crops, flax, hops, tobacco, and fruits. Livestock farming is also important, as farms all over Poland raise dairy cows, beef cattle, pigs and poultry (EAAP, 2015). Employment across different sectors of the Polish bioeconomy stood at over 2.3 million in 2019, with gross value add from the different bioeconomy sectors at almost €37 billion (Knowledge Centre for Bioeconomy, 2023). The largest share of turnover comes from the food, feed and beverage production sectors, accounting for nearly half of the total turnover. There are 91 bio-based industry facilities located in Poland, 88 of which are commercial plants, with the remaining being pilot or demo facilities. The largest focus of these facilities are related to pulp and paper, with a smaller number of plants focused on sugar and starch, liquid biofuels, timber, chemicals and composites and fibres (JRC, 2022).

Poland does not currently have a national strategy for the development of the bioeconomy, although a number of initiatives and projects are underway that support the emergence of a strategy including BioEcon, BIOEASTsUP, CEE2ACT, MainstreamBIO, BioRural, BIOECO-UP, etc. Key strategies related to bioeconomy development in Poland include: National Energy and Climate Plan for the years 2021-2030, National Smart Specialisation Strategy, Roadmap on Circular Economy, Polish National Strategy for Adaptation to Climate Change (NAS2020) with the perspective by 2030, Strategy for Sustainable Rural Development, Agriculture and Fisheries 2030, National Environmental Policy and Energy Policy of Poland until 2040. Poland has enormous potential when it comes to biomass production and utilization (Loizou et al., 2019) and waste biomass production (Hamelin et al., 2019), with prospects for further development to supply local, national and international markets. Poland has significant potential for bioeconomy development within its R&D institutions, but barriers remain. Some perceived weaknesses surrounding the Polish bioeconomy, are an insufficient level of research and knowledge about the bioeconomy's sustainability, a low level of recognition of the relationships occurring between bioeconomy sectors (Loizou et al., 2019), and a low level of interaction between industry and research sectors (Kulišić et al. 2020).

In Poland, agricultural and food processing research is conducted by the Research Institutes under the supervision of the Ministry of Agriculture and Rural Development, Polish Academy of Sciences and Universities. Bio-based products and bio-processing research is carried out by institutes managed by the Ministry of Development and Technology, mainly in Łukasiewicz Research Network and Universities. The Ministry of Climate and Environment manages the research institutes related to forestry and environmental protection, while there is also one non-public research unit, POLBIOM, which conducts several bioeconomy projects.

There are: 10 Universities with Agricultural Faculty, 7 Universities with Forestry Faculty, 2 Universities with Aquaculture / Fisheries Faculty, 12 Agricultural Research Institutes, 1 Forestry Research Institute, 2 Aquaculture / fisheries Research Institute, 24 Research Institutes for bio-products and biomass processing, 62 Agricultural Secondary Schools, 11 Forestry Secondary Schools. RDI Institutions specialized in the bioeconomy are also relevant and these include: Institute of Soil Science and Plant Cultivation State Research Institute, Polish Bioeconomy Technological Platform, Centre for Bioeconomy and Renewable Energy (CBEO), South Poland Cleantech Cluster (SPCleantech). Key European (scientific) projects implemented for the development of the bioeconomy in Poland are: BioEcon (H2020), BIOEASTsUP (H2020), MainstreamBIO (HE), BioRural (HE), CEE2ACT (HE), BIOECO-UP (Interreg CE).

The MainstreamBIO MIP region of Poland is centred around the NUTS2 region Lubelskie (Lublin) Voivodeship (L81) which is comprised of the subregions Bialski, Chełmsko-zamojski, Lubelski and Puławski. Agricultural land in the Lubelskie Region accounts for about 70%, and forest land for about 25% of the area (Jurga et al., 2021). Lubelskie Voivodeship can be categorized as a traditional economy. Employment in the agricultural sector dominates the region (37%). A recognised challenge of the region's economy is low competitiveness and innovation (Skwarek, 2021). The region contains over 1.5 million ha of farm area, making it rich in biological resources which could support the development of the bioeconomy. (EuroStat, 2022). Lubelskie Voivodeship has a very high potential for the development of the bioeconomy, with some differences in relation to Poland as a whole. Important economic sectors for the development of a bioeconomy including agri-food, energy, pharmaceutical, chemical, paper, wood, and furniture (Jurga et al., 2021).

8.1 Value Chain 1 – Sugar beet leaves

The sown area of sugar beet in Lubelskie Voivodeship in 2020 amounted to 36 thousand ha (14.6% of the sown in Poland), yielding a harvest of 19.3 million tDM, making it the third-largest sugar producing region in Poland (Statistics Poland, 2023). Residues from the sugar beet harvesting, such as beet leaves, can play a key role in soil nutrient quality. IUNG has conducted research to evaluate the degree to which specific components in the leaves left in the field are utilized by successor crops. After ploughing the leaves, the following crop can use 50-60% of potassium, up to 40% of nitrogen and magnesium and up to 25% of phosphorus. This indicates its usefulness in the crop cycle.

8.1.1 *Biomass arisings and flows*

Within the MIP region of Poland, it is estimated that the total amount of residues from sugar beet harvesting, stands at around 1,386,699 tDM. This is composed mainly of sugar beet leaves, along with other residues such as broken-down roots. The largest share of this comes from the Chelmsko-Zamojski region constituting over 900,000 tDM, with Lubelski as the other large production area with over 350,000 tDM. Most of this residue stream (over 1.2 million tDM) is estimated to be ploughed back into the soil, with the remainder left on the field or converted to silage. The flow of sugar beet harvesting residues by region is provided in Figure 39, while a map of biomass arisings across the MIP region is provided in Figure 40. A data summary of the arising per region for this value chain is included in Appendix 2.

Figure 39. Sankey diagram showing the sugar beet harvest residues and flows and fates across different regions of the Polish MIP region.

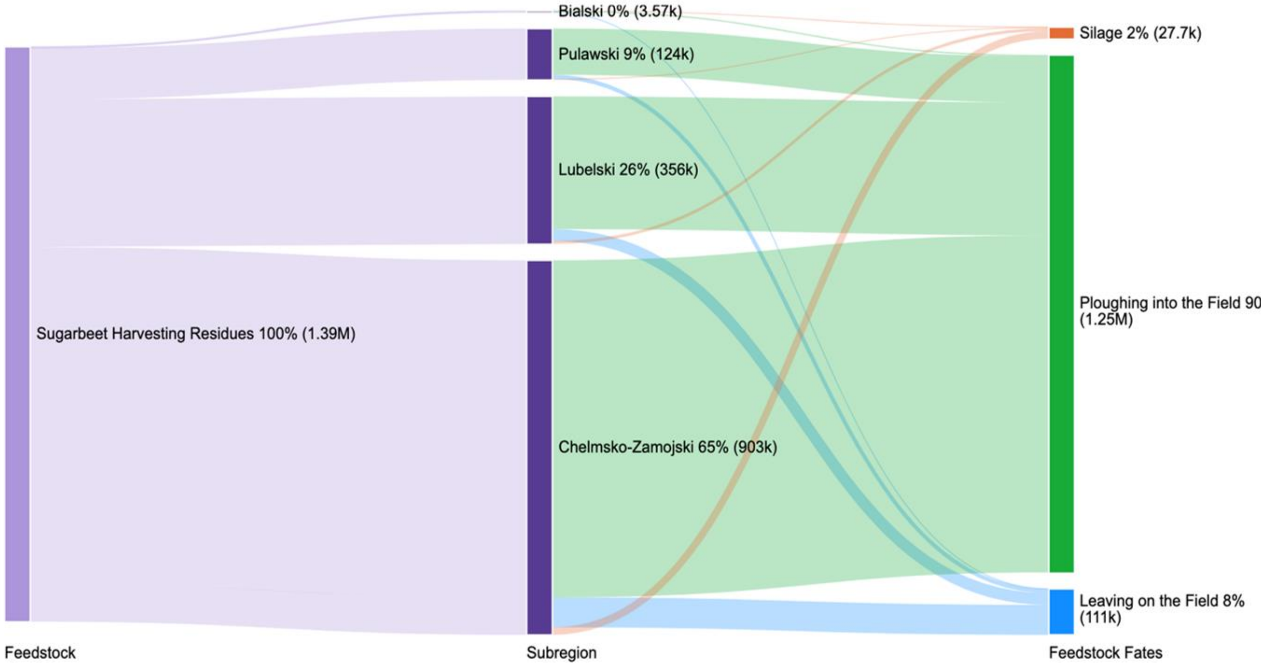
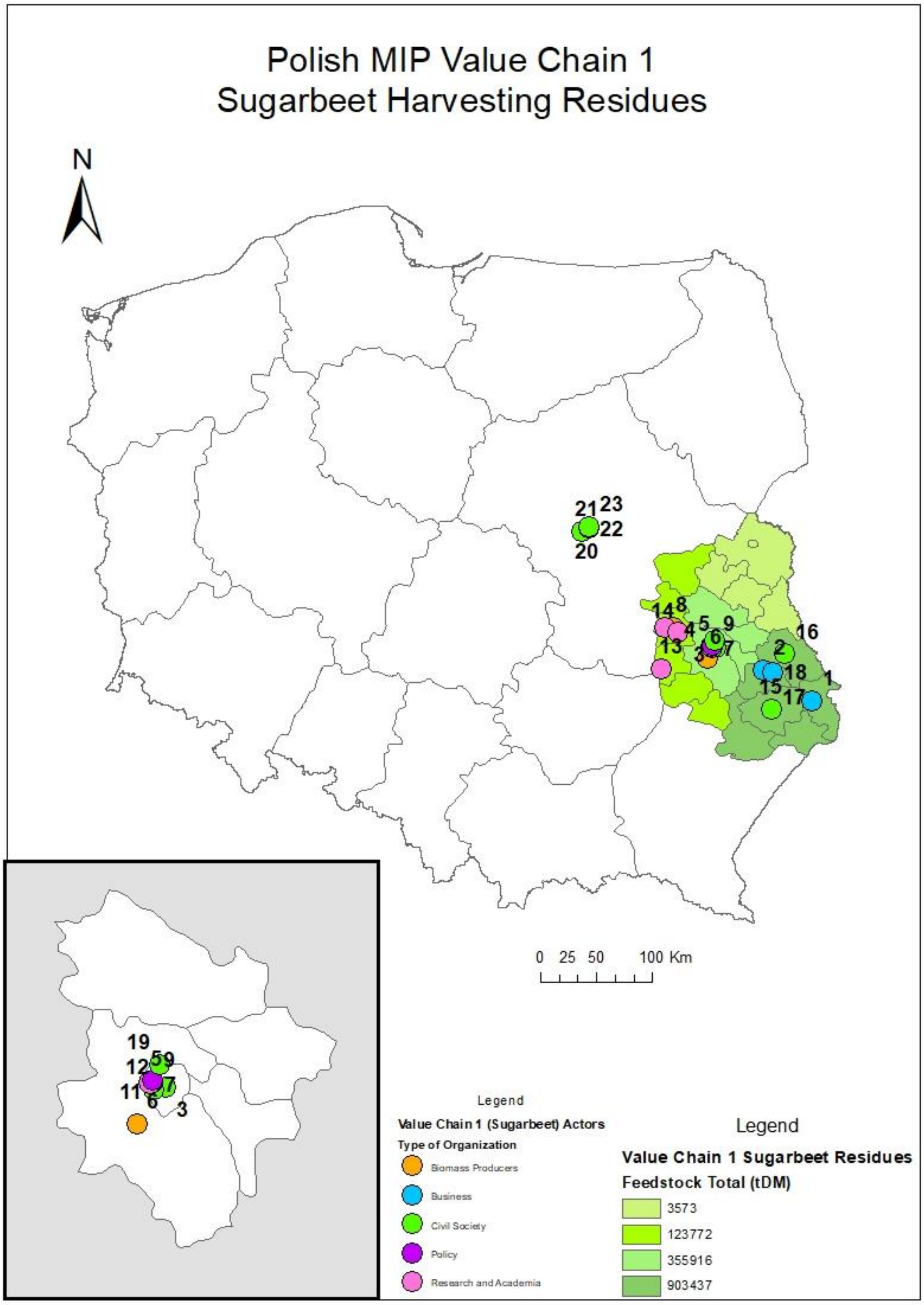


Figure 40. Map of arisings of sugar beet harvesting residue biomass and key stakeholders within the Polish MIP region.



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Biomass Producers		Business		Civil Society		Policy		Research & Academia	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
4	Lublin Agricultural Advisory Centre (LODR)	1	Sugar Factory Werbkowice	3	Lubelska Izba Rolnicza	9	Marshal Office of the Lubelskie Voivodeship in Lublin	5	University of Life Sciences in Lublin
6	Przemysław Wójcik Farm	2	Sugar Factory Krasnystaw	7	Wojewódzki Związek Plantatorów buraka cukrowego w Lublinie	11	Wydział Środowiska i Rolnictwa Lubelskiego Urzędu Wojewódzkiego w Lublinie	8	Institute of Soil Science and Plant Cultivation State Research Institute
		18	Chemirol Partner i Doradca w Rolnictwie	15	Okręgowy Związek Plantatorów Buraka Cukrowego w Zamościu	12	Agencja Restrukturyzacji i Modernizacji Rolnictwa Lubelskie Biuro Powiatowe	10	Wydział Nauk o Żywności i Biotechnologii Uniwersytet Przyrodniczy w Lublinie / FACULTY OF Food Science and Biotechnology
				16	Związek Plantatorów Buraka Cukrowego w Chełmie			13	Zespół Szkół Rolniczych w Kluczkowicach
				17	Lubelsko-Zamojski Związek Plantatorów Buraka Cukrowego			14	Zespół Szkół Agrobiznesu im. Macieja Rataja w Klementowicach
				19	Oddział Regionalny Polskiej Izby Produktu Regionalnego i Lokalnego w Lublinie				
				20	Polska Izba Biomasy				
				21	Polskie Stowarzyszenie Obsługi Rolnictwa				

				22	Polska Izba Produktu Regionalnego i Lokalnego (główna siedziba)				
				23	Krajowy Związek Plantatorów Buraka Cukrowego (główna siedziba)				

8.1.2 *Biomass value chain actors*

A variety of value chain actors from across the Polish MIP region have been identified in Figure 40. These include stakeholders on the primary producer side, and agri-advisory side, including Przemysław Wójcik Farm and Lublin Agricultural Advisory Centre (LODR). Businesses who are involved in the processing of sugar beet such as the Sugar Factory Werbkowice and the Sugar Factory Krasnystaw are also key actors. There are also participants of civil society which have been identified, such as Wojewódzki Związek Plantatorów buraka cukrowego w Lublinie, who represent the sugar beet growers in Lublin region. Finally, various research and academic partners with expertise in agronomy, food production and biotechnology have been identified within the MIP region, indicated in Figure 40.

8.1.3 *New Biomass Value Chain Opportunities and Examples*

If the sugar beet field residues can be sustainably harvested beyond what is needed to reuse on soil, there is potential to utilize these materials in high value applications, creating new value chain opportunities. Regional examples of this in action include within the region of Puławy, through the start-up company Waste Lab who have been working to make biodegradable products such as disposable planting pots. Separate research work in Poland has found that sugar beet residues such as leaves and pulp can be utilised to produce the building block furfural and its derivatives, such as furfuryl alcohol (FA) and tetrahydrofurfuryl alcohol (THFA) for use as fuel additives, covering domestic demand for these mostly imported materials (Modelska et al., 2020). Internationally, work is being undertaken to demonstrate the potential to extract human-grade RuBisCO protein through the Green Protein demonstration biorefinery project headquartered in Netherlands. The demo plant developed through the project aims to process 1500 kg/h of sugar beet leaves into 28 kg of RuBisCo protein powder per hour. The protein has many valuable food industry applications based on functionalities like gelling, foaming and emulsifying, with excellent market projection in growing markets like high protein, vegan and halal foodstuff (CBE JU, 2021).

8.2 Value Chain 2 - Berries

Poland is the world's leading chokeberry producer, while ranking second in the world in current production. Poland is also a significant producer of blueberries in the European Union, with a 19% share in the harvest, while ranking fourth in global production (after the United States, Canada and Mexico), with a 3% share. Poland is also the largest producer of raspberries in the European Union and the third largest producer of this fruit in the world (Krajowy Ośrodek Wsparcia Rolnictwa, 2018). Lublelskie Voivodeship is also at the forefront of orchard farming, which occupies more than 70,500 ha (almost 22% of the area of orchards in Poland), supplying the market with almost 18% of fruit from trees and berries (2nd place in Poland). From these fruit, various residuals are left behind which may offer an opportunity for new value chain development in a bioeconomy.

8.2.1 *Biomass Arisings and Flows*

Within the MIP region of Poland, it is estimated that the total amount of berries crop residues being produced amount to 197,045 tDM. The largest share of this comes from the Pulawski constituting over 110,000 tDM, with smaller volumes produced in the other MIP subregions. The majority of the residues, approximately 95%, is considered to end up as waste, with a small amount which falls during vegetation, about 2%, left on the field, and a further 3% being burned in the field. Berries can fetch a revenue of up to €1,500 per ha. Berry residues are currently not sold in the region, so the estimated cost is not known. The flow of berries residues and breakdown by region is provided in Figure 41 and 42 respectively. A full summary of the arising per region for this value chain are included in Appendix 2.

Figure 41. Sankey diagram showing the arisings and flows and fates of berries residues of different regions of the Polish MIP region.

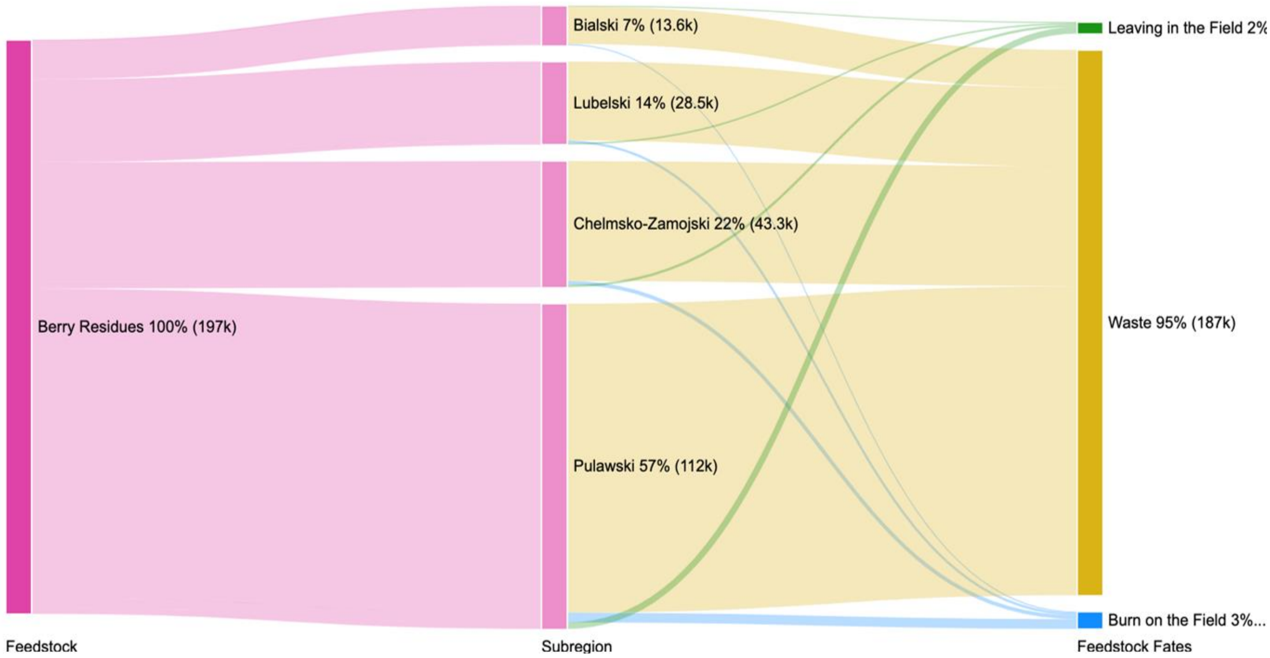
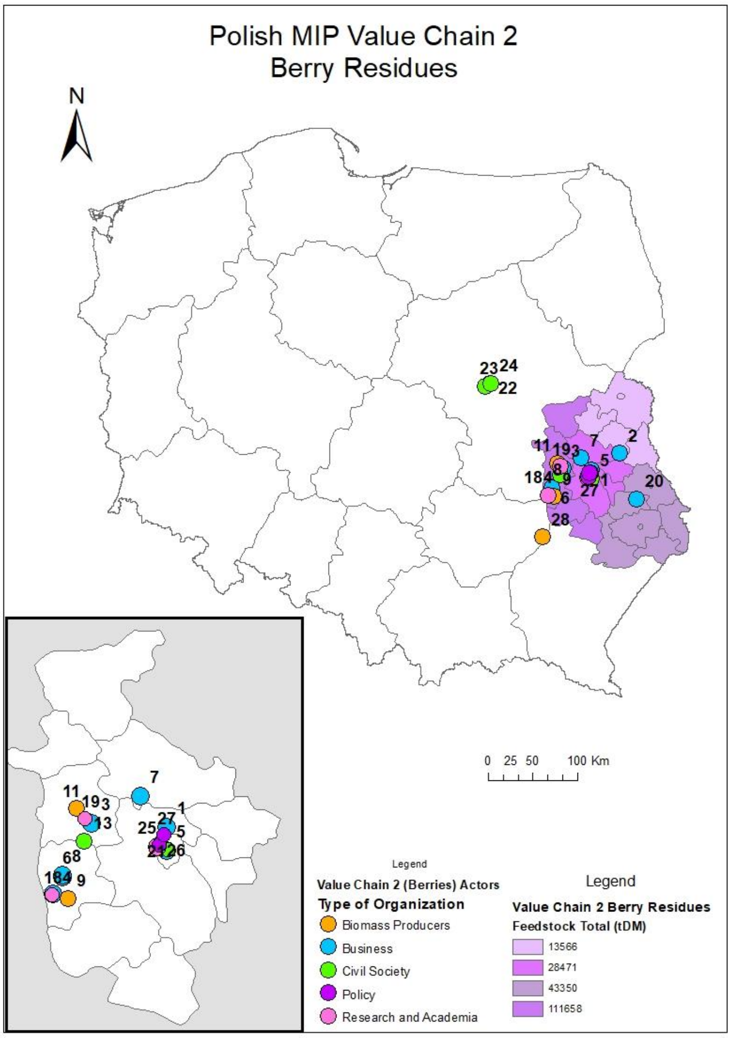


Figure 42. Map of arisings of berries residues and key stakeholders within the Poland MIP region.



Biomass Producers		**Business**		**Civil Society**		**Policy**		**Research & Academia**	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
9	Anna Wagnerowska Farm	1	Agricola-Lublin Ltd.	10	Lubelska Izba Rolnicza	14	Marshal Office of the Lubelskie Voivodeship in Lublin	12	University of Life Sciences in Lublin
11	Lublin Agricultural Advisory Centre (LODR)	2	Agronom Plants Ltd.	13	Polskie Stowarzyszenie Producentów i Przetwórców Owoców	16	Wydział Inżynierii Produkcji Uniwersytet Przyrodniczy w Lublinie / FACULTY OF	15	Wydział Agrobioinżynierii w Uniwersytecie Przyrodniczym w Lublinie / FACULTY OF Agrobioengineering

							Production Engineering		
28	AGROEKOTON Association	3	Andros Ltd.	21	Oddział Regionalny Polskiej Izby Produktu Regionalnego i Lokalnego w Lublinie	17	Agencja Restrukturyzacji i Modernizacji Rolnictwa Lubelskie Biuro Powiatowe	18	Zespół Szkół Rolniczych w Kluczkowicach
		4	RAUCH Polska Ltd.	22	Polska Izba Biomasy	26	Wydział Środowiska i Rolnictwa Lubelskiego Urzędu Wojewódzkiego w Lublinie	19	Zespół Szkół Agrobiznesu im. Macieja Rataja w Klementowicach
		5	Ribes Technologies	23	Polskie Stowarzyszenie Obsługi Rolnictwa	27	Agencja Restrukturyzacji i Modernizacji Rolnictwa Lubelskie Biuro Powiatowe	25	Wydział Nauk o Żywności i Biotechnologii Uniwersytet Przyrodniczy w Lublinie / FACULTY OF Food Science and Biotechnology
		6	Horti Team	24	Polska Izba Produktu Regionalnego i Lokalnego (główna siedziba)				
		7	Korab Garden Ltd.						
		8	Pol-Owoc						
		20	Chemirol Partner i Doradca w Rolnictwie						

8.2.2 *Biomass Value Chain Actors*

Some key regional value chain actors for this value chain have been identified in the MIP and can be seen in Figure 42 above. These include stakeholders on the primary producer side, including growers as well as advisory partners. There are various relevant business partners present in the value chain, include Rauch, who operate factories for the processing of fruit, along with technology provider Ribes Technologies, who develop technologies for disease management in the crop. Associations of berry and fruit producers, such as Polskie Stowarzyszenie Producentów i Przetwórców Owoców have also been identified. A number of relevant policy stakeholders who interact with the berries sector have been identified, including Agencja Restrukturyzacji i Modernizacji Rolnictwa Lubelskie Biuro Powiatowe, who oversee the restructuring and modernization of agriculture in the region. Relevant supporting partners on the research side of this value chain, such as University of Life Sciences in Lublin, are also included. The AGROEKOTON Association, which supports fruit producers by focusing on sustainable production and promoting agricultural innovation, is also an important stakeholder.

8.2.3 *New Biomass Value Chain Opportunities and Examples*

Research in Poland to develop new innovations around this value chain takes place at different stages in the chain. At the production phase, agro-tech start-up Ribes Technologies have developed an AI-powered technology to support autonomous supervision and visual recognition of the plants. The technology can support precision application of plant health products to minimize production costs and quickly identifies diseases attacking plantations. Where residual raspberries are not being harvested and packaged for food retailer, research in Poland has shown that these have the potential to form a source of highly available micronutrients (Samoraj et al., 2022). Raspberry seeds, for example, can be used to produce a modern fertilizer for organic farming. Berries also possess antioxidant capacity thanks to their bioactive compounds, such as phenolic compounds and anthocyanins, so extracts have the potential to be used as high value ingredients in food and nutritional products (Romero et al., 2022). There is also potential for biotransformation of these residue streams into material products. For example, the conversion of berry residue extracts to be used to produce biodegradable pectin films for sustainable seafood packaging has been demonstrated at a research level (Romero et al., 2022).

8.3 Value Chain 3 - Corn

In terms of corn (maize) cultivation area, Lubelskie Voivodeship ranks in the middle of the regions in Poland, having a significant growing area of 48,810 ha (2021) (Statistics Poland, 2023). The total yield is 3,807,180 tDM (2021) (Statistics Poland, 2023). The main use of corn is for the feed milling industry and for on-farm feed. Recently, however, Polish corn is gaining popularity for the production of bioethanol. Biofuels are considered one of the most important components of future energy sources. It is worth noting, however, that at the moment the biggest cost of biofuel production in Poland is the high cost of crop cultivation (Bórawski et al., 2022). Some of the corn is also used in biogas plants across the country. Polish studies have demonstrated higher biogas yields where ensiled corn has been included as a feedstock (Bulak et al., 2020). The by-products that remain following corn harvesting, such as stover, are an abundant and potentially interesting resource for developing new bio-based opportunities in Poland.

8.3.1 *Biomass Arisings and Flows*

Within the MIP region of Poland, corn is either grown for grain or silage production. It is estimated that the total amount of corn residue from grain production alone is 997,158 tDM. The largest share of this arises from the Chelmsko-Zamojski region constituting almost 350,000 tDM, with Bialski and Pulawski each producing in excess of 250 ktDM. The flow of this residue to different applications is presented in Figure 43. About 18% of the corn residue is estimated to be left on the field. The majority of the crop, approximately 75% is considered to be ploughed into the soil, with around 3% used directly as feed, a further 3% used for heating, and approximately 1% used as mulch. Corn residue is currently not usually being sold, so there is no price available, however the price for fresh corn is estimated at approximately €33 per ton. The arisings of corn straw by region is provided in Figure 44 and a full summary of the arising per region are included in Appendix 2.

Figure 43. Sankey diagram showing the arisings and flows and fates of corn residues across different regions of the Polish MIP region.

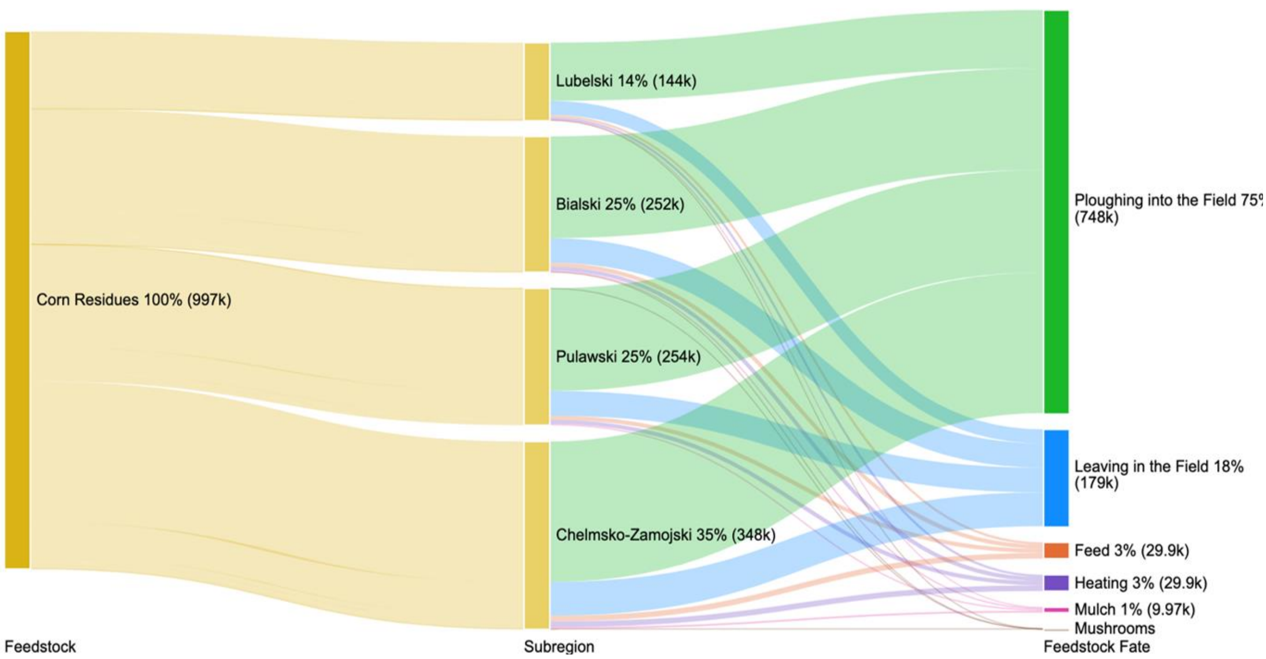


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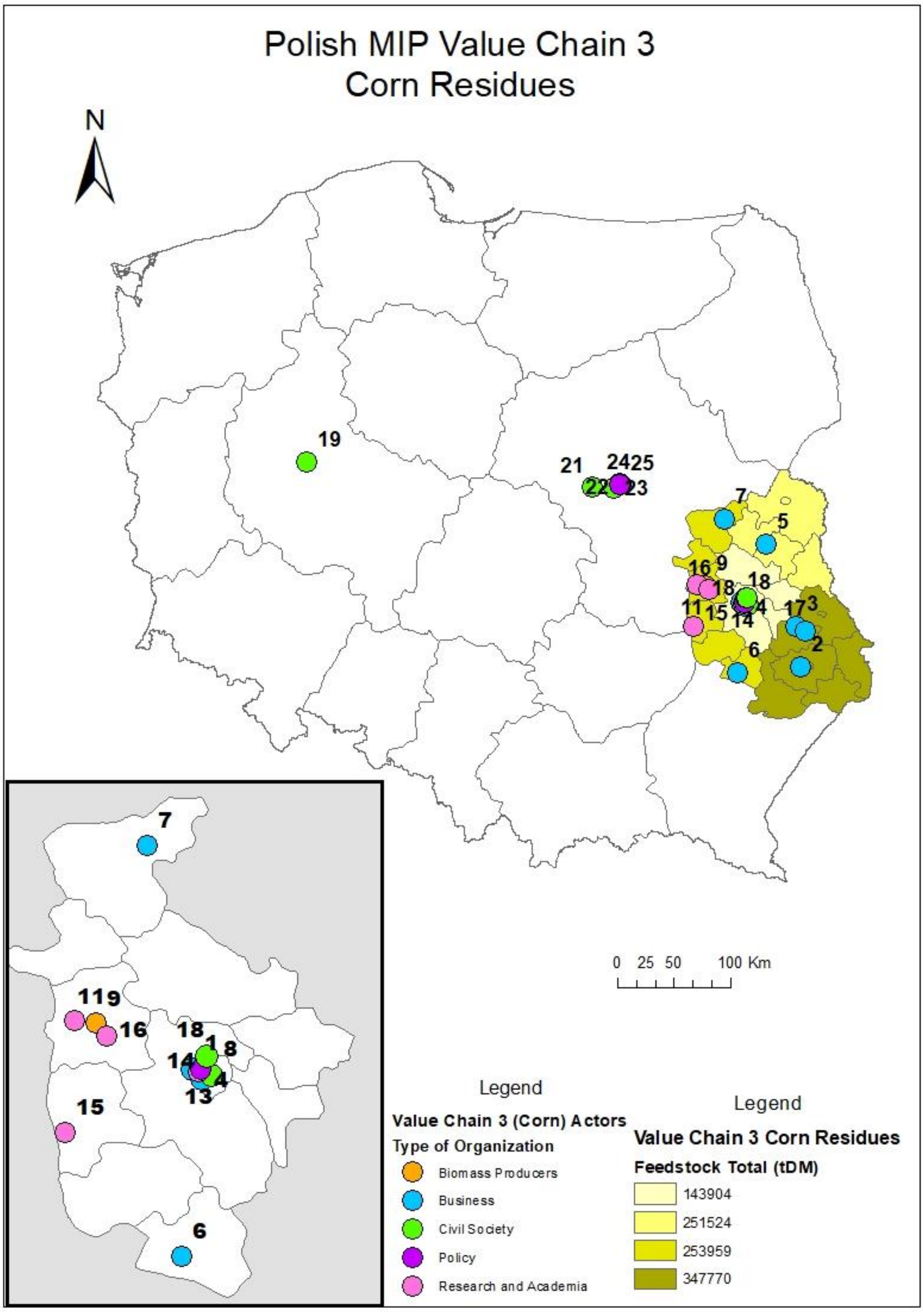
Figure 44. Map of arisings corn residual biomass and key stakeholders within the Polish region.



Biomass Producers		Business		Civil Society		Policy		Research & Academia	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*

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9	Lublin Agricultural Advisory Centre (LODR)	1	Bioenergia Plus Ltd	8	Lubelska Izba Rolnicza	13	Wydział Środowiska i Rolnictwa Lubelskiego Urzędu Wojewódzkiego w Lublinie	10	University of Life Sciences in Lublin
		2	AM Farmer	18	Oddział Regionalny Polskiej Izby Produktu Regionalnego i Lokalnego w Lublinie	14	Agencja Restrukturyzacji i Modernizacji Rolnictwa Lubelskie Biuro Powiatowe	11	Institute of Soil Science and Plant Cultivation State Research Institute
		3	Konrad Piróg - Usługi Dla Rolnictwa	19	Polski Związek Producentów Kukurydzy	25	Izba zbożowo-paszowa	12	Wydział Nauk o Żywności i Biotechnologii Uniwersytet Przyrodniczy w Lublinie / FACULTY OF Food Science and Biotechnology
		4	Lubella Ltd.	20	Krajowa Federacja Producentów Zbóż			15	Zespół Szkół Rolniczych w Kluczkowicach
		5	DMG Ltd.	21	Polski Związek Producentów Roślin Zbożowych			16	Zespół Szkół Agrobiznesu im. Macieja Rataja w Klementowicach
		6	Janex Ltd.	22	Polska Izba Biomasy				
		7	ŁukPasz Ltd.	23	Polskie Stowarzyszenie Obsługi Rolnictwa				
		17	Chemirol Partner i Doradca w Rolnictwie	24	Polska Izba Produktu Regionalnego i Lokalnego (główna siedziba)				

8.3.2 *Biomass Value Chain Actors*

Some key regional value chain actors have been identified in the MIP region and can be seen in Figure 44 above. These include agri advisory partners Lublin Agricultural Advisory Centre (LODR) in Końskowola who provide advice on agriculture, rural development, agricultural markets and rural households, aimed at improving the level of agricultural income and the market competitiveness of farms, supporting sustainable rural development and raising the level of professional skills of farmers and other rural residents. There are various relevant business farmers present in the value chain. These include those on the bioenergy side such as Bioenergia Plus Ltd who specialize in bioenergy production, those related to food (e.g., breakfast cereals) production such as Lubella and companies such Chemirol and Lukpasz who produce compound feeds with corn as ingredients. A number of relevant policy stakeholders who interact with the corn production sector have been identified, such as Agencja Restrukturyzacji i Modernizacji Rolnictwa Lubelskie Biuro Powiatowe, who oversee the restructuring and modernization of agriculture in the region, also the Department of Environment and Agriculture at the Lubelskie Voivodeship Office (called Wydział Środowiska i Rolnictwa Lubelskiego Urzędu Wojewódzkiego w Lublinie). Relevant supporting partners on the research side of this value chain, such as University of Life Sciences in Lublin, are also included. A number of academic and research partners supporting different areas of the chain have also been identified in Figure 44 above.

8.3.3 *New Biomass Value Chain Opportunities and Examples*

As mentioned, there is a growing interest in bioeconomy opportunities coming from corn and corn residue utilisation. This can be seen from the increased interest in corn for bioethanol production, with corn being the most important raw material for the production of bioethanol in Poland in 2019. BIOAGRA SA, for example is one of the largest bioethanol factories in Poland, which started production in 2009, processing 350,000 tDM of corn into 140 million L of ethanol and over 100,000 tDM of dried distillers' grains and solubles (DDGS) for use in animal feeding. The plant capacity has since increased to 210 million L (Piwowar and Dzikuć, 2022). However, the share of corn in the quantitative consumption of raw materials for ethanol production decreased by almost 25% in the analysed period, from 80.53% in 2015 to 55.61% in 2019 (Piwowar and Dzikuć, 2022). This is part of a broader trend towards shifting to more residual feedstock streams, including corn stover, for bioethanol production. Work is also underway internationally to evaluate the use of corn stover, not only to produce ethanol, but also to produce value-added materials such as building block chemicals, bioplastics and biocomposites (Guo et al., 2021; Patel et al., 2018).

Figure 45. BioAgra SA. Bioethanol Production Plant (source: https://www.biotechnika.net/en/bioagra-s-a/).

8.4 Value Chain 4 - Rapeseed

Within the Polish MIP region, the area of sown rapeseed and canola amounted to 128,000 (13% of the sown in Poland) in 2021, while the harvest was about 10% higher than in previous years and amounted to about 3.8 million tDM. In terms of rapeseed production, the Lubelskie Voivodeship is the second largest regional producer in Poland (Zarząd Województwa Lubelskiego, 2022). The cultivation of rapeseed in Poland has changed over the years, particularly following Poland's shift to an open economy in 1989 following which new rapeseed varieties were introduced. Once grown solely for edible oil, it is now becoming one of the main feedstocks needed for biodiesel production, a sector which has been growing in Poland in recent years (Bórawski et al., 2022). Changes in rapeseed varieties have also contributed to a better-quality cake, which is a by-product of rapeseed processing. This affects the price and quality of animal feed (Klepacka et al., 2019). In general, the rapeseed production within the region is increasing. In 2013 the area was 40-50 thousand ha, and between 2017-2019 this had increased to approximately 80-90 thousand ha.

8.4.1 *Biomass Arisings and Flows*

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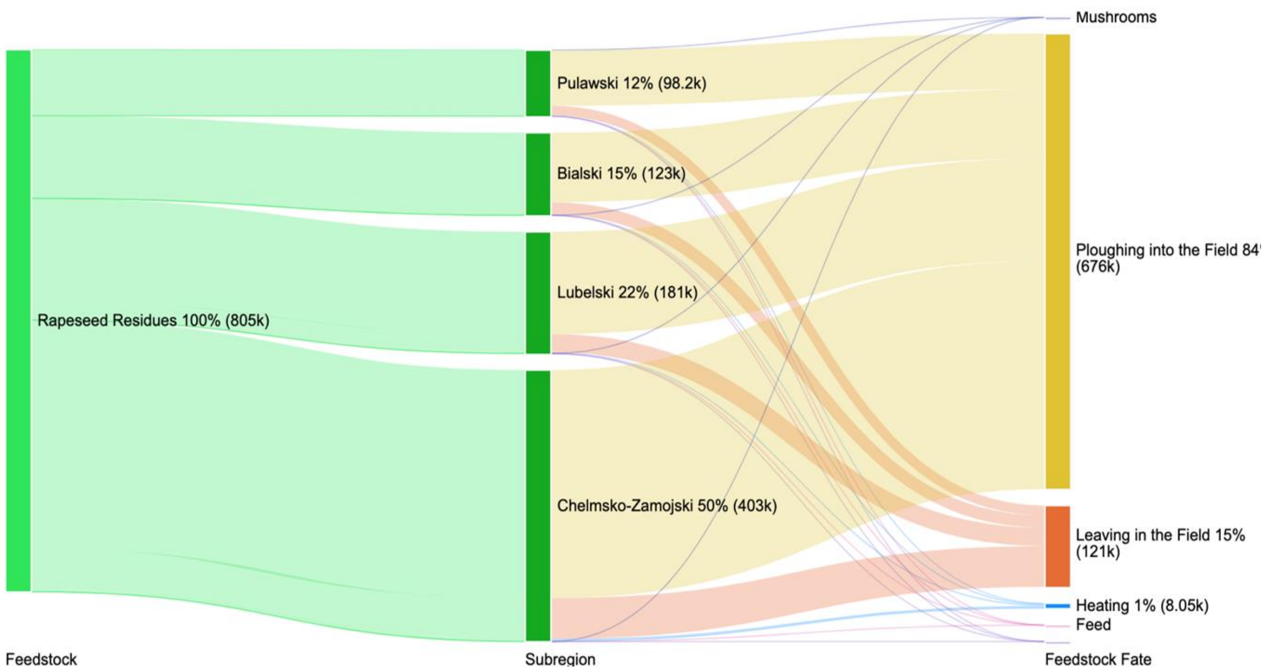
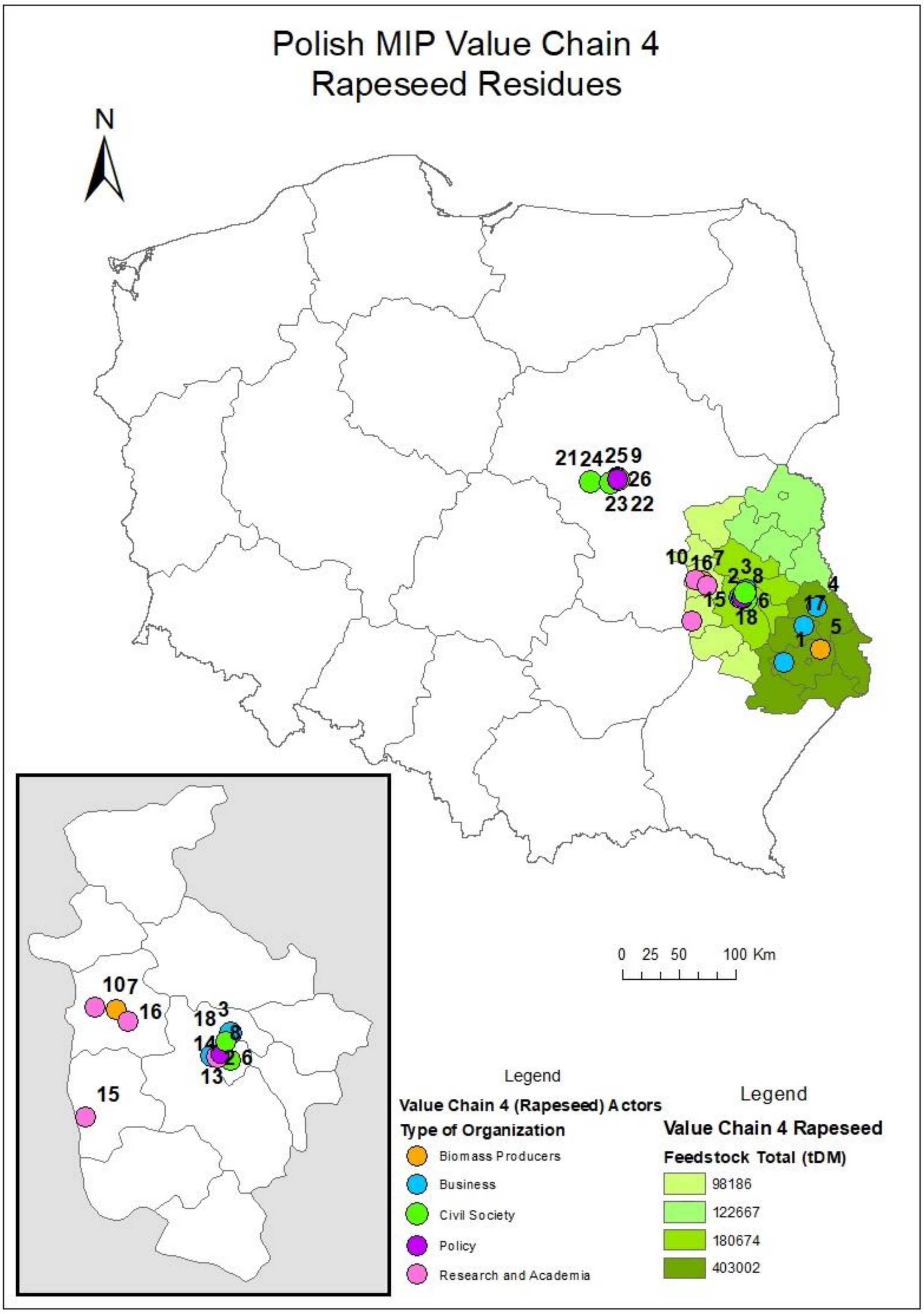
Within the Polish MIP region of Lubelskie Voivodeship, it is estimated that the total amount of rapeseed harvest residues being produced amounts to 804,528 tDM. Around half of this production (403,002 tDM) comes from the Chelmsko-Zamojski region, with the remainder distributed quite evenly between the other three regions. About 15% of the crop is estimated to be left on the field, with the largest fraction of the crop, around 84% ploughed into the soil. A further 1% is estimated to be used for heating purposes. The flow of rapeseed residue within the region and its arising breakdown across the region is provided in Figure 46 and 47 below. A full summary of the arising data for this value chain is included in Appendix 2.

Figure 46. Sankey diagram showing the arisings and flows and fates of rapeseed residues across different regions of the Polish MIP region.



Funded by the European Union

Figure 47. Map of arisings of rapeseed residue biomass and key stakeholders within the Polish MIP region.



Biomass Producers	Business	Civil Society	Policy	Research & Academia

ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
5	Wieslaw Gryn Farm	1	Viterra Bodaczow Ltd.	6	Lubelska Izba Rolnicza	11	Marshal Office of the Lubelskie Voivodeship in Lublin	8	University of Life Sciences in Lublin
7	Lublin Agricultural Advisory Centre (LODR)	2	Bioenergia Plus Ltd.	9	Okręgowe Zrzeszenie Producentów Rzepaku i Roślin Białkowych	13	Wydział Środowiska i Rolnictwa Lubelskiego Urzędu Wojewódzkiego w Lublinie	10	Institute of Soil Science and Plant Cultivation State Research Institute
		3	Agricola-Lublin Ltd.	18	Oddział Regionalny Polskiej Izby Produktu Regionalnego i Lokalnego w Lublinie	14	Agencja Restrukturyzacji i Modernizacji Rolnictwa Lubelskie Biuro Powiatowe	12	Wydział Nauk o Żywności i Biotechnologii Uniwersytet Przyrodniczy w Lublinie / FACULTY OF Food Science and Biotechnology
		4	Albatros Biokom	19	Krajowa Federacja Producentów Zbóż	26	Izba zbożowo-paszowa	15	Zespół Szkół Rolniczych w Kluczkowicach
		17	Chemirol Partner i Doradca w Rolnictwie	20	Krajowe Zrzeszenie Producentów Rzepaku i Roślin Białkowych			16	Zespół Szkół Agrobiznesu im. Macieja Rataja w Klementowicach
				21	Polski Związek Producentów Roślin Zbożowych				
				22	Krajowa Izba Biopaliw				
				23	Polska Izba Biomasy				
				24	Polskie Stowarzyszenie Obsługi Rolnictwa				
				25	Polska Izba Produktu Regionalnego i Lokalnego				

					(główna siedziba)				

8.4.2 *Biomass Value Chain Actors*

Some of the key regional value chain actors related to the rapeseed chain have been identified from across the MIP region and can be seen in Figure 47 above. These include agri advisory partners (LODR) and primary producer stakeholders (Wieslaw Gryn Farm). Some relevant business stakeholders include Albatros Biokom and Bioenergia Plus Ltd with a focus on biodiesel and other bioenergy sources, compound feed producer Chemirol and Agricola-Lublin Ltd who supply inputs for farmers. Relevant civil society groups include the National Association of Rapeseed and Protein Crops Producers (Okręgowe Zrzeszenie Producentów Rzepaku i Roślin Białkowych) and Lublin Chamber of Agriculture (Lubelska Izba Rolnicza). Several relevant government departments and research institutes were also identified.

8.4.3 *New Biomass Value Chain Opportunities and Examples*

The main purpose of rapeseed in the region currently is to supply the food market. The production scale of raw rapeseed oil ranks Poland as the largest third producer in the European Union (after Germany and France) and the sixth producer in the world. The Polish contribution to the EU production of rapeseed oil amounts to about 13% (Voedselkwaliteit, 2021). However, initiatives are also underway to develop this sector to produce biodiesel and other biofuels to meet the needs of the transport market. Several biodiesel plants are already operational in the country, including the Malbork plant operated by ADM, and Czechowice plant owned by Grupa Lotos. ALBATROS BIOKOM Spółka, based in Lubelskie Voivodeship, established in 2016, is another company which has developed innovative technological solutions aimed at improving the energy utilisation of biomass through the production of biodiesel and glycerol from rapeseed. Other innovators in the space include NAPIFERYN BIOTECH who have developed a sustainable processing pathway to extract food-grade protein from rapeseed cake by-product of rapeseed oil production, without the need for harmful solvents. Researchers in Poland have also been investigating the production of biofuels and biochemicals, including bioethanol and succinic acid based on rapeseed straw (Kuglarz et al., 2018). Internationally research is ongoing to evaluate the use of rapeseed straw in structural bio-based materials (Hajj Obeid et al., 2022; Klímek and Wimmer, 2017). Various innovations have been happening at farm level in the MIP region also, such as combined cultivation of rapeseed with faba bean, and the increasing integration of precision farming.

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9. Spanish MIP Region

Spain is the second largest country in the European Union, with an area of 505,990 km^2 and a population of over 47 million inhabitants. In addition, Spain has a coastline which spans almost 5000km (4964km). In 2018 primary land use in the country was largely dedicated to either agriculture (42%) or forestry (27%) (Eurostat, 2021b).

Spain's large agri-food industry generates revenue close to €140 bn, employs more than 440,000 people, and is one of the country's main manufacturing activities (La Moncloa, 2022). With such a large agri-food sector, naturally Spain is a country that is rich in biological raw materials. For example, it is the world's leading producer of olive oil (1,401,600 t in the 2015-2016 campaign) and is the largest pig producer in Europe, generating more than 50 million tDM of pig slurry per year, as well as being one of the main horticultural exporting countries in Europe. Furthermore, in terms of absolute forest biomass resources, Spain ranks third in Europe and is also the country with the greatest increase in forests, with an annual growth rate of 2.2%, much higher than the EU average (0.51%).

In 2019, the bioeconomy sectors of Spain generated 69 billion euros in added value (10% of the EU-28 total) and over 1.4 million jobs (8% of the EU-28 total) (Knowledge Centre for Bioeconomy, 2023). In the country, 108 bio-based industry facilities have been identified, the majority of which (95) are commercial scale (JRC, 2022). Most of these are facilities focused on pulp and paper, bio-based chemicals and liquid biofuels, with a smaller number focused on starch and sugar, biocomposites, timber and biomethane.

There are already many leading innovators operating on the ground in the bio-based industry in Spain. These include the NATAC Group who specialize in the extraction of high-value ingredients such as bioactive, and polyphenol ingredients, from different process residue streams. These ingredients are used to manufacture food, nutraceutical, pharma and cosmetic products. Another company, Respol are currently constructing a biorefinery with an investment of €200 million, which will have the capacity to produce 250,000 tons per year of advanced biofuels such as biodiesel, bio jet fuel, bionaphtha, and biopropane to be used in airplanes, trucks, or cars, allowing a reduction of 900,000 tons of CO_2 per year (Respol, 2022). On the bio-materials side, a BASF-Purac joint venture, Succinity, operates a 10,000t/year bio-succinic acid plant in Montmeló, Spain.

Spanish companies and universities are also involved in key European research initiatives. These include the CBE JU AgriMax initiative which includes a Spanish multi-feedstock biorefinery demonstration aimed at the conversion of food waste into bio-based ingredients and materials. Other key initiatives include POWER4BIO, COOPID, URBIOFIN, MODEL2BIO, ICT-BIOCHAIN and many more.

At national level, the main instrument for the development of the bioeconomy is the Spanish Bioeconomy Strategy: Horizon 2030. The strategy, published in 2016, includes the agri-food sector (comprising agriculture, livestock, fisheries and aquaculture, and food processing and marketing) as well as other sectors such as forestry, industrial bioproducts, bioenergy obtained from biomass, and services associated with rural environments (Government of Spain, 2016).

The MIP region of Spain is focused around the Ebro River Basin and consists of the NUTS2 Regions of Navarra (ES22), Aragón (ES24) and Catalonia (ES51). At regional level, several regions have or are currently working on some kind of bioeconomy planning through specific initiatives (for example, the Bioeconomy Strategy of Catalonia 2021-2030, while others address it within the framework of the circular economy (Aragón Circular 2030, Agenda for the development of the Circular Economy in Navarra 2030) or through other types of regulations. The total farmland contained within the MIP regions is just over 5 million ha, broken down by Aragon (2,830,410 ha), Catalonia (1,723,820 ha), and Navarre (624,330 ha) (EuroStat, 2022).

9.1 Value Chain 1 – Pig Slurry

Pig slurry is one of the most important environmental problems for the agricultural sector in Spain, affecting climate change, water quality and air quality. The management of manure is one of the criticisms levelled at large livestock farms. For farmers of Aragon and Catalonia, pig slurry management is a particular challenge, since these regions account for 61% of pig production in Spain. The potential to use this slurry for biogas production can help reduce environmental risks posed and contribute to the circular economy with the co-production of organic fertilisers.

9.1.1 *Biomass Arisings and Flows*

Within the MIP regions of Spain, it is estimated that the total amount of pig slurry produced is 28,361,479 tDM. The majority of this is estimated to arise in the Catalonia region, which is 17,614,511 tDM, while there are smaller amounts produced in Aragón and Navarra, 8,851,674 and 1,895,293 tDM respectively. The majority of this is understood to be currently applied to land, with a smaller volume being used for biogas or organic fertiliser respectively. Although the precise ratio per application is not fully known. Pig slurry is considered to have a value of approximately €17.50 per tDM in the region. The breakdown of pig slurry arisings across the MIP region is provided in Figure 48. A full summary of the arisings per region for this value chain is included in Appendix 2.

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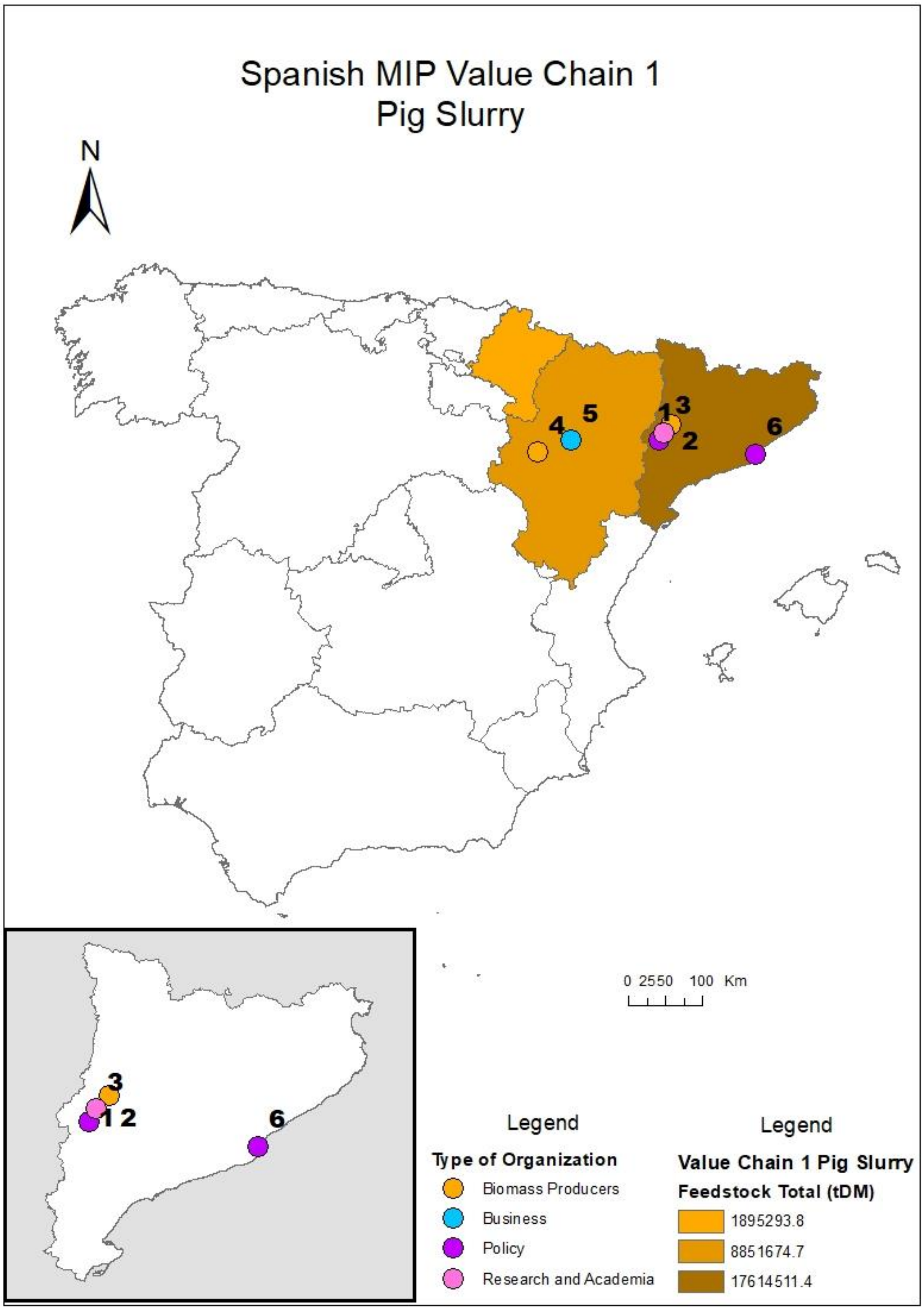
Figure 48. Map of arisings of pig slurry biomass and key stakeholders within the Spanish MIP region.



Biomass Producers		***Business***		***Policy***		***Research & Academia***	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
2	Leridana de Piensos S.A.	5	Cisternas Agudo	1	BIOHUBCAT - Bioeconomy HUB of Catalonia (Diputación de Lleida)	3	Centre d'Estudis Porcins
4	Llograsa S.A.			6	Generalitat de Catalunya		

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9.1.2 *Biomass Value Chain Actors*

Some relevant actors participating in the pig slurry chain from the Spanish MIP have been identified in Figure 48, above. These include stakeholders on the pig production side, such as Leridana de Piensos S.A. and Llograsa S.A., as well as in the business sector, such as Cisternas Agudo who support in slurry management technologies. Relevant policy stakeholders, include Generalitat de Catalunya, the Government of Catalonia, as well as BIOHUB CAT - Bioeconomy HUB of Catalonia (Diputación de Lleida). BIOHUB CAT is one-stop-shop to support the development of the circular bioeconomy in Catalonia. On the research side, the Centre d'Estudis Porcins offers expertise related to pig research including slurry management.

9.1.3 *New Biomass Value Chain Opportunities and Examples*

Due to the high concentration of pig production in the region, and the associated arisings, it is important that the slurry be managed sustainability to avoid pollution issues caused by nutrient excesses. Anaerobic digestion of these slurries to produce manure is one potential way to manage this risk, while making use of this nutrient rich resource. In 2022, two new biogas projects were marked for investment in the Catalonia region. The plants of Sentiu and Linyola will use organic waste including pig manure from local farms, as well as slaughterhouse wastes and other industrial wastes. Together, it is estimated that these biogas plants will reduce CO_2 emissions by more than 150,000 tons per year, while creating new jobs in the region (Energy News, 2022). Meanwhile, researchers at Catalan Institute of Agrifood Research and Technology (IRTA) are involved in the EU Circular Agronomics project, through which pig slurry will be treated in a factory in Lérida (Catalonia) to produce biogas and organic fertilisers. In this model, the AD process is coupled with innovative processing involving (i) solar drying for concentrated fraction of digestates and (ii) stripping (N-recovery) for concentrates (clarified fraction of digestates). The biogas plant at PORGAPORCS, S.L. in Lérida will form part of the demonstration.

Figure 49. PORGAPORCS, S.L. in Lérida (source: https://fedarene.org/).

9.2 Value Chain 2 - Lucerne

Lucerne also called alfalfa, is a perennial flowering plant in the legume family Fabaceae. It is cultivated as an important forage crop in many countries around the world. It is used for grazing, hay, and silage, as well as a green manure and cover crop. Spain is the third largest exporter of fodder in the world and the second largest exporter of lucerne. Of all the regions, Aragon leads lucerne production in Spain, followed by the autonomous community of Catalonia.

9.2.1 *Biomass Arisings and Flows*

Within the Spanish MIP regions, it is estimated that the total amount of lucerne harvested is 1,059,617 tDM. The majority of this is being produced in Aragon, with a total of 715,151 tDM. Smaller amounts are produced in the other regions, with the largest other amounts being produced in Catalonia, 281,009 tDM. The majority of lucerne produced within the MIP region (858,290 tDM), is estimated to be baled as animal feed, with the remainder being processed into feeding pellets (see Figure 50 below). A map of the risings across the MIP region is provided in Figure 51. The current market value of lucerne in the region is estimated to be as high as €350 per tDM. A full summary of the arisings for this value chain and sources is included in Appendix 2.

Figure 50. Sankey diagram showing the arisings and flows and fates of lucerne across different regions of the Spanish MIP region.

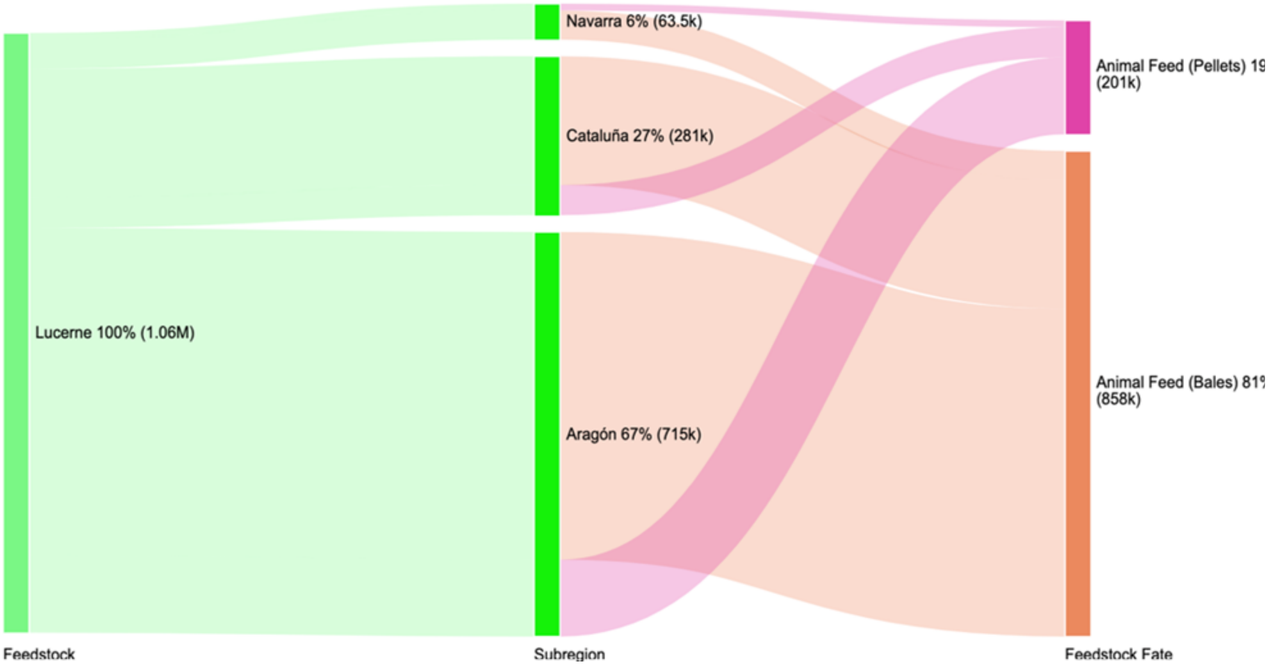
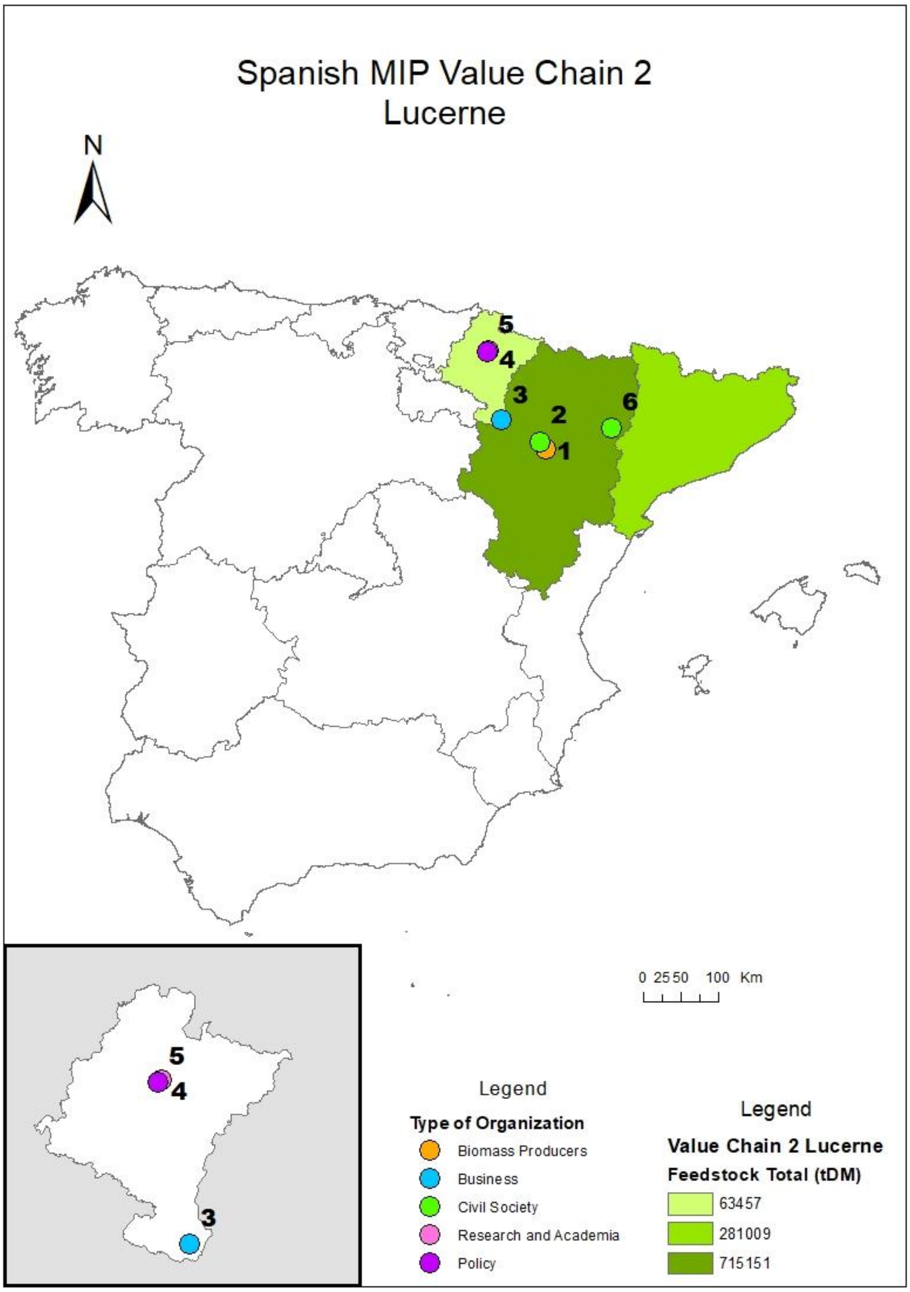


Figure 51. Map of arisings of lucerne biomass and key stakeholders within the Spanish MIP region.



Biomass Producers		***Business***		***Civil Society***		***Policy***		***Research & Academia***	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
1	APS - Agroindustria l Pascual Sanz	3	Liverco S.L.	2	AEFA (Asociación Española de Fabricantes de	5	Gobierno de Navarra	4	Instituto de Agrobiotecnologí a

					Alfalfa Deshidratada)				
				6	AAMCHAA (Asociación de Amigos del Maíz de Consumo Humano y semilla Alfalfa Aragón)				

9.2.2 *Biomass Value Chain Actors*

Some of the key value chain actor on the Lucene value chain for the Spanish MIP region are identified in Figure 51 above. This includes Agroindustrial Pascual Sanz, S.L., a company that obtains feedstock from the biomass suppliers in the region for the production of forage in bales and pellets. Liverco S.L. on the business side, specialize in the distribution of forage products. Stakeholders also include representative groups such as the Spanish Association of Manufacturers of Dehydrated Lucerne (AEFA) and the Association for Corn and Lucerne in Aragon region (AAMCHAA). On the research side the Instituto de Agrobiotecnología have different researchers specializing in the sustainable production and management of lucerne.

9.2.3 *New Biomass Value Chain Opportunities and Examples*

Currently, lucerne has mainly been used or sold as a fodder source in a bale or pellet (compact granules) format. Regional companies such as Agroindustrial Pascual Sanz, S.L. lead in such developments. At their facility, lucerne is dehydrated and stored in closed warehouses until it is sold. The factory infrastructure can currently reach a production capacity of 100,000 tons/year. The facility supplies regularly in Spain as well as internationally in Europe, the Middle East and Asia. Aside from feed application, there has also been some interest in Spain in exploring the potential use of this crop for bioenergy applications (Gallego et al., 2011). Researchers in Spain have already investigated its potential use in bioethanol production (González-García et al., 2010). Internationally work has been undertaken to investigate the potential of biorefining lucence for produce multiple novel products. For example, at the pilot plant in Havelland, Germany, the lucerne is refined to obtain a fibre press cake and green protein for feeding cows and monogastrics, with other planned products including a high-value white protein and fermentation media (Kamm et al., 2010). This approach may help to increase the efficiency of lucerne biomass. Another initiative has focused on the conversion of lucerne and similar green plants into biochemicals like lactic acid (Ecker et al., 2012).

Figure 52. Agroindustrial Pascual Sanz, S.L facility (source: https://www.alfalfaspain.es/).

9.3 Value Chain 3 - Forest Industry Biomass

Spain is the third European country in terms of absolute forest biomass resources and its forestry resource is growing faster than any EU country. The total area of Spain dedicated to woodlands is 175,161km^2. The Spanish forest-based sector, which includes forest owners, forestry companies, the pulp and paper industry, and the wood processing and furniture industries, has an overall annual turnover of €16.717 million and employs 189,875 people in 29,623 companies. Woodland accounts for 15,910km^2 of Catalonia's land use, 14,438km^2 of Aragon's land use and 4,010km^2 of Navarre's land use (EuroStat, 2022). While in Navarre and nationally, most woodland is dedicated to broadleaf specifies, in the Aragon and Catalonia regions, the focus is mainly on coniferous woodland.

9.3.1 ***Biomass Arisings and Flows***

Within the Spanish MIP regions and looking specifically at the forest industry (products) sector, the total amount of forestry biomass within the production sector is estimated at over 1.3 million tDM. The majority of this is being processed in Catalonia, with a total of 695,205 tDM. A large amount is also being processed in Navarra (457,357 tDM), with a smaller amount being processed in Aragon (211,466 tDM). As shown in Figure 53, the majority of wood in the MIPs wood processing industries goes towards pulp production (about 36%), sawmill (30%) and board production (22%), with smaller amounts going towards firewood and bioenergy (about 9%) and the remainder going for other uses, such as poles and fences. The current market value of forestry biomass in the region is estimated on average at €35 per tDM. The flow of forest industry biomass across the MIP region is provided in Figure 53, while a map of arisings is included in Figure 54. A full summary of the arising per region are included in Appendix 2.

Figure 53. Sankey diagram showing the arisings and flows and fates of forest industry biomass across different regions of the Spanish MIP region.

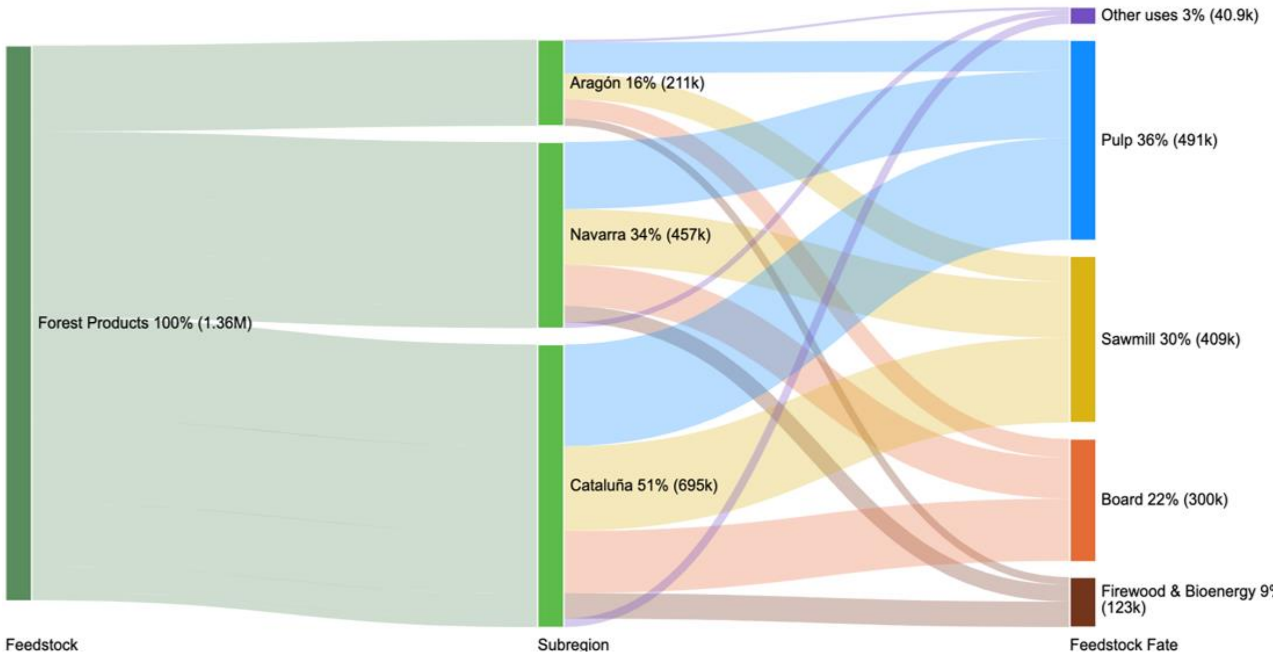


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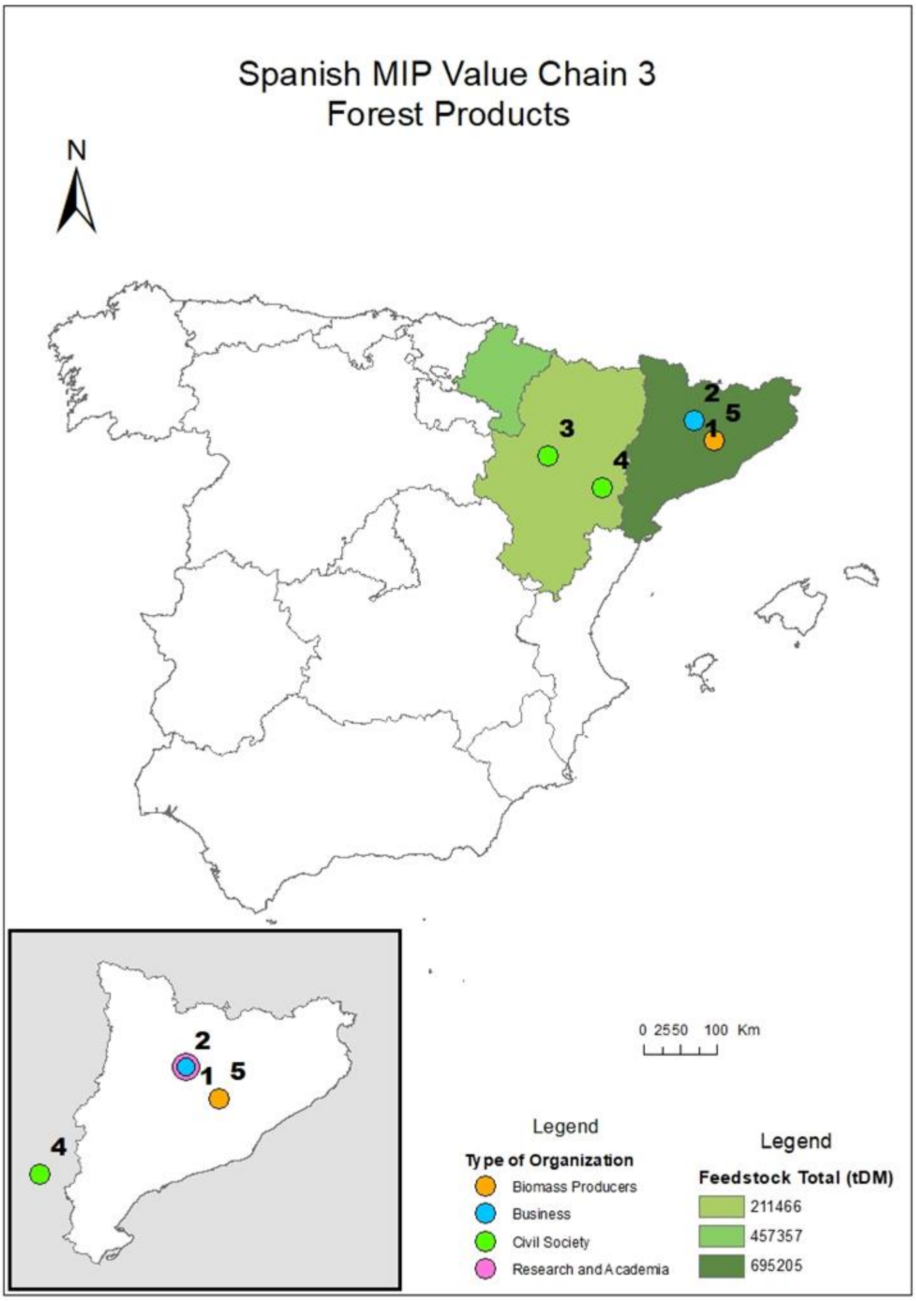
Figure 54. Map of arisings of forest products biomass and key stakeholders within the Spanish MIP region.



Biomass Producers		***Business***		***Civil Society***		***Research & Academia***	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
5	Cluster Bioenergía Catalunya	2	FBS	3	Fondo Natural	1	CTFC - Centre for Forestry Science and Technology of Catalonia
				4	La Casa Bosque		

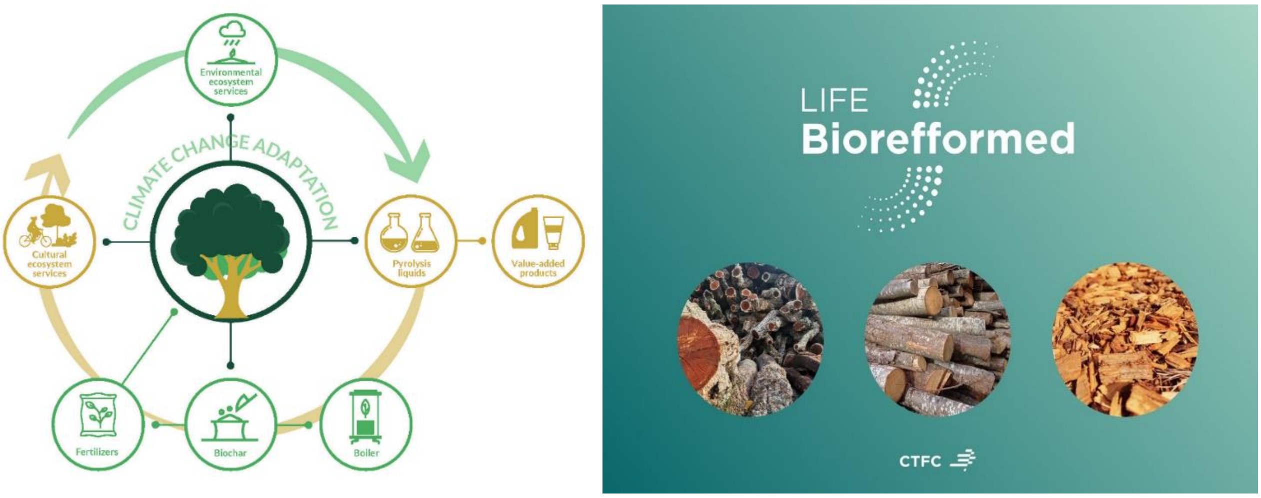
9.3.2 *Biomass Value Chain Actors*

Some of the key actors involved in the forest industry value chain for the MIP region are indicated on Figure 54 above. On the biomass producer side is the Cluster Bioenergía Catalunya that work between the relevant value chain partners to support new bioenergy initiatives. On the business side is the organization FBS who support on technology transfer. Civil society stakeholders include Fondo Natural and La Casa Bosque. Supporting activities on the research side is the Centre for Forestry Science and Technology of Catalonia (CTFC) who aim to contribute to research in the fields of sustainable forest management, biodiversity, and the circular bioeconomy.

9.3.3 *New Biomass Value Chain Opportunities and Examples*

In the region the CTFC supports innovation within the forestry industry sector. They work through three programmes: multifunctional forest management, landscape dynamics and biodiversity, and bioeconomy and governance. Part of the activity conducted in the programmes is transferred through the technology transfer company FBS. The research carried out at CTFC focuses on addressing key challenges such as the balance of functions of the natural environment, adaptation to climate change and competitiveness along value chains. CTFC participate on a wide variety of relevant projects including the LIFE BIOREFFORMED project which focuses on implementing a Mediterranean biorefinery to boost forest management through the production of value-added products. The project uses conversion technologies such as torrefaction and pyrolysis (TP) to produce renewable chemicals and fuels from forest biomass. Within the project, bio-oil, biochar and non-condensable gases are produced. Bio-oil will be subsequently fed into the extraction unit to separate the antioxidants phase (polyphenols) from an aqueous phase. The biochar, in turn, will be used in biomass boilers to produce heat and the resulting ashes will be returned to the forest demonstration areas as an external input of nutrients and minerals, closing the biomass cycle. Within the region there are also exemplar villages such as Llinars del Vallès, which are looking to becoming energy self-sufficient, using largely woody biomass.

Figure 55. Schematic of the biorefinery approach of the LIFE BIOREFFORMED project (source: https://lifebiorefformed.eu/).



9.4 Value Chain 4 - Camelina

Production of Camelina is a profitable alternative to fallow land and arid dry land in disuse or with low productivity, which is very abundant in Aragon. It also useful as a rotation crop with traditional cereals. It is estimated that approximately 40,000 ha of Camelina have been planted to date across Spain. Since Camelina grows on idle land, it does not displace traditional food crops. There are also potential environmental benefits from this crop, with previous researching demonstrating that camelina provided the lowest nitrate levels at 30, 60, and 100 cm compared to clean till, no-till, and other cover crops like radish, rye, and pennycress (Company, 2022). From its harvesting and processing, biofuels are obtained for the automotive (biodiesel) and aviation (biokerosene) sectors, while its flour, rich in protein and omega 3, is used in animal feed for cattle, pigs, poultry and fish.

9.4.1 ***Biomass Arisings and Flows***

Within the Aragon region of the Spanish MIP only it is estimated that about 1000 tDM of camelina are being processed currently. Approximately 330 tDM of this are being converted to camelina oil, while about 650 tDM being produced as a cake product for use as animal feed, with about 20 tDM being lost as a by-product of the process. The current market value of Camelina in the region is estimated as high as €700 per tDM. The breakdown of camelina across the MIP region is provided in Figure 56, while arisings of the biomass on a regional basis is included in Figure 57. A full summary of the arising for this value chain in the MIP region is included in Appendix 2.

Figure 56. Sankey diagram showing the arisings and flows and fates of camelina biomass across different regions of the Spanish MIP region.

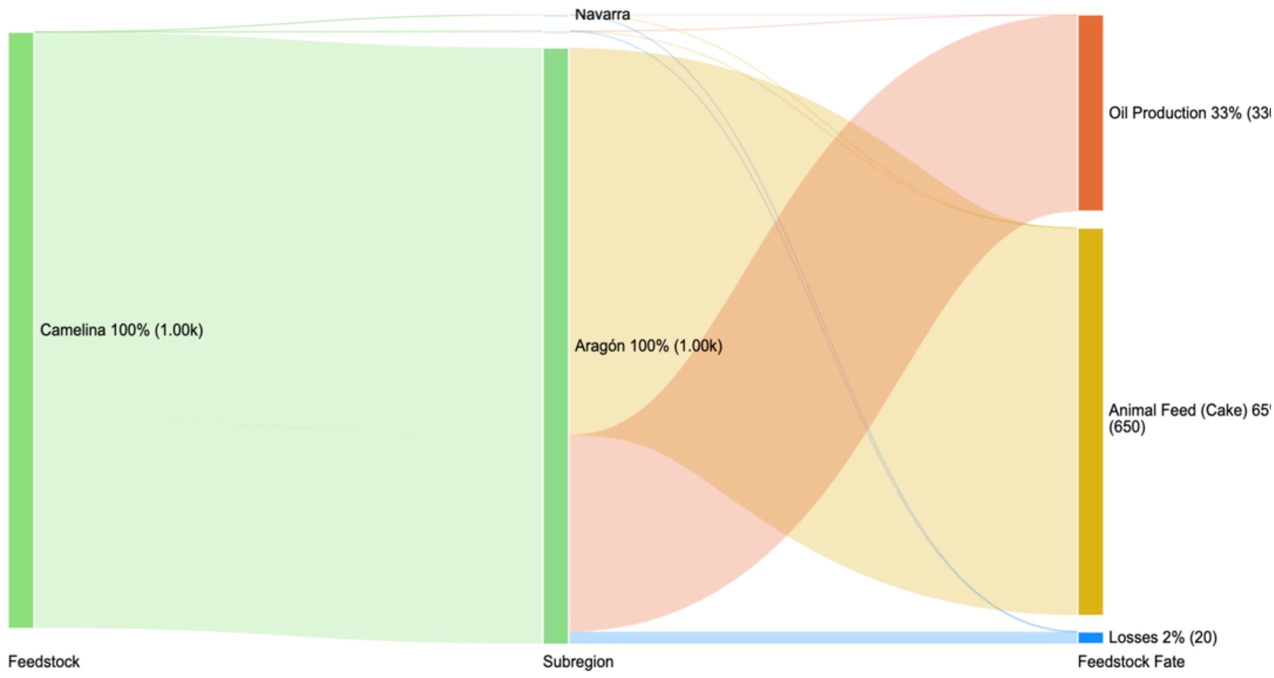
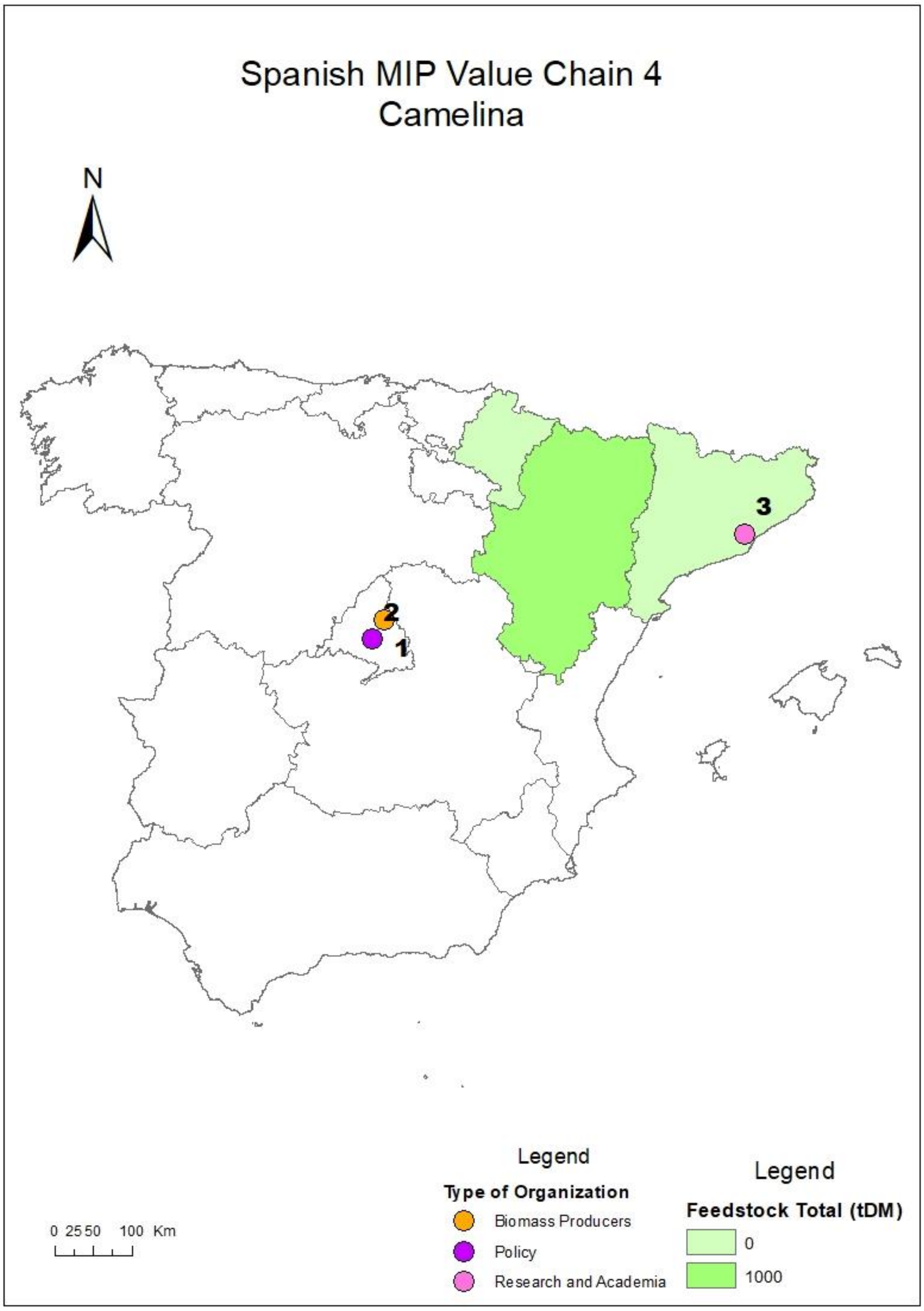


Figure 57. Map of arisings of camelina biomass and key stakeholders within the Spanish MIP region.



Biomass Producers		***Policy***		***Research & Academia***	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*

1	Camelina Company	2	Ministerio de Agricultura, Pesca y Alimentación	3	Universidad Autónoma de Barcelona

9.4.2 *Biomass Value Chain Actors*

Various stakeholders of the Camelina value chain relevant to the Spanish MIP are identified in Figure 57 above. These include the Camelina Company who supply seeds, and support farmers who convert land to camelina with technical support during the agronomic cycle. The ministry for agriculture are also relevant since they can set policies which incentivize farmers towards cultivation of new crops on underutilised land. On the research side, the Universidad Autónoma de Barcelona are actively involved in research related to camelina.

9.4.3 *New Biomass Value Chain Opportunities and Examples*

The Camelina Company recently launched a new camelina innovation centre in Spain. The 420m^2 Innovation Centre at Daimal will allow the company to significantly expand their research and development while enhancing their presence in one of the best performing camelina regions in Spain. Part of this will focus on breeding research, as farmers in Spain have increasingly adopted camelina cultivation, doubling yields to achieve over 2,500 kg/ha, thanks to strategic breeding and improved farmers' practices (Biodiesel Magazine, 2022). There is the opportunity to use the products of camelina for the food and feed markets, which currently happens in the region. But there are also opportunities to produce industrial products from this crop. Camelina is seen as a promising energy crop due to its high oil content and can be converted to biofuels such as renewable jet fuel, green diesel, and biodiesel (Arshad et al., 2022). The high unsaturated fatty acid content and unique characteristics of camelina oil compared to other common seed oils makes it also an attractive potential feedstock for various other industrial applications, as these unsaturated fatty acids can be easily functionalized into useful polymer building blocks or prepolymers, biocomposites, coatings and adhesives and resins (Arshad et al., 2022).

9.5 Value Chain 5 - Brewery Spent Grain

The brewing sector in Spain is the fourth largest beer producer in Europe and eleventh Worldwide, with 503 breweries producing 34,692 million hectolitres (hl) in 2020 (Brewers of Europe, 2022). The top four Spanish producing companies in 2017 were Mahou-San Miguel Group (12.3 million hl), Heineken España (10.5 million hl), S.A Damm (9.6 million hl) and Hijos de Rivera (2.8 million hl) (Bord Bia, 2018). The main solid residue from the brewing process is the spent grain obtained after the mash. For each 1000L of beer produced, the brewery process typically produces approximately 200 kg of brewery spent grain. The valorisation of this biomass is complicated due to the high level of humidity (around 80%). Most of the breweries sell or give this waste to livestock farmers to feed cattle.

9.5.1 *Biomass Arisings and Flows*

Within the Spanish MIP regions, it is estimated that 151,540 tDM brewery spent grain (BSG) are produced as by-product of the brewing sector, with the vast majority of this (142,065 tDM) being produced in the Catalonia region. This by-product mainly goes for feed applications, although some also goes to landfill. The current market value of BSG in the region is estimated at €50 per tDM, although in some cases this is made available to farmers as feed for free. The flow of BSG biomass and distribution of arisings across the MIP region is provided in Figure 58 and 59 respectively, while more data on this value chain can be found in Appendix 2.

Figure 58. Sankey diagram showing the arisings and flows and fates of brewers spent grain biomass across different regions of the Spanish MIP region.

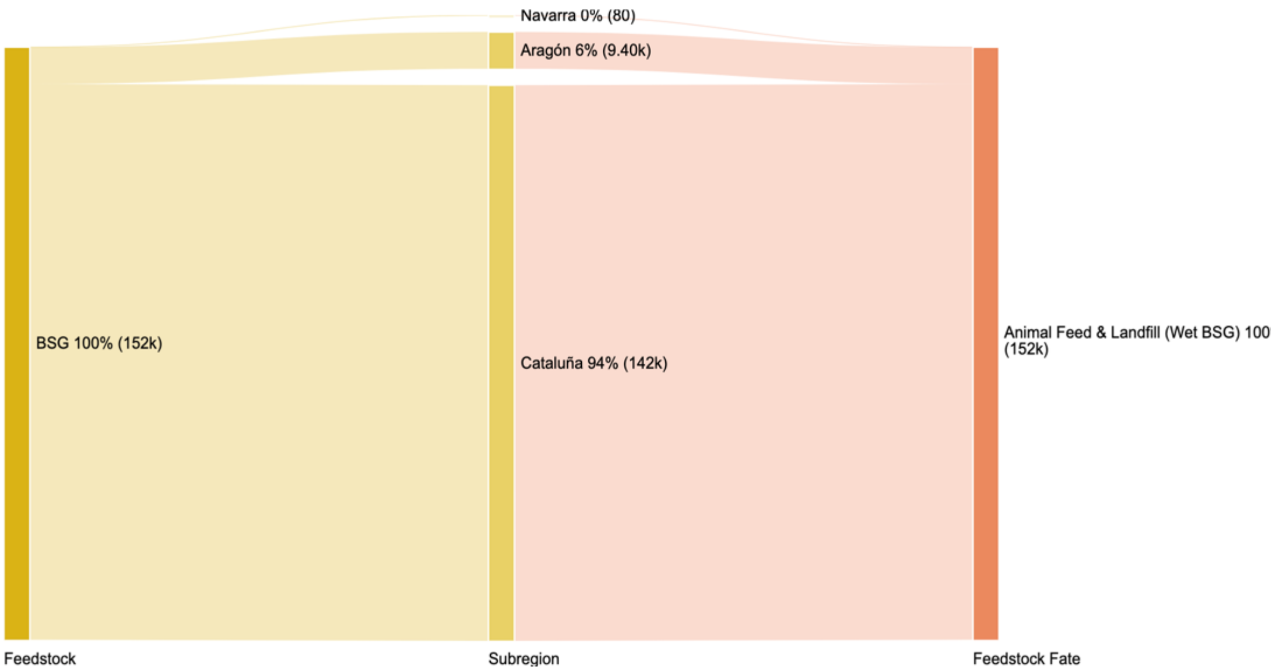


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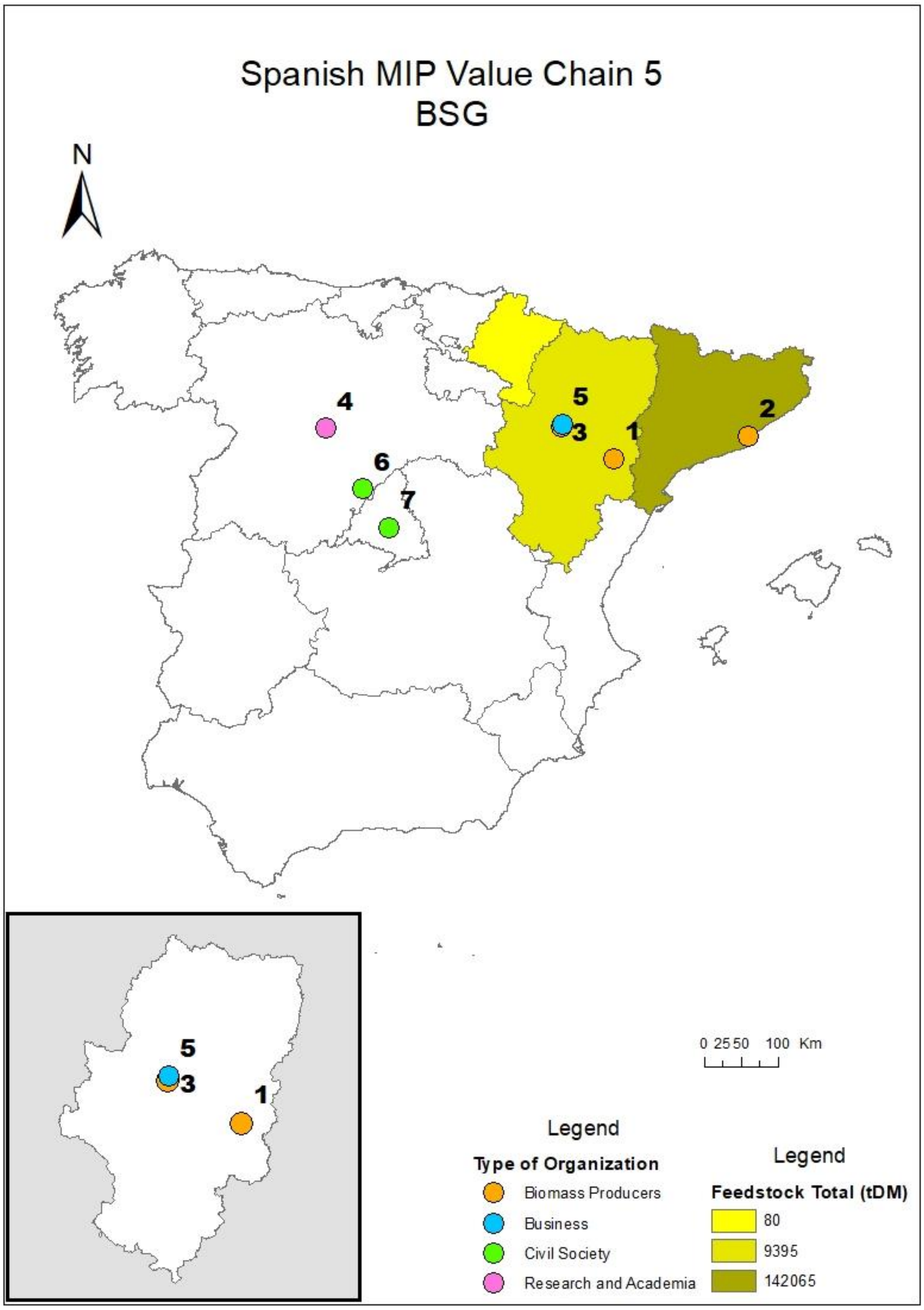
Figure 59. Map of arisings of brewers spent grain biomass and key stakeholders within the Spanish MIP region.



Biomass Producers		***Business***		***Civil Society***		***Research & Academia***	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*	*ID*	*Organization*
1	Cervezas Cierzo	5	Franquipan S.L.	6	AECAI	4	Universidad de Valladolid

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2	DAMM			7	ACE		
3	La Zaragozana			8	Gecan (Gremi d'elaboradors de cerveza artesana i natural) *		
				9	Aragón Beers *		

9.5.2 *Biomass Value Chain Actors*

Some of the key actors related to the BSG value chain are indicated in Figure 59 above. This includes actors related to production of BSG, which includes brewing companies likes Cervezas Cierzo and La Zaragozana, and business organisations like Franquipan S.L. Civil society actors include associations such as the Craft and Natural Brewers Guild (Gremi d'elaboradors de cerveza artesana i natural) and AECAI who are the Spanish Association of Independent Craft Brewers. Supporting innovation in the brewing sector, the Universidad de Valladolid are involved in different initiatives looking at these opportunities.

9.5.3 *New Biomass Value Chain Opportunities and Examples*

While in most cases BSG is distributed to animal feed applications, there are other potential avenues for using this material in fuel or material applications. Researchers in Spain have already been evaluating techniques to separate the components of BSG into fermentable sugars for bio-based products and lignin as a separate stream (Outeirino et al., 2019; Outeiriño et al., 2019; Outeiriño et al., 2022). Researchers in Catalonia have been investigating targeted products resulting from the biotransformation of BSG to produce compostable polymer polyhydroxyalkanoates and lignocellulolytic enzymes and in a two-stage valorization approach (Llimós et al., 2022). Other researchers have looked at the potential to extract bioactive compounds from BSG (Alonso Riaño, 2019). According to Sganzerla et al. (2021) depending on the technological route various high value materials can be produced from BSG including arabinoxylans, proteins, ferulic acid, xylitol, xylose, lactic acid, butanol, biogas, fertilizer, and ethanol.

10. Swedish MIP Region

Located in Northern Europe, Sweden has a population of almost 10.5 million and is the largest of the Nordic countries at over 447,425km^2. The Swedish bioeconomy was estimated to have an annual value of 258 billion Swedish Kronor, or six percent of GDP in 2015. The sector employed approximately 260,000 people across its different sectors in 2019. Around half of the value added comes from industries that Statistics Sweden classifies as 100 percent bioeconomic – such as agriculture and forestry, food, wood, paper and pulp. The other half comes from industries that are classified as bioeconomic only in part – for example, textiles, construction and chemistry.

The sustainably used forest is a key resource for the Swedish bioeconomy. Wood is the main raw material for a wide range of climate-smart products, such as wood products, buildings, furniture, pulp, cardboard, textiles, chemicals, fuels and energy. Seventy percent of the land area in Sweden is covered by forests, and 57% of Sweden's total land area consists of productive forests (Fischer et al., 2020). Of the products produced from forest raw materials in Sweden today, about 80 percent are exported. Along with hydropower and mining, the development of the export-oriented forestry industry is often referred to as the backbone of the Swedish economy (Fischer et al., 2020). When forest raw material is processed on an industrial level, side streams arise in the form of e.g., sawdust, lignin and tall oil, which in turn can be further refined. For example, today most of the lignin produced is burned for energy.

According to JRC (2022) there are 284 bio-based industry facilities operational in Sweden, mainly commercial plants (277) and largely operating in the timber or pulp and paper sectors (144 and 42 facilities respectively), with a high number of facilities focusing on biomethane (63), chemicals (27), liquid biofuels (16), sugar and starch (8) and composite fibres (7). Examples of well-established companies operating demonstration or commercial scale biorefinery processes for a mixture of material and energy products from forestry biomass are SEKAB, Sunpine and Domsjö Fabriker. 2021 figures show that there were 281 biogas plants producing in total 2.3 TWh of biogas in 2021, with 71 biomethane upgrading units producing about 1.4 TWh biomethane (Klackenberg, 2021).

While the forestry sector dominates land use, Sweden's agriculture sector is a smaller but important primary sector with about 7.5% of land use (Eurostat, 2021b). Swedish fields are mainly used to grow crops for feed and for food production, but some are also used for raw materials to make chemicals and fuels. Some examples of these raw materials are sugar-based or starch-based crops such as sugar beets, or oil-based crops such as rapeseed. In agriculture, residual streams with the potential for further processing also arise – for example, straw, husk cakes or seed cakes.

Residual streams also arise from industries (including forest industry and food industry), agriculture and society. These are streams that consist of biomass in the form of e.g., packaging waste, textile waste, food waste and sewage sludge. At the moment, many of these streams lead into energy recycling, with the exception of packaging and paper waste which is recycled in the form of recycled fibres. However, the value of residual streams can be upgraded through improved sorting and increased material recycling.

Nationally, the Swedish Science Council for Environment, Agriculture and Spatial Planning (Formas) commissioned the government and, in collaboration with the Swedish Energy Agency and the Academy of Innovation, published a national bioeconomy strategy, the "Swedish Research and Innovation Strategy for a Biobased Economy" in 2012. According to the strategy, negative effects on the climate and the consumption of fossil raw materials can be minimized through the sustainable production of biomass, with opportunity areas, for example, in the transport, automotive, construction and chemical industries. Various supporting activities are underway to support bioeconomy development on the ground. BioInnovation is a strategic innovation program with the vision that Sweden will have made the conversion into a bioeconomy in 2050. The program was initiated by the Swedish Forest Industries Federation, IKEM (the Innovation and Chemical Industries in Sweden) and TEKO (Swedish Textile and Clothing Industries Association) and is initiating a range of projects across a broad range of feedstocks (BioInnovation, 2022).

RISE (Research Institutes of Sweden) works with climate smart materials, fossil-free fuels and green chemicals – as well as system analysis, resource efficiency, trial services, service design, and new business models and policy issues. Cooperation, such as The Bioeconomy Research Programme, is a vital element in the transformation process (RISE, 2022). There are also many R&D and investments activities by the large forest companies and by emerging SME’s.

The focus regions of the Swedish MainstreamBIO MIPs are NUTS2 regions of Middle Norrland (SE 32), containing the counties of Västernorrland and Jämtlandand; and Upper Norrland (SE 33) which includes counties Västerbotten and Norrbotten. The region of Middle Norrland, was home to 375,709 inhabitants in 2021 with its economy largely focused on forestry, natural resources, advanced manufacturing and tourism (European Commission, 2022). The region has ambitious fossil free transports targets by 2030, and a 10% target for annual reduction of greenhouse gases between 2020-2030. Upper Norrland is the Northernmost region of Sweden, and also Sweden’s largest region by area with a population of 522,806 in 2021 (European Commission, 2022). From a total of 279,329,km_2 of forestry in Sweden, 51,327km_2 and 98,458km_2 of this forest can be found in Middle and Upper Norrland, respectively, accounting for over 50% of the entire country (EuroStat, 2022). There are 64 cogeneration plants, 28 sawmills and 9 pulp and paper mills in this region (upper and middle Norrland).

10.1 Value Chain 1 - Forestry Residues

GROT (branches and treetops also called logging residues) is a by-product from felling of trees in the forest and has become a large resource used for bioenergy where some of the GROT is burned and converted into energy, but most still remains left in the forest. The conversion of GROT to energy is, from a climate point of view, positive but has negative impacts for the many species that depend on dead wood. Careful selection of the tree species and the areas in which GROT is removed from the forest, as well as in how storage and transport take place, should make it possible to reduce these negative effects. GROT is only taken from spruce dominated areas. Since the soil is poor in pine dominated areas, GROT is left behind as nourishment.

Due to the large bulky nature of GROT, it is not economically justifiable to use a transport distance exceeding 70-100 km for transporting by truck due to high costs. For train and boat transport, on the other hand, a transport distance of at least 200 and 500 km is required to achieve economic profitability.

10.1.1 *Biomass Arisings and Flows*

An overview of the total flow of GROT and estimated arisings within the Swedish MIP region is provided in Figures 60 and 61 below.

For Middle Norrland the total arising of GROT residues is estimated at 910,755 tDM per annum, broken down by Västernorrland (497,444 tDM) and Jämtlandand (413,311 tDM) respectively. For Upper Norrland the total produced GROT is estimated at 870,401tDM, with the majority coming from Västerbotten (478,109 tDM), and the remainder from Norrbotten (392,292 tDM). A value of approximately 180 SEK (€15-20) tDM is associated with this biomass.

In terms of the flow of GROT, it is estimated that about 99% of this ends up on the land, with only about 1% being used in Combined Heat and Power Plant (CHP) and heating operations. There is therefore the opportunity to find innovative uses of this GROT biomass, but this must be done while ensuring minimum impact on the forest eco-system. The logging residues are only currently removed from spruce dominated areas, and not from pine dominated areas, since pine land is poorer in nutrients (lean soil), so the logging residues are left for fertilizing. A more detailed summary of the availability and flow of biomass across the region for this value chain can be found in Appendix 2.

Figure 60. Sankey diagram showing the arisings and flows and fates of logging residue biomass across different regions of the Swedish MIP region.

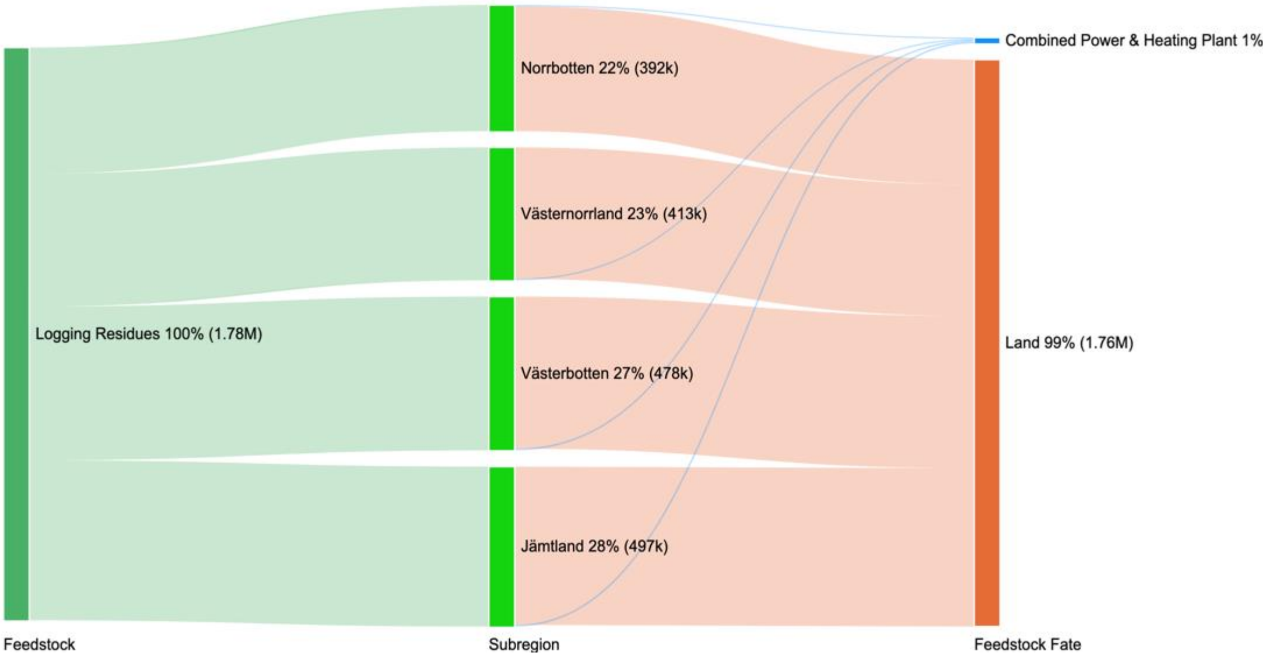
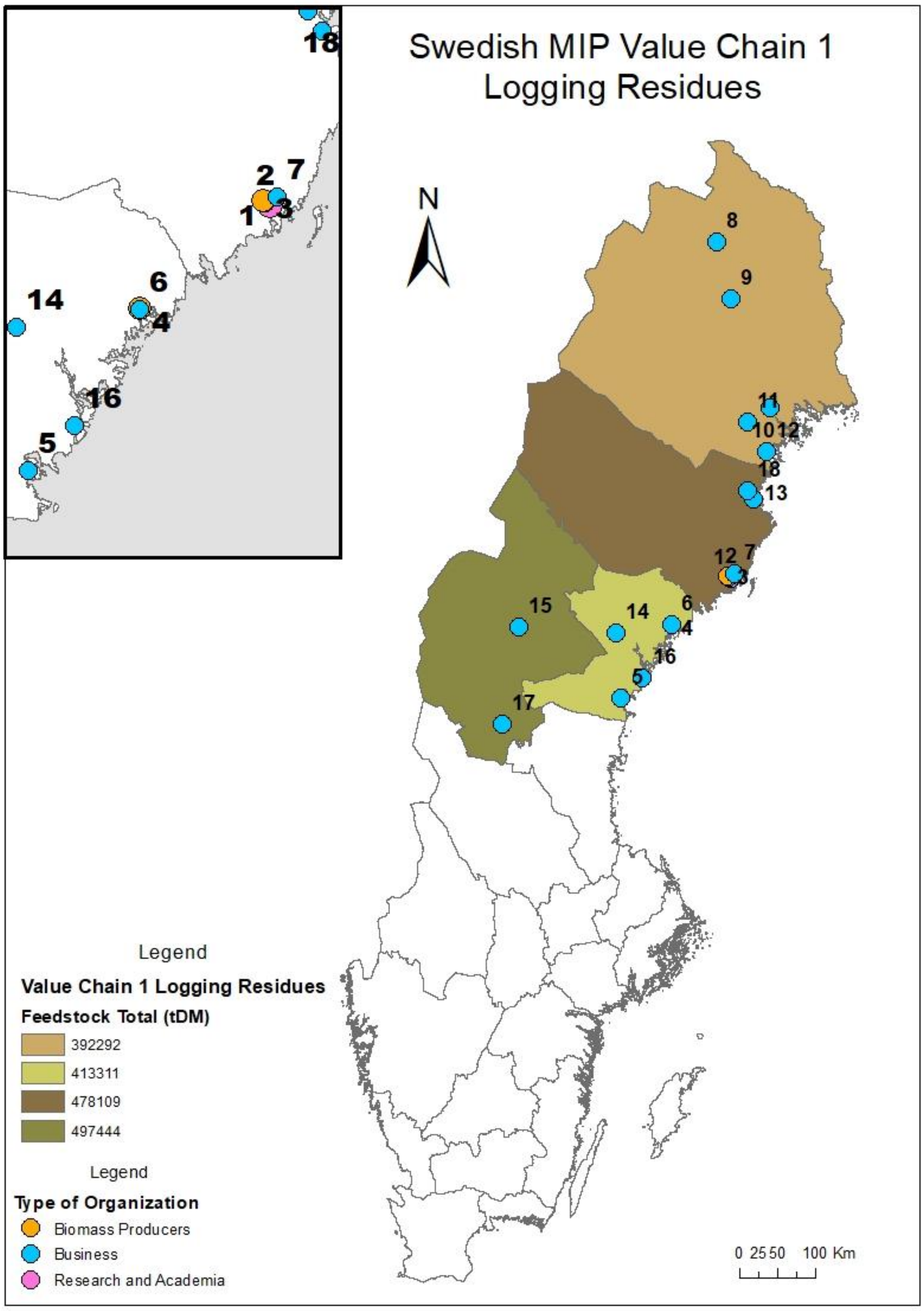


Figure 61. Map of arisings logging residue biomass and key stakeholders within the Swedish MIP region.



Biomass Producers		*Business*		*Research & Academia*	
ID	*Organization*	*ID*	*Organization*	*ID*	*Organization*
3	Sveaskog	2	REBIO	1	SLU - Swedish University of Agricultural Sciences, Department of Forest Economics
4	Holmen Skog	5	Sundsvall Energi, Korstaverket		

		6	Övik Energi		
		7	Umeå Energi (Dåva)		
		8	Tekniska Verken, Kiruna		
		9	Gällivare Energi		
		10	Boden Energi		
		11	Älvsbyns Energi		
		12	Piteå Energi		
		13	Skellefteå Kraft		
		14	Eon Värme Sollefteå		
		15	Jämtland Värme, Lugnviksverket		
		16	Härnösand Energi		
		17	Härjeåns Energi		
		18	SCA Skog AB		

10.1.2 *Biomass Value Chain Actors*

A number of key actors to this value chain have been identified within the Swedish MIP region. These include producer actors Sveaskog and Holmen Skog who are among Sweden's largest forest owners, as well as different industry actors using the biomass. These include companies who are primarily focused on green energy production, such as Älvsbyns Energi, Piteå Energi, Boden Energi and Gällivare Energi. The Swedish University of Agricultural Sciences, through their Department of Forest Economics are an important academic stakeholder within the value chain. The Department is responsible for putting together the national forest assessment ("Riksskogstaxeringen") each year. The main purpose of the national forest assessment is to describe the condition and changes in Sweden's forests. The data is used, for example, for follow-up and evaluation of current forest, environmental and energy policy. The national forest assessment is part of Sweden's official statistics. The key identified actors are highlighted in Figure 61 above.

10.1.3 *New Biomass Value Chain Opportunities and Examples*

Commercially, the main focus of using by-products from this chain is currently on energy production. Övik Energi, for example, operate a CHP plant in Örnsköldsvik, at which GROT by-products are used to produce renewable electricity and district heating (approximately 219 GWh and 54MW, respectively). Given the large quantities of forestry by-products such as branches and tops (GROT) which are currently unharvested, there is the opportunity to process these further in various ways to obtain a higher energy value. These opportunities are being explored by local partners. For example, using biomass from branches and tops, RISE together with other project partners are developing bio-based granules that are suitable for 3D printing of special packaging (RISE, 2018). The project has demonstrated that GROT-based composites can significantly reduce material costs compared to the plastic granules used today. Researchers are also looking into converting the GROT and other residual streams from the forest industry to replace cotton in, for instance, clothing (Stockholm University, 2020). Moreover, the development of a unique value chain from the forest residual stream to the table has been conducted in the international project FISK. Residual streams such as GROT have been used as a raw material in the production of Single Cell Protein (SCP) as a new sustainable protein source. This in turn could be used in the salmon farming industry which is one of the sectors that is foreseen to increase their production capacity in the coming years (RISE, 2020).

10.2 Value Chain 2 - Biosludge

The pulp and paper industry is an important economic sector for Sweden and the MIP regions of Middle and Upper Norrland. Sweden is the world's second largest exporter of pulp, paper and sawn wood products combined (Forest Sweden, 2022). Of the pulp and paper production, close to 90% is exported. As for pulp production, around a quarter of the total consumption of pulp within the EU are manufactured in Sweden (Forest Sweden, 2022). Treating wastewater from the pulp and paper industry produces large quantities of pulp and paper bio-sludge (PPBS). ~0,7 % PPBS per ton of pulp (based on 11.7 million ton of wood pulp in Sweden, 190 million ton globally, (Food and Agricultural Organization, 2021)). The composition of PPBS varies depending on the paper mill process and wastewater treatment, but typically it contains crude protein 1.5–8.3%, fat 0.3–3.3%, 10–30% dry substance (DS), lignin 17–40% DS, nitrogen 18,000–84,000 mg/kg DS, phosphorus 1,700–21,000 mg/kg DS, potassium 200–4,600 mg/kg DS and ash (27% DS) (Norgren et al., 2020).

10.2.1 *Biomass Arisings and Flows*

An overview of the total estimated PPBS arisings within the Swedish MIP region is provided in Figure 63 below.

For Middle Norrland the total production is estimated 16,000 tDM per annum, which is allocated to Västernorrland county. For Upper Norrland the total produced PPBS is estimated at 10,000 tDM, with the majority arising in Norrbotten (10,000 tDM) and the remaining arising in Västerbotten (2,000 tDM). Estimated prices associated with PPBS biomass vary between negative value to some value (not defined but usually based on heating value).

Looking at the existing flow and fates of PPBS, it is estimated that about 60% is used in energy recovery after pre-evaporation, while the remainder is cover material for waste deposit. A small amount is foreseen to go towards new alternative applications such as biocoal or compost, but this is considered to be small and is not yet quantified. The fates of this biomass are presented in Figure 62, while arisings per region are represented in Figure 63. A more detailed summary of the availability and flow of biomass per county can be found in Appendix 2.

Figure 62. Sankey diagram showing the arisings flows and fates of Bio Sludge biomass across different regions of the Swedish MIP region.

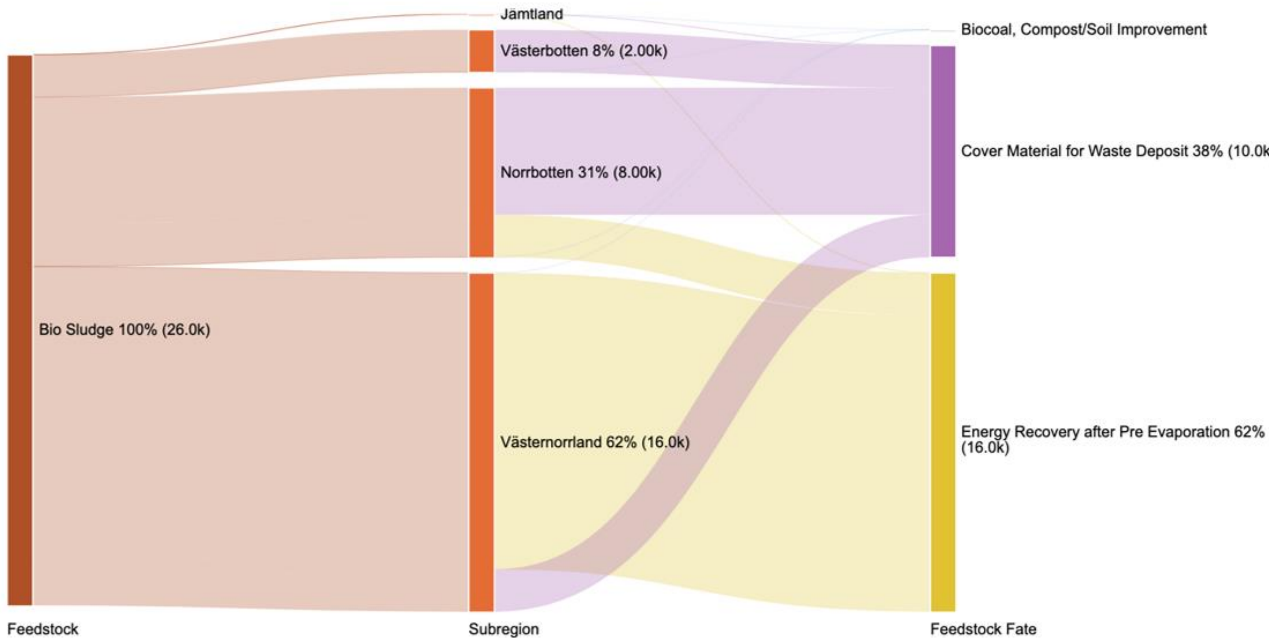


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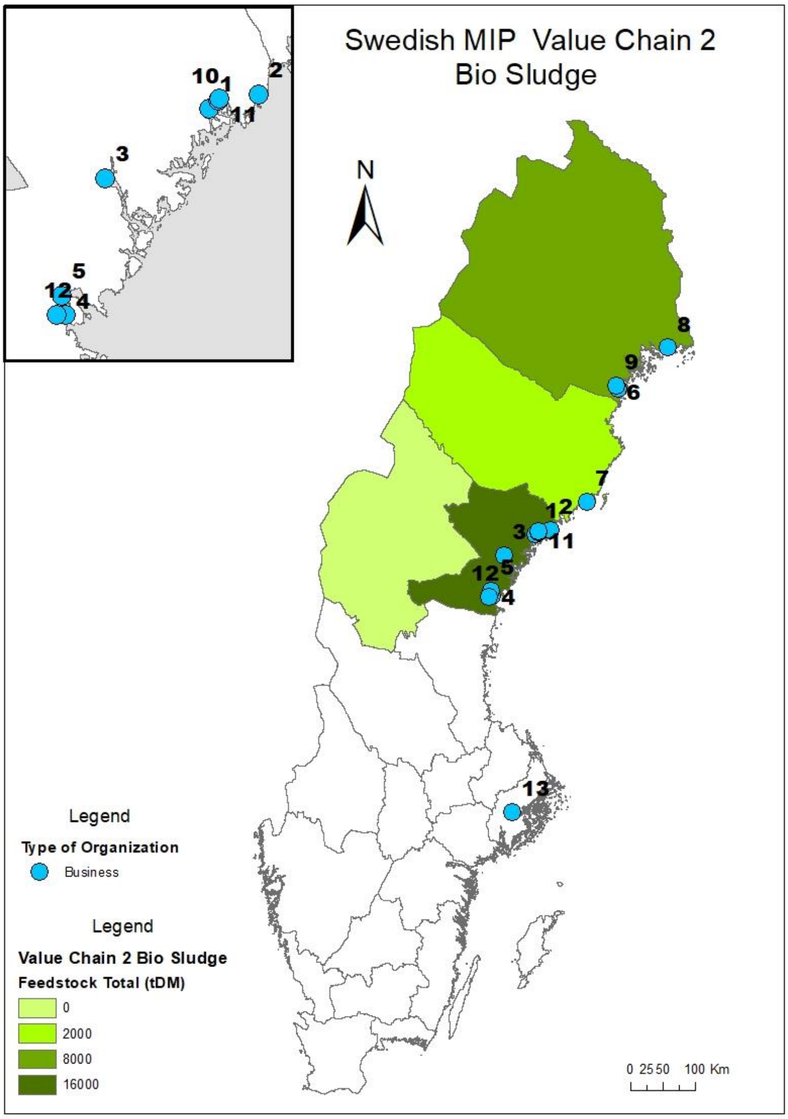
Figure 63. Map of arisings of biosludge biomass and key stakeholders within the Swedish MIP region.



Business	
ID	*Organization*
1	Domsjö Fabriker, Örnsköldsvik
2	Metsä Board Sverige, Husum
3	Mondi Dynäs, Kramfors
4	SCA Ortviken
5	SCA Östrand
6	SCA Munksund

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7	SCA Obbola
8	Billerud, Kalix/Karlsborg
9	Smurfit Kappa, Piteå
10	Stena
11	Rang-Sells
12	Biocompost
13	C-Green

10.2.2 *Biomass Value Chain Actors*

For the PPBS value chain a number of key relevant MIP actors have been identified and are included within Figure 63. These include regionally located pulp mills such as SCA Ortviken, SCA Östrand, SCA Munksund, Mondi Dynäs, Smurfitt Kappa, Metsä Board Sverige and SCA Obbola. These companies produce PPBS as a by-production of pulp production. Other industries in the value chain which focus on producing additional value-added products include biorefining company Domsjö Fabriker who produce cellulose, lignin and ethanol from softwood, and companies such as C-Green who are developing innovative solutions for this feedstock.

10.2.3 *New Biomass Value Chain Opportunities and Examples*

While the main applications today are to burn the material (directly or by pre-evaporation) or to use it as cover material on waste deposit, there are promising new alternatives such as investment in biocoal production with biosludge as raw material. An example of interesting new development is C-Green, whom in January 2023 signed a cooperation agreement with the environmental company Ragn-Sells, one of Sweden's largest sludge handlers, with the goal of establishing 8–10 C-Green biorefineries in the coming years. The first facility will be located outside Norrköping and become operational in 2023, a project that is partly financed by the Swedish Energy Agency with about SEK 40 million (C-Green, 2023). As mentioned, Domsjö Fabriker is a biorefinery located in Örnsköldsvik producing intermediates (in most cases in the beginning of the value chain). The company has a production capacity of 230,000 tonnes of dissolving cellulose, 120,000 tonnes of lignin and 20,000 tonnes of bioethanol, all with an origin in sustainable Swedish forestry. At research level work has been undertaken to evaluate PPBS in various, intermediates, such as fermentation media and into products (Naicker et al., 2020).

10.3 Value Chain 3 - Fibre Sludge/Fibre Reject

In addition to biosludge from wastewater, the pulp and paper industry also produces a fibre sludge/fibre reject which comes from the production of virgin wood fibre. This is sometimes broken down by brown fibre sludge, uncooked pulpwood/knots collected in the screening after cooking of wood, and white fibre sludge, a bleached fibre mainly collected after bleaching and in the drying process. However since, since various pulping approaches can be applied, (e.g., sulphate or Kraft process), the type of fibre sludge can vary depending on the upstream processing. Approximately a 2 % fibre sludge per ton of pulp is estimated to be produced. Currently in Sweden this residue is primarily burnt for energy production. Fibre sludge as waste material has many potential applications such as in the development of nanocellulose, insulation, growth substrate/soil conditioner and other materials. There has been various research looking into this potential, but no large-scale application has reached the market yet.

10.3.1 *Biomass Arisings and Flows*

An overview of the total estimated fibre sludge arisings within regions of the Swedish MIP is provided in Figure 65 below, with a total figure of 61,000 tDM.

For Middle Norrland the estimated total production is 34,000 tDM per annum, which is allocated entirely to Västernorrland county. For Upper Norrland the total produced fibre sludge is estimated at 27,000tDM, with the majority arising in Norrbotten (22,000 tDM) and the remaining arising in Västerbotten (5,000 tDM). As with PPBS, estimated prices associated with fibre sludge vary between negative value to some value based on heating value.

Looking at the existing flow and fates of fibre sludge, all fibre sludge from Västernorrland and Västerbotten is estimated to be used for energy recovery at the mill. In the case of Norrbotten, over 80% goes for energy recovery at the mill, with a small amount of the remaining sludge going towards fuel production (i.e., sold to CHP plant), and as a filler in recycled paper. The fates of this biomass are presented in Figure 64. A more detailed summary of the availability and flow of biomass per county can be found in Appendix 2.

Figure 64. Sankey diagram showing the arisings and flows and fates of Fibre Sludge biomass across different regions of the Swedish MIP region.

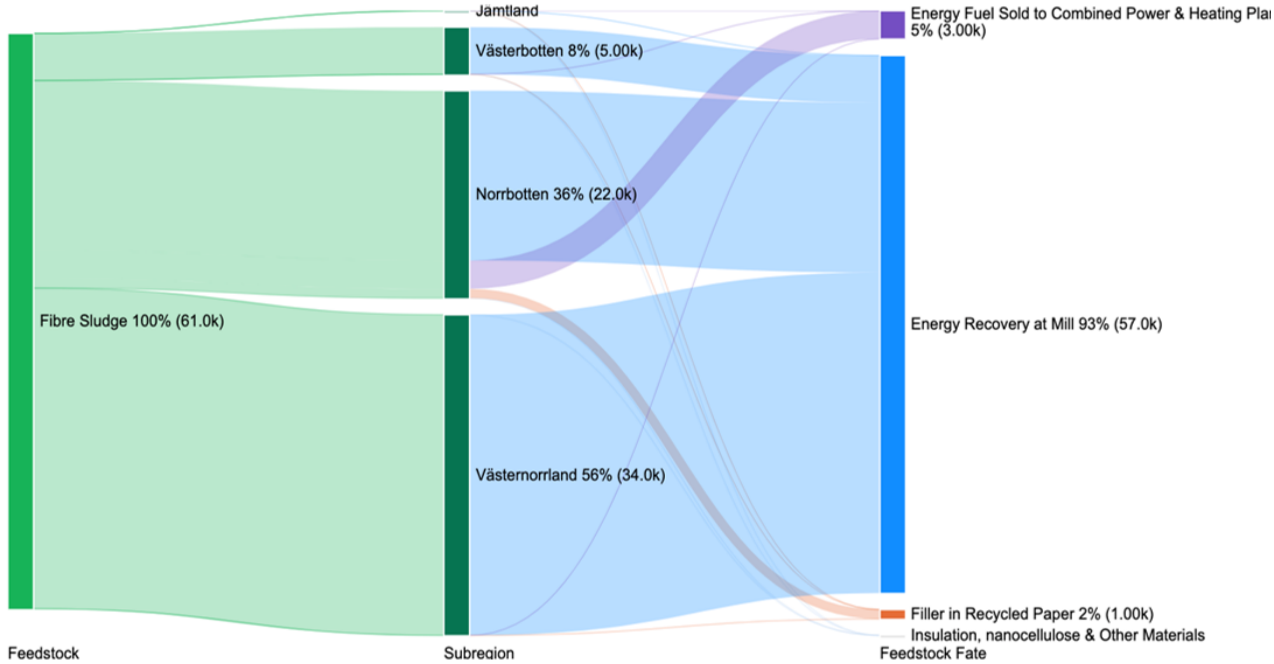

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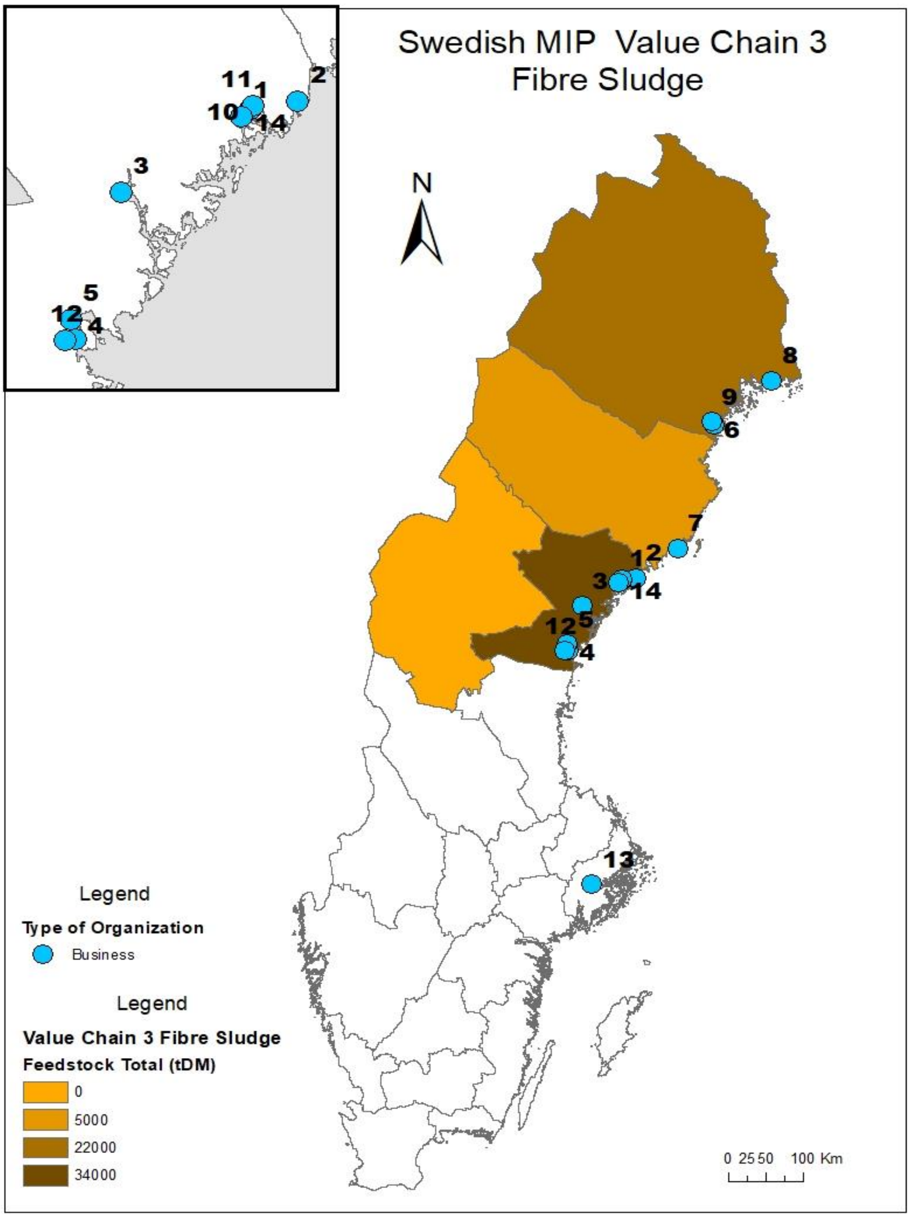
Figure 65. Map of arisings of Fibre sludge biomass and key stakeholders within the Swedish MIP region.



Business	
ID	*Organization*
1	Domsjö Fabriker, Örnsköldsvik
2	Metsä Board Sverige, Husum
3	Mondi Dynäs, Kramfors
4	SCA Ortviken
5	SCA Östrand

6	SCA Munksund
7	SCA Obbola
8	Billerud, Kalix/Karlsborg
9	Smurfit Kappa, Piteå
10	Stena
11	Rang-Sells
12	Biocompost
13	C-Green
14	Cass material

10.3.2 *Biomass Value Chain Actors*

Since this feedstock is largely based on the pulp and paper industry, a number of similar value chain actors are identified as in the PPBS chain. These include regionally located pulp mills mentioned above who produce this by-product. Other businesses participating in the value chain include those focused on waste management such as Rang-Sells, as well as companies such as Biocompost and Cass Material who focus on the development of novel products from these types of by-products. Some of the different relevant stakeholders are outlined in Figure 65 above.

10.3.3 *New Biomass Value Chain Opportunities and Examples*

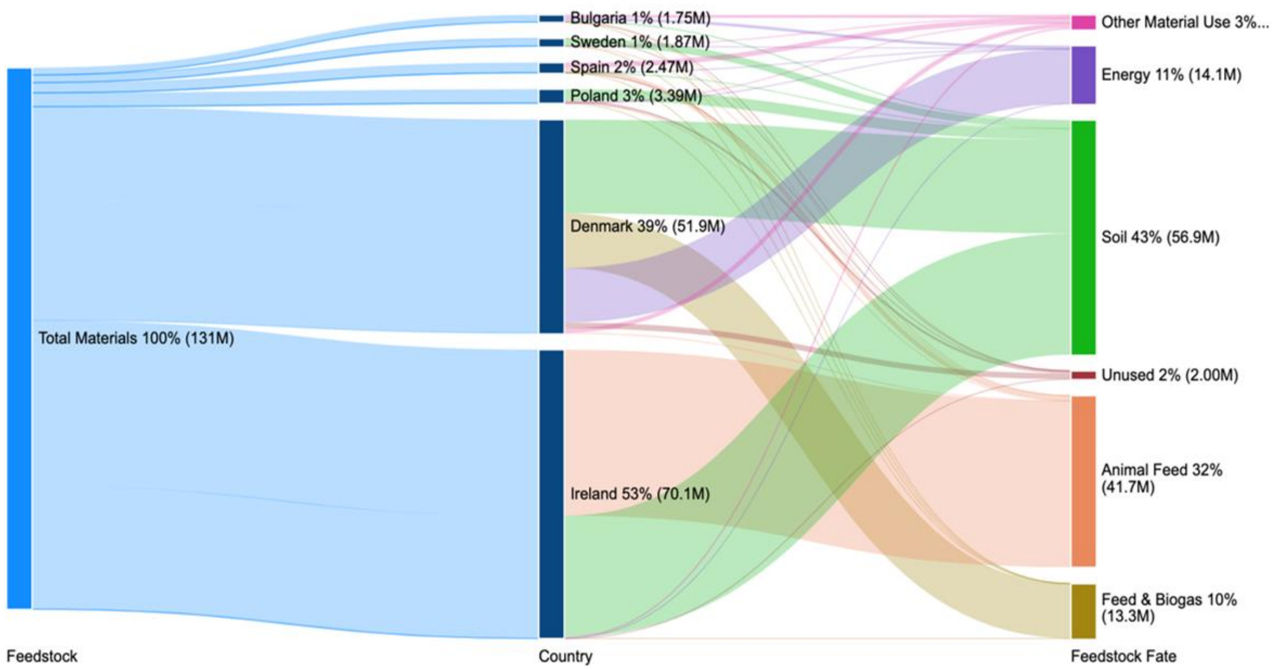
While most of the fibre sludge goes towards energy recovery at the mill, there are potentially other innovative materials which could be developed. Gibril et al. (2018) for example, has undertaken work to investigate the beneficiation of fibre sludge to, on one hand, produce high-value products such as crystalline nanocellulose while alleviating the challenges associated with conventional methods of sludge disposal, such as landfilling and incineration. The use of fibre sludge in this case would reduce the consumption of fresh raw materials in the synthesis of nanocellulose which is usually produced from high-purity cellulose pulps. Preliminary research has found some potential to produce valuable materials while the cost of production can be economically viable since the raw material cost is cheaper compared to the use of wood pulp (Gibril et al., 2018). The company Cass Materials are currently investigating the use of these types of products in their unique biodegradable foam products.

11. Analysis of Findings

11.1 Arisings, Flow and Accessibility of Biomass

Through Sections 4-10, 27 value chains from across the 7 MIP regions are described per country with a breakdown of value chains per country of Bulgaria (3), Denmark (3), Ireland (6), Netherlands (3), Poland (4), Spain (5) and Sweden (3). The value chains included ranged from large primary production streams such as grasses and forestry streams in several countries, to smaller volume, high-value niche crops e.g., from the horticultural sectors. From the analysis of this task, it can be seen that there are many diverse feedstock-based value chain opportunities arising in MIP regions across Europe, particularly in agriculture, but also in forestry and marine sectors, along with the residual streams and by-products from these sectors. A total of 172 million tDM of biomass was included within the mapping exercise, which included per regional jurisdiction; Bulgaria (1.75 million tDM); Denmark (51.9 million tDM); Ireland (70.5 million tDM); Netherlands (12.4 million tDM); Poland (3.4 million tDM); Spain (30.9 million tDM) and Sweden (1.9 million tDM). Due to project limitations, the data collected represents just a snapshot of the total biomass contained within these regions, and since the selection of feedstocks was made on the basis of interests to the MIP regions, we find that partners which have selected large and broad sectors such as livestock-related feedstock, generally hold the largest volume of mapped feedstocks within this study. This includes, for example, Ireland and Denmark, which include its total grass and animal slurry-based resources which are significant. Some of the other stakeholders have selected either more niche crops, or at times only part of their sidestreams (e.g., fibre sludge from Sweden's pulp sector), and so the volume of some of these individual streams is comparatively smaller. However, the overall figures provide good context, for supporting the mobilisation of new value chains across the MIP regions.Based on the analysis of the biomass arisings and their flows we can get a better sense of the accessibility of these feedstocks and the opportunities that may exist for developing new bio-based value chains. Assessing the flow and existing use of biomass, provides insight to the possibilities, for adding value to residual or underutilised biomass. It can also to help us to understand the trade-offs associated with using this biomass in new applications. The displaced function which occurs from diversion of biomass from an existing application such as soil nutrition into a new bioeconomy application such as biofuels or bio-based products, has been referred to by Tonini et al. (2016) as "lost opportunities" and can come with unintended consequence which should be fully considered prior to changing use. Panoutsou and Maniatis (2021) used the term "sustainable potential" to describe the amount of primary agricultural residues that can be removed from the land without adversely affecting the soil quality, causing negative impacts to biodiversity and water in each region, and this sustainable potential is considered to be lower than the technical potential. Analysing the mapped flow of materials over the 7 regions, we find that the vast majority of feedstocks which have been allocated, may already be serving an important function. For example, Figure 66 below shows that only 2% of allocated biomass could be described as unused, with the vast majority of allocated biomass going towards either soil, feed or energy production. While this underscores the needs to make sustainable and informed decisions, it also doesn't preclude against the possibility for the bio-based economy to offer solutions which enhance these value chains both economically and environmental. This has already been highlighted by some of the innovations contained within this report. For example, in Ireland where grass serves as forage either as silage or grazing, there are possibilities for further process this to improve the protein efficiency, so that both cattle and pigs or poultry can benefit from this protein. Preliminary research has indicated that this approach can offer environmental benefits over the conventional soy-based feeding route for pigs or poultry (Franchi et al., 2020). Small-scale bio-based and nutrient recycling solutions can also help to ensure that solutions are applied taking into account local contexts and available biomass, as opposed to larger scale, centralized processing which require longer supply chains and large volumes of biomass.

Figure 66. Flow of allocated biomass across different end applications.



Another issue to be factored in when considering feedstock accessibility, is the price of feedstock. In many cases, the by-products and residues are not currently being traded, so it was difficult to ascertain a market value. However, from the data collected, it appears that feedstock prices depend on source, current use and country. For example, in the case of accessing grass, this analysis found that the price varies by type and country. Roadside grass and nature grass, which are of interest for biorefining in the Netherlands, range from negative value (typically coming at a cost of collecting and disposing), to approx. €10 per tDM, while higher quality grass-clover and ryegrass which are of interest for biorefining in Denmark and Ireland, are already being used for ruminant forage in many cases and can cost between €100-200 per tDM. Likewise, accessing animal slurry, for example, for anaerobic digestion, seems to range between countries from negative value to, up to, approximately €20 per tDM. For actors who wish to develop new innovations in the bio-based economy, a feedstock which is available at low cost, or is currently disposed of at a cost can be an attractive target for valorisation, although feedstock quality and its suitability for valorisation should also be considered (Zero Waste Scotland, 2017). However, it should also be noted, that since much of the biomass and biomass residues are generated at the primary production level, farmers and other primary producers and their participation and willingness to supply, will be significantly influenced by the selling price of biomass (Gérard and Jayet, 2023). The concept of cooperatively owned biorefineries has been proposed as an approach which may allow the "in-house" processing of biomass by a circular of farmers or primary produces through their cooperative. According to Lange (2022), the cooperatively owned bio-based production is the only business model that inherently integrates the primary producers, not only being feedstock suppliers but part of the value chain.

11.2 Analysis of Regional Stakeholders

If these feedstocks and by-products can be harnessed sustainably to develop new value chains, then stakeholders will need to be involved across the value chain to achieve this. Some of the key current stakeholder across the existing value chains within the MIPs have been identified. Based on the regional analysis and input from interviews, a total of 363 value chain stakeholders have been identified across the 7 MIP regions. The largest share of these stakeholders is in the business category (152), followed by research and academia (69), biomass producers (56), civil society (52) and policy (34). Business stakeholders was the largest stakeholder group identified in value chains considered in Bulgaria, Denmark, Ireland and Sweden, while primary producer organisations and civil society stakeholders were the most identified in Netherlands and Poland respectively. Spain had an equal share of primary producer organisations and civil society organisations as its largest identified stakeholder. It should be said that these stakeholders, only represent a snapshot of the actors within the value chain. To develop new value chains, it is important to understand who are the existing actors across the value chains. Some of these stakeholders may become part of new value chains. However, in some cases, gaps may exist, and the new value chains may be dependent on involving further stakeholders such as new technology providers in order to achieve this. It may also be the case, that relevant stakeholders, technologies and initiatives in one MIP region may be

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relevant to support new value chain development in another MIP region. Some of the future activities of MainstreamBIO will focus on providing support to the development of new stakeholder consortia including innovation and network support.

11.3 Value Chain Innovation Opportunities

The report has also sought to identify some of the selected value chain innovation opportunities which are being developed within the regions, which have covered an array of technology and product outputs.

Considering the number of value chains studied within the regions, it is useful to categorize these to identify common themes across regions. Various taxonomy or classification systems to categorize these value chains based on their feedstocks or other value chain criteria could be applied (Cherubini et al., 2009; Lange et al., 2016). For the purposes of this report, the approach of Lange et al. (2016) who proposed a taxonomy of biorefinery value chains based on colour, is used. The approach is chosen as its taxonomy is closely linked to feedstock input, which can be closely related to the findings of this report. This taxonomy includes:

The Yellow Biorefinery – e.g., Recalcitrant yellow biomass, straw, stover and wood

The Green Biorefinery – e.g., Green grass and other fresh/green plant materials

The Grey Biorefinery -e.g., Agroindustrial sidestreams

The Blue Biorefinery – e.g., Marine biomass, from fish waste and discard; and from macroalgae

The Brown Biorefinery – e.g., Sludge from wastewater treatment for example, animal slurry is assumed to fall within this description.

A preliminary look at some of the common emerging themes is presented in Table 3.

Table 3. Emerging areas of value chain interest within the 7 MIP regions.

	Green Biorefinery	Yellow Biorefinery	Grey Biorefinery	Blue Biorefinery	Brown Biorefinery
	Green grass and other fresh/green plant materials	Recalcitrant yellow biomass, straw, stover and wood	Agroindustrial sidestreams	Marine biomass, from fish waste and discard; and from macroalgae	Sludge from wastewater treatment for example
Bulgaria	x	x			
Denmark	x	x			x
Ireland	x	x	x	x	x
Netherlands	x				x
Poland	x	x	x		
Spain	x	x			x
Sweden		x	x		x

This classification can help in identifying opportunities for deploying new technologies or value chains within and across the regions. It may also help in identifying common areas of interest between the regions, which may support future knowledge and technology transfer of cooperation. For example, the learnings obtained from green biorefinery projects in Denmark, Ireland and the Netherlands, including the technologies and collaborators, may be very relevant for sharing and cooperation within these regions, but they may also be relevant for countries like Bulgaria, Spain and Poland, which have identified green biomass feedstock opportunities in case of greenhouse biomass, lucerne and sugar beet leaves respectively. Similarly, some of the opportunities identified from across the forestry sectors of Sweden, Bulgaria and Spain, or the crops sector of Denmark and Ireland, may allow for new learning or collaboration in the scope of yellow biorefining. A number of regions also report animal slurries as a key feedstock area, with various approaches focused on nutrient concentration and recycling and energy production reported from the various regions. Certainly the regions will have more areas of common interest but due to limitations, the taxonomy examples provide are meant to facilitate initial communication among regions, not to frame or restrict collaboration.

While many of these opportunities may be relevant around the more efficient, valuable and circular use of these materials, such as in biorefinery, food, feed, biomaterial, bioenergy and fertilizer applications, other bioeconomy-related value chain opportunities may emerge which are less production focused. Rinn et al. (2023) for example, notes the potential for bioeconomy-based tourism as an “output-based” bioeconomy service, which has the opportunity to bring opportunities in the future. They link the bioeconomy concept to the sustainable hospitality sector, noting that it can be closely linked by applying practices such as: minimizing water and energy consumption, reducing pollution, using renewable and local resources and products, reducing solid waste, etc. According to Rinn et al. (2023) the appropriate affiliation to the bioeconomy services is not judged on the basis of input (as, for example, in agriculture), but on the basis of the outputs it brings to society.

We have seen from the rose industry of the South Central Bulgaria or the developments of CloughJordan Eco-Village in Southern Region of Ireland that the bioeconomy can play a role in realising these additional opportunities, which may also be relevant for other MIP regions.

12. Summary and Conclusions

This Deliverable 1.3 report on “Mapping of Regional Bio-based Value Chains” has used a structured methodology for value chain data collection, implemented in 7 diverse MIP regions of Europe. The approach combines a desk literature review within the focal regions conducted by MTU (IE) WR (NL), IUNG (PL), FBCD (DK), PROC (SE), AUP (BG) and INNV (ES), complemented by interviews with key experts. The analysis covers the biomass arisings, flows, fates, stakeholders and technologies or innovations under development within these value chains. A number of key findings can be summarized from the analysis:

In total, 27 value chains were described across the 7 MIP regions, covering a total of 172 million tDM of biomass arisings from different sources. All of the primary sectors of agriculture, forestry and the marine were represented in the study, with agriculture being the most represented producer. The largest biomass arisings are found in the regions which focused on large livestock sectors such as ruminant production (e.g., Denmark (51.9 million tDM); Ireland (70.5 million tDM, were largely dominated by biomass from the livestock sectors). However, several smaller sectors, focused on high value products, such as rose oil and walnut oil production were also included.

While the arisings of biomass are often large, it seems that the feedstocks are often already in some existing use, which may serve a very important function. Even if there are other opportunities to increase the value of this biomass, care therefore needs to be taken to ensure that any diversion of feedstock towards new applications is managed in a sustainable way.

Despite the diversity of feedstock contained within the regions, there are also many identified common opportunities across the regions in sectors such as grassland, forestry, cereals and livestock. These are also potential opportunities for cross-regional learning, cooperation and collaboration, as many innovations, technologies or expertise may be transferrable between the MIP regions.

The findings in this report will serve as a baseline analysis for the regions and will help to inform and inspire the MIPs which are currently under development within the 7 regions, aiming to assess and deploy small-scale bio-based solutions. At the next phase, multi-actor partnerships will be developed and supported through the development of the MainstreamBIO toolbox (WP2) and innovation services (WP3). Part of the findings of this report will be incorporated within the toolbox, to allow regional partnerships to assess the current status quo and to understand some potential areas for new value chain development.

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14. Appendix

14.1 Appendix 1 – Interview Template

Task 1.3: Interview Template

Write down your notes in a way that ensures that information is recorded in a comprehensive and distinct way. Always make sure that the answer provided by the interviewee, fully responds to the respective question. Please, include interesting quotations, if possible.

Interviewee: [First Name] [Last Name] Title:

Date: [Date]

Interviewer: [First Name] [Last Name]

Total Estimated duration: 40’ – 45’

These questions will rely on the depth of information available for the collection template, i.e., some may not need to be asked.

Part 1: Description of the Regional Value Chain (some of the information may be useful for tab 2 of the collection template along with tab 4)

Question 1:

Can you briefly describe the value chain which your company/organisation operates within?

- Where does your company/organisation fit in within the value chain?

Part 2: Regional Value Chain Feedstock Flows: (some of the information may be useful for tab 3 of the template where literature data gaps exist, e.g. biomass fate/flows data)

- Data not initially available for the collection template, will be collected during these questions.

Question 2:

- What is the total volume of the value chain feedstock of focus arising in your region?

Question 3:

- What is the current price per tonne of the specific feedstock?

Question 4:

- Feedstock Fate: What is the percentage (%) breakdown of the specific feedstock across different uses/applications?

Question 5:

- Subregions
- How would you subdivide (geographically) your region?

Question 6:

- How would you allocate the specific feedstock arisings within these subregions?

Part 3: Regional Value Chain Actors (some of the information may be useful for tab 4)

Question 7:

- Who are some of the key regional actors operational within this value chain in your region?

Part 4: Existing Regional Bio-based Process or Services – linked to value chain respondent operates within. (can be used to complete tab 5)

Question 8:

• Are there any innovative bio-based processes or services which are operational or under development in your region, which may help to improve the sustainability of your sectorial value-chain?

If so please provide details on process/service, market readiness, environmental, economic and societal considerations

Part 5: Final Thoughts:

Question 9:

- Would you like to share any final thoughts? Anything you consider important to highlight?

Part 6: Background Information:

Question 10:

- Type of Organisation
  - Biomass Producers
  - Business
  - Research and Academia
  - Civil Society
  - Policy

Question 11:

- Gender
  - Male
  - Female
  - Diverse/nonbinary
  - Prefer not to say

Question 12:

- Nationality:

14.2 Appendix 2 – Biomass Arising and Flow Tables per Region

Biomass Arising and Flow tables from Bulgarian MIP Region

Table 4: Biomass arisings for Bulgaria value chain 1; Forestry.

	Biomass arising (tDM)				
Region	Feedstock Value Chain 1 (Forestry)				
Price per tonne	€ 117.50				
Fate	Construction timber	Shredded paper	Chipboards	Cellulose	**Total**
Fate %	70	10	15	5	**100**
Region (e.g. South central Bulgaria, NUTS2)	505,596	72,228	108,342	36,114	**722,280**
Subregion A (Pazardjik)	202,238	21,668	43,336	14,445	**281,689**
Subregion B (Kurdzhali)	50,559	7,222	21,668	3,611	**83,062**
Subregion C (Plovdiv)	50,559	28,891	32,502	7,222	**119,176**
Subregion D (Smolyan)	176,958	7,222	5,417	7,222	**196,821**
Subregion E (Haskovo)	25,279	7,222	5,417	3,611	**41,531**

Table 5: Biomass arisings for Bulgaria value chain 2; Greenhouse biomass.

	Biomass arising (tDM)		
Region	Feedstock Value Chain 2 (Greenhouse biomass)		
Price per tonne	€15.50		
Fate	Fertilizers/composting	Biogas	**Total**
Fate %	30	70	**100**
Region (e.g. South central Bulgaria, NUTS2)	306,018	714,043	**1,020,062**
Subregion A (Pazardjik)	214,213	214,213	**428,426**
Subregion B (Kurdzhali)	30,601	71,404	**102,006**
Subregion C (Plovdiv)	30,601	357,021	**387,623**
Subregion D (Smolyan)	9,180	21,421	**30,601**
Subregion E (Haskovo)	21,421	49,983	**71,404**

Table 6: Biomass arisings for Bulgaria value chain 3; Rose oil.

	Biomass arising (tDM)		
Region	Feedstock Value Chain 3 (Rose oil)		
Price per tonne	€5,000.00		
Fate	Rose blossoms	Rose oil	**Total**
Fate %	99.98	0.02	**100.00**
Region (e.g. South central Bulgaria, NUTS2)	4,160	0.86	**4,160.86**
Subregion A (Pazardjik)	-	-	**-**
Subregion B (Kurdzhali)	-	-	**-**
Subregion C (Plovdiv)	4,160	0.86	**4,160.86**
Subregion D (Smolyan)	-	-	**-**
Subregion E (Haskovo)	-	-	**-**

Table 7: Biomass arisings for Bulgaria value chain 3; Orchards - walnut oil.

	Biomass arising (DM)			
Region	Feedstock Value Chain 4 (Orchards - walnut oil)			
Price per tonne	€1,500.00			
Fate	Nuts	Oil	Walnut shells	**Total**
Fate %	80	15	5	**100**
Region (e.g. South central Bulgaria, NUTS2)	3,800	713	238	**4,750**
Subregion A (Pazardjik)	40	-	-	**40**
Subregion B (Kurdzhali)	310	-	-	**310**
Subregion C (Plovdiv)	850	210	58	**1,118**
Subregion D (Smolyan)	100	-	-	**100**
Subregion E (Haskovo)	2,500	503	180	**3,183**

Table 8: Reference table for the Bulgaria MIP Region biomass arisings.

Source References	
Value Chain	**Reference:**
Value Chain 1	Production data: https://www.moew.government.bg/en/national-forestry-accounting-plan-of-bulgaria-including-forest-reference-levels-for-the-period-2021-2025/ NATIONAL FORESTRY ACCOUNTING PLAN OF BULGARIA, INCLUDING FOREST REFERENCE LEVELS FOR THE PERIOD 2021-2025, verified by interview data Price: http://www.iag.bg/data/docs/nationalen_plan.pdf National Forest Biomass Energy Action Plan 2018-2027 ,verified by Interview Fate: http://www.iag.bg/data/docs/nationalen_plan.pdf National Forest Biomass Energy Action Plan 2018-2027
Value Chain 2	Production data: Interview data Price: https://www.cei.int/sites/default/files/2022-04/CELEBio_Bioeconomy%20Dossier_%20Bulgaria.pdf BioStep - working paper Fate: https://bgbiom.org/bg/wp-

	content/uploads/2017/07/consumer_information__bg.pdf BioRes deliverable
Value Chain 3	Production data: https://www.fao.org/faostat/en/#data/QCL FAO database, Bulgaria Price: https://www.nsi.bg/bg/content/809/%D1%81%D0%B5%D0%BB%D1%81%D0%BA%D0%BE-%D1%81%D1%82%D0%BE%D0%BF%D0%B0%D0%BD%D1%81%D1%82%D0%B2%D0%BE National Statistical Yearbook- 2022 Fate: Data from interview FAO database, Bulgaria and survey
Value Chain 4	Production data: https://www.nsi.bg/bg/content/809/%D1%81%D0%B5%D0%BB%D1%81%D0%BA%D0%BE-%D1%81%D1%82%D0%BE%D0%BF%D0%B0%D0%BD%D1%81%D1%82%D0%B2%D0%BE National Statistical Yearbook- 2022 Price: https://www.nsi.bg/bg/content/809/%D1%81%D0%B5%D0%BB%D1%81%D0%BA%D0%BE-%D1%81%D1%82%D0%BE%D0%BF%D0%B0%D0%BD%D1%81%D1%82%D0%B2%D0%BE National Statistical Yearbook- 2022 Fate: https://www.mzh.government.bg/bg/statistika-i-analizi/prebroyavane-na-zemedelskite-stopanstva-prez-2020-g/ Census of agricultural holdings - 2020

Biomass Arising and Flow tables from Danish MIP Region

Table 9: Biomass arisings for Denmark value chain 1; Grass.

	Biomass arising (tDM)		
Region	Feedstock Value Chain 1 (grass)		
Price per tonne	€29.00		
Fate	Protein for feed	Grass for feed and biogas	**Total**
Fate %	0.7	99.3	**100**
Region (Denmark, NUTS2)	159,018	22,716,861	**22,877,000**
Subregion A (Mid Jutland)	48,069	6,818,931	**6,867,000**
Subregion B (Northern Jutland)	36,624	5,195,376	**5,232,000**
Subregion C (Eastern Denmark)	8,932	1,267,068	**1,276,000**

Table 10: Biomass arisings for Denmark value chain 2; Animal manure.

	Biomass arising (tDM)		
Region	Feedstock Value Chain 2 (animal manure)		
Price per tonne			
Fate	Biogas	Fertilizer	**Total**
Fate %	35	65	**100**
Region (Denmark, NUTS2)	12,250,000	22,750,000	**35,000,000**
Subregion A (Mid Jutland)	-	-	-
Subregion B (Northern Jutland)	-	-	-
Subregion C (Eastern Denmark)	-	-	-

Table 11: Biomass arisings for Denmark value chain 3; Fibre sludge.

	Biomass arising (tDM)				
Region	Feedstock Value Chain 3				
Price per tonne	€80.00				
Fate	Straw for feeding/bedding	Straw for heating	Straw for biogas	Not salvaged	**Total**
Fate %	32	27.2	0.8	40	**100**
Region (Denmark, NUTS2)	1,363,808	40,112	2,005,600	5,014,000	**1,363,808.00**
Subregion A (Mid Jutland)	413,168	40,112	607,600	1,519,000	**413,168.00**
Subregion B (Northern Jutland)	238,816	12,152	351,200	878,000	**238,816.00**
Subregion C (Eastern Denmark)	295,392	7,024	434,400	1,086,000	**295,392.00**

Table 12: Reference table for the Denmark MIP Region biomass arisings.

Source References	
Value Chain	**Reference:**
Value Chain 1	**Production data:** https://www.statistikbanken.dk/statbank5a/default.asp?w=1920 Business -> crop production -> harvest by region, crop and unit -> GRASS, GREEN FODDER and AFTERMATH, total 2021, all Denmark (unit: production, million kg) https://dca.au.dk/aktuelt/nyheder/vis/artikel/gode-muligheder-for-dansk-selvforsyning-med-protein#:~:text=I%20dag%20ligger%20gr%C3%A6sudbyttet%20i,omkring%2040%20procent%20af%20proteinet. **Price:** Price for fresh grass is €0,029 per kg, giving a price of €29 per tonne. Calculation is based on Farmtal online and standards. Farmtal online requires a login. https://farmtalonline.dlbr.dk/Navigation/NavigationTree.aspx The majority of grass that is either used for feed or the small amount for biorefining, is often produced on the farm and hence is very rarely traded. **Price for grass protein is €67 per tons (biorefined grass)** The value of the protein paste is calculated based on the protein content of the paste and a price of soy with a protein content of 48% of DKK 300/Hkg. The value of the fiber residue is calculated based on a roughage price of DKK 1.3/FEN and a content of 0.75 FEN/kg TS. Finally, the value of brown juice [1] is assessed based on the dry matter content, a gas yield of 2 Nm^3 CH4/t brown juice and a natural gas price of DKK 5/Nm^3 If the protein pasta can be produced in organic quality, the pasta will have approx. the double value. [2] [1]. M. Santamaria-Fernández et. al. "Biogas potential of green biomass after protein extraion in an organic biorefinery concept for feed, fuel and fertilizer production. Renewable Energy 129, 2018 [2] https://www.landbrugsinfo.dk/basis/9/4/0/energi_klovergres_som_proteinfoder_for_grise_og_fjerkre#references Protein pasta (20% DM) - value 0,5 DKK/kg. The Fibre fraction (fiberrest) and the brown juice (brunsaft) is going into biogas, and some of the fibre is used for feeding cattle (in research mainly). **Fate [b]:** https://www.landbrugsinfo.dk/basis/9/4/0/energi_klovergres_som_proteinfoder_for_grise_og_fjerkre#references+B14 https://www.rm.dk/siteassets/regional-udvikling/ru/klima-og-miljo/klimatilpasning/delanalyse_muligheder_i_samproduktion_af_grasprotein

	_og_biogas.pdf https://biorefine.dk/p/om-biorefine Fate[b]: It is very difficult to estimate how the current fate is for grass for feeding and how much for biorefining, as the biorefining is not very commercialised yet. Biorefine Denmark estimates to produce 7000 tons grass protein from 3000 ha/year. With an average production yield of 50 tons/ha, this gives a proportion of approx. 0.6% of the total yield of grass. Since Marine protein dries approximately 300 tons and Aarhus University dries a small proportion for research purpose, the total fate remains low.
Value Chain 2	**Production data:** Total is estimated of total production. The percentage of manure that is degassed in biogas facilities vary a lot within regions. E.g., animal manure in southern region is approaching 45% and the average in rest of DK is 35%. Therefore, the biomass is presented as a total in Denmark. Info from the company ConTerra.: https://www.linkedin.com/company/conterra-aps/ Map of current biogas facilities illustrates how expanded the industry is in Denmark https://ens.dk/sites/ens.dk/files/Statistik/biogas_2018_10.pdf **Price**: Price fluctuates a lot and is often €0. https://lemvigbiogas.com/gylle/ The reason is that many farmers exchange manure with degassed manure, which often is of a better quality, easier to allocate, and is often delivered in buffer tanks in the fields rather than at the farm. Thus, the farmer saves money on transport and logistics.(from Questionnaire data) Because biomasses for biogas production are highly requested, SEGES Innovation suggests that manure at least can bring in between €1,3 - 2,6 per tonne. https://landbrugsavisen.dk/analyse-gylle-til-biogas-burde-koste-en-tier-pr-ton-mindst **Fate:** https://klimarealisme.dk/2020/09/26/biogas/

Value Chain 3	**Production data**: https://www.statistikbanken.dk/statbank5a/default.asp?w=1920 Business -> crop production -> straw yield and use per region -> CEREALS TOTAL 2021, all Denmark (unit: million kg) **Price:** https://www.kredslob.dk/professionel/for-leverandoerer/halm-og-flis-til-energi/halm-til-energi#:~:text=410%20kr.%2Fton%20og%20100,i%20h%C3%A5ndteringsgebyr.&text=Kredsl%C3%B8b%20Halmenergi%20A%2FS%20modtager,slags%20halmtyper%3A%20kornhalm%20eller%20mikshalm. https://effektivtlandbrug.landbrugnet.dk/artikler/planter/76165/ny-prisberegner-afsloerer-at-halm-saelges-for-billigt.aspx Interview Data https://landbrugsavisen.dk/analyse-gylle-til-biogas-burde-koste-en-tier-pr-ton-mindst **Fate:** https://www.statistikbanken.dk/statbank5a/default.asp?w=1920 Straw for heating fate was estimated from the amount given in statistics regarding straw used for energy, exert 27,7%. Business -> crop production -> straw yield and use per region -> CEREALS TOTAL 2021, all Denmark (unit: million kg) https://klimarealisme.dk/2020/09/26/biogas/

Biomass Arising and Flow tables from Irish MIP Region

Table 13: Biomass arisings for Irish value chain 1; grasses.

	Biomass arising (tDM)				
Region	Feedstock Value Chain 1 (grass from grasslands which purpose is silage only)		Feedstock Value Chain 1 (grass from grasslands which purpose is intensive farming only)		
Price per tonne	€121-204/ t DM		€121-204/ t DM		
Fate	Livestock feed	Total	Grazing	Silage	Total
Fate %	100	100	70	30	100
Region (e.g., Southern Region Ireland, NUTS2)	8,587,505	8,587,505	22,190,497	9,510,213	31,700,711
Subregion A (Carlow)	225,249	225,249	483,174	207,074	690,249
Subregion B (Clare)	887,670	887,670	-	889,473	2,964,912
Subregion C (Cork)	2,308,554	2,308,554	5,805,556	2,488,095	8,293,652
Subregion D (Kerry)	975,345	975,345	2,717,841	1,164,789	3,882,630
Subregion C (Kilkenny)	756,332	756,332	1,902,230	815,241	2,717,472
Subregion C (Limerick)	988,023	988,023	2,438,195	1,044,941	3,483,136
Subregion C (Tipperary)	1,312,677	1,312,677	3,788,737	1,623,744	5,412,481
Subregion C (Waterford)	522,223	522,223	3,788,737	590,643	1,968,810

Subregion C (Wexford)	611,429	611,429	1,601,155	686,209	2,287,365

Table 14: Biomass arisings for Irish value chain 2; Livestock manure.

	Biomass arising (tDM)	
Region	Feedstock Value Chain 2 (livestock manure)	
Price per tonne	Opportunity value of €6/ton of manure	
Fate	Back to soil	Total
Fate %	100	100
Region (e.g., Southern Region Ireland, NUTS2)	29,353,039	29,353,039
Subregion A (Carlow)	1,095,920	1,095,920
Subregion B (Clare)	1,468,271	1,468,271
Subregion C (Cork)	8,812,148	8,812,148
Subregion D (Kerry)	2,309,849	2,309,849
Subregion C (Kilkenny)	2,327,240	2,327,240
Subregion C (Limerick)	2,730,816	2,730,816
Subregion C (Tipperary)	5,617,770	5,617,770
Subregion C (Waterford)	2,583,361	2,583,361
Subregion C (Wexford)	2,407,659	2,407,659

Table 15: Biomass arisings for Irish value chain 3; Cereal straw.

	Biomass arising (tDM)									
Region	Feedstock Value Chain 3 (Wheat straw)				Feedstock Value Chain 3 (Straw Oats)			Feedstock Value Chain 3 (Straw Barley)		
Price per tonne	€59.26				€63.16			€64.86		
Fate	Land	Mushroom	Animal bedding and feed	Total	Land	Animal bedding and feed	Total	Land	Animal bedding and feed	Total
Fate %	10	24.5	65.5	100	6.5	93.5	100	6.5	93.5	100
Region (e.g., Southern Region Ireland, NUTS2)	5,806	14,224	38,029	58,060	3,489	50,190	53,679	26,064	374,931	400,996
Subregion A (Carlow)	881	2,158	5,770	8,810	486	6,999	7,486	2,626	37,778	40,404
Subregion B (Clare)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	24	351	375
Subregion C (Cork)	1,501	3,677	9,832	15,011	640	9,214	9,855	7,097	102,101	109,199
Subregion D (Kerry)	128	315	843	1,287	53	773	827	355	5,113	5,469

Subregion C (Kilkenny)	515	1,261	3,373	5,150	461	6,641	7,103	2,476	35,626	38,103
Subregion C (Limerick)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	158	2,276	2,435
Subregion C (Tipperary)	1,005	2,464	6,587	10,057	681	9,808	10,490	3,529	50,765	54,294
Subregion C (Waterford)	301	2,464	1,975	3,015	681	3,737	3,997	3,529	16,538	17,688
Subregion C (Wexford)	1,472	3,608	9,647	14,728	904	13,013	13,918	8,646	124,378	133,025

Table 16: Irish seaweed species, yields production and price.

Seaweed species harvested in the south of Ireland	Yields in the south of Ireland (wt/2km)	National total production (wt)	Price (€/wt)
Saccharina latissima	0.66	12.3	1,500
Pelvetia canaliculata	0.1	4	n.d.
Palmaria palmata	0.5-75	134.4	1,500
Nori	0.165	1.9	n.d.
Laminaria digitata	0.15-0.165	45.5	850
Himanthalia elongata	0.66	58.5	1,500
Fucus serratus	0.005-0.035	219.8	800
Chrondrus crispus	0.33	37.4	1,500
Alaria esculenta	6.5	14.8	1,500

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Table 17: Biomass arisings for Irish value chain 5; Apple residues.

	Biomass arising (tDM)					
Region	Feedstock Value Chain 5 (Apple residues)					
Price per tonne	Apple residues = low value (€750/ton for eating apples and €185-266/ton for cider apples)					
Fate	Juice for Cider production	Dry fibre/pulp from cider production	Total of damaged apples to cider production	Pruning residues Back to soil	Total	Total Dry fibre/pulp from cider production
Fate %	80	20	100	100	100	100
Region (e.g., Southern Region Ireland, NUTS2)	1,090	272	1,363	373	373	273
Subregion A (Carlow)	16	4	20	6	6	4
Subregion B (Clare)	5	1	6	2	2	1
Subregion C (Cork)	137	34	172	47	47	34
Subregion D (Kerry)	11	3	14	4	4	3
Subregion C (Kilkenny)	264	66	330	90	90	66

Subregion C (Limerick)	14	3	19	5	5	4
Subregion C (Tipperary)	207	51	259	71	71	52
Subregion C (Waterford)	352	88	441	121	121	88
Subregion C (Wexford)	81	20	102	28	28	20

Table 18: Biomass arisings for Irish value chain 6; Hemp.

	Biomass arising (tDM)		
Region	Feedstock Value Chain 6 (Hemp)		
Price per tonne	n.d.		
Fate	Straw	Seed	Total
Fate %	n.d.	n.d.	n.d.
Region (e.g., Southern Region Ireland, NUTS2)	-	-	-
Subregion A (Carlow)	10	8	18
Subregion B (Clare)	9	7	16
Subregion C (Cork)	21	18	39
Subregion D (Kerry)	5	4	9.
Subregion C (Kilkenny)	-	-	-
Subregion C (Limerick)	5	4	9
Subregion C (Tipperary)	1	1	2
Subregion C (Waterford)	2	2	4
Subregion C (Wexford)	-	-	-

Table 19: Reference table for the Irish MIP Region biomass arisings.

Source References	
Value Chain	**References**
Value Chain 1	Production data: Pasture and Silage hectares has been provided by CSO in January 2023.Yields are from 2016 from PastureBase 2016 publication (https://www.teagasc.ie/media/website/crops/grassland/PastureBase-Ireland-Open-Day-paper-final-draft.pdf). For the counties that are missing yields in that publication, 14.6 t/ha has been used as yield because according to Teagasc publications, swards with perennial ryegrass and white clover, with a 150 kg/ha of Nitrogen fertiliser spread reached yields of 14.6 t DM/ha. (Teagasc publications: https://www.teagasc.ie/news--events/daily/dairy/the-effect-of-sward-type--nitrogen-fertiliser-application-rate-on-milk--herbage-production-.php and https://www.teagasc.ie/news--events/daily/environment/incorporating-white-clover-and-protected-urea-into-intensive-grazing-systems.php). These proportions of grasses were applied for pasture in intensive farms grazed by cattle: White clover %ha coverage in winter (5-25%) Perennial ryegrass %ha coverage in winter (75-95%) White clover %ha coverage in summer (Jl,Au,Sp,Oc) (30-35%) Perennial ryegrass produced in summer (Jl,Au,Sp,Oc) (coverage about 65-70% of total pasture). For grass silage: 100% perennial ryegrass (https://www.sciencedirect.com/science/article/pii/S0022030218300638#fig1 and https://www.teagasc.ie/media/website/about/research-and-innovation/Incorporating-white-clover-into-perennial-ryegrass-pastures-in-dairy_DH.pdf) Hectares: https://www.gov.ie/en/publication/cfa39-basic-payment-scheme-crop-areas/ Price: Interview data Fate: Interview data
Value Chain 2	Production data: Total livestock heads: https://www.cso.ie/en/releasesandpublications/ep/p-coa/censusofagriculture2020-preliminaryresults/livestock/Cattle: https://www.teagasc.ie/media/website/publications/2020/Manure-Management-Practices-Report.pdf Chicken: The Economic Importance of the Poultry (Meat and Egg) Sector in Ireland Prof. Thia Hennessy Cork University Business School, University College Cork, Ireland (https://monaghan.ie/wp-content/uploads/2021/08/Baseline%20Study%20Poultry%20Sector%20Co.Monaghan%20July%202021.pdf) Sheep: https://www.teagasc.ie/news--events/daily/sheep/reducing-ewe-wintering-costs.php#:~:text=A%20typical%20housing%20period%20for,like%20straw%20and%20labour%20requirement. Slurry generation rates: https://www.irishstatutebook.ie/eli/2022/si/113/made/en/pdf Price: Interview data

	Fate: Interview data
Value Chain 3	Production data: https://www.gov.ie/en/publication/cfa39-basic-payment-scheme-crop-areas/ https://www.teagasc.ie/media/website/rural-economy/rural-development/diversification/Energy-13-Straw-for-Energy.pdf https://www.cso.ie/en/releasesandpublications/ep/p-coa/censusofagriculture2020-preliminaryresults/landutilisation/ https://ws.cso.ie/public/api.restful/PxStat.Data.Cube_API.ReadDataset/AQA06/XLSX/2007/en https://ec.europa.eu/eurostat/databrowser/view/APRO_CPSH1__custom_2590689/default/table?lang=en Price: http://tillageindustryireland.ie/wp-content/uploads/2020/07/Economic-Impact-Assessment-of-the-Tillage-Sector-in-Ireland.pdf Fate: Interview data
Value Chain 4	Yields and price: Marine Institute EMFF Webinar 2nd March 2022 – Colum Gibson (https://vimeo.com/685783965)
Value Chain 5	Production data: https://www.gov.ie/en/publication/cfa39-basic-payment-scheme-crop-areas/ https://data.cso.ie/table/GCA06 https://www.bordbia.ie/globalassets/bordbia.ie/industry/irish-sector-profiles/horticulture-censuses/national-apple-orchard-census-2017.pdf https://www.epa.ie/publications/research/waste/Research_Report_410.pdf Price: Interview data Fate: Interview data
Value Chain 6	Production data: co2 received from HPRA, 2023 Yield: https://www.teagasc.ie/media/website/rural-economy/rural-development/diversification/9-Diversification-Industrial-Hemp.pdf

Biomass Arising and Flow tables from Netherlands MIP Region

Table 20: Biomass arisings for Netherlands value chain 1; Manure.

	Biomass arising (tDM)		
Region	Value chain 1 - Manure		
Price per tonne	"-10 to -15 euro/ton"		
Fate	Digestion	directly to the land	**Total**
Fate %	n.d.	n.d.	**100**
Friesland	-	-	**10,911,000**
Flevoland	-	-	**1,398,000**

Table 21: Biomass arisings for Netherlands value chain 2; Grass.

	Biomass arising (tDM)		
Region	Value chain 2 - Grass		
Price per tonne	Negative value for roadside and some low-quality nature grass		
Fate	Roadside grass	Nature grass	**Total**
Fate %	8.1	91.9	**100**
Friesland	9,110.00	103,000.00	**112,110**
Flevoland	3,881.00	1,278.00	**5,159**

Table 22: Biomass arisings for Netherlands value chain 3; Pumpkins.

	Biomass arising (tDM)		
Region	Value chain 3 - Pumpkins		
Price per tonne	Price depends on the use		
Fate	Pig feed	Digester feedstock	**Total**
Fate %	n.d.	n.d.	**100**
Friesland	-	-	**700**

Flevoland	-	-	**8,975**

Table 23: Reference table for the Netherlands MIP Region biomass arisings

Source References	
Value Chain	**References**
Value Chain 1	**Production:** https://www.host.nl/nl/case/biogasopwerking-jelsum-nederland/ https://erkenergy.nl/ **Price:** CBS, o.b.v. 2021; and Interview data
Value Chain 2	**Production:** nature gras CBS, o.b.v. 2021 (wegen), BVOR (Biomassa) roadside gras Friesland (Alterra, 2008) **Price:** Interview data
Value Chain 3	**Production:** CBS, areaal obv 2021 en KWIN-AGV 2022, opbrengst

Biomass Arising and Flow tables from Polish MIP Region

Table 24: Biomass arisings for Poland value chain 1; Sugar beet.

	Biomass arising (tDM)			
Region	**Feedstock Value Chain 1 (Sugar beet)**			
Price per tonne	-			
Fate	Ploughing into the field	Leaving on the field	Silage	**Total**
Fate %	90	8	2	**100**
Subregion A (Bialski)	3216	286	71	**3573**
Subregion B (Pulawski)	111395	9902	2475	**123772**
Subregion C (Lubelski)	320325	28473	7118	**355916**
Subregion D (Chelmsko-Zamojski)	813093	72275	18069	**903437**

Table 25: Biomass arisings for Poland value chain 2; Berries.

	Biomass arising (tDM)			
Region	**Feedstock Value Chain 2 (Berries)**			
Price per tonne	-			
Fate	Leaving in the field	Burn on the field	Waste	**Total**
Fate %	2	3	95	**100**
Subregion A (Bialski)	271	407	12888	**13566**
Subregion B (Pulawski)	2233	3350	106075	**111658**
Subregion C (Lubelski)	569	854	27047	**28471**
Subregion D (Chelmsko-Zamojski)	867	1300	41182	**43349.6**

Table 26: Biomass arisings for Poland value chain 3; Corn.

	Biomass arising (tDM)						
Region	**Feedstock Value Chain 3 (Corn)**						
Price per tonne	-						
Fate	Ploughing into the field	Leaving in the field	Feed	Heating	Mushrooms	Mulch	**Total**
Fate %	75	18	3	3	0	1	**100**
Subregion A (Bialski)	188643	45274	7546	7546	0	2515	**251524**
Subregion B (Pulawski)	190469	45713	7619	7619	0	2540	**253959**
Subregion C (Lubelski)	107928	25903	4317	4317	0	1439	**143904**
Subregion D (Chelmsko-Zamojski)	260828	62599	10433	10433	0	3478	**347770**

Table 27: Biomass arisings for Poland value chain 4; Rapeseed.

	Biomass arising (tDM)						
Region	**Feedstock Value Chain 4 (Rapeseed)**						
Price per tonne	-						
Fate	Ploughing into the field	Leaving in the field	Feed	Heating	Mushrooms	Mulch	**Total**
Fate %	84	15	0	1	0	0	**100**
Subregion A (Bialski)	103040	18400	0	1227	0	0	**122667**
Subregion B (Pulawski)	82476	14728	0	982	0	0	**98186**
Subregion C (Lubelski)	151766	27101	0	1807	0	0	**180674**
Subregion D (Chelmsko-Zamojski)	338522	60450	0	4030	0	0	**403002**

Table 28: Reference table for the Poland MIP Region biomass arisings

Source References	
Value Chain	**Reference:**
Value Chain 1	The Agency for Restructuring and Modernisation of Agriculture (ARMA) data Statistics Poland data Interview data
Value Chain 2	The Agency for Restructuring and Modernisation of Agriculture (ARMA) data Statistics Poland data Interview data
Value Chain 3	The Agency for Restructuring and Modernisation of Agriculture (ARMA) data Statistics Poland data Interview data "ZAGOSPODAROWANIE SŁOMY A BILANS GLEBOWEJ MATERII ORGANICZNEJ"; Kus.J, Madej. A; ZAGADNIENIA DORADZTWA ROLNICZEGO NR 4/2017
Value Chain 4	The Agency for Restructuring and Modernisation of Agriculture (ARMA) data Statistics Poland data Interview data "ZAGOSPODAROWANIE SŁOMY A BILANS GLEBOWEJ MATERII ORGANICZNEJ"; Kus.J, Madej. A; ZAGADNIENIA DORADZTWA ROLNICZEGO NR 4/2017

Biomass Arising and Flow tables from Spanish MIP Region

Table 29: Biomass arisings for Spain value chain 1; Pig Manure.

	Biomass arising (tDM/year)			
Region	Feedstock Value Chain 1: PIG MANURE			
Price per tonne	€17.50			
Fate	Organic fertiliser	Biogas production	Land	**Total**
Fate %	-	-	-	**100**
Region (Ebro River basin)	-	-	-	**28,361,479**
Subregion A (Navarra)	-	-	-	**1,895,293**
Subregion B (Aragón)	-	-	-	**8,851,674**
Subregion C (Cataluña)	-	-	-	**17,614,511**

Table 30: Biomass arisings for Spain value chain 2; Lucerne.

	Biomass arising (tDM)		
Region	Feedstock Value Chain 2: LUCERNE		
Price per tonne	€350.00		
Fate	Animal feed: bales	Animal feed: pellets	**Total**
Fate %	81	19	**100**
Region (Ebro River basin)	858,290	201,327	**1,059,617**
Subregion A (Navarra)	51,400	12,057	**63,457**
Subregion B (Aragón)	579,272	135,879	**715,151**
Subregion C (Cataluña)	227,617	53,392	**281,009**

Table 31: Biomass arisings for Spain value chain 3; Forest products.

	Biomass arising (tDM)					
Region	**Feedstock Value Chain 3: FOREST PRODUCTS**					
Price per tonne	€35.00					
Fate	Firewood & bioenergy	Pulp	Board	Sawmill	Other uses (poles, fences, etc.)	**Total**
Fate %	9	36	22	30	3	**100**
Region (Ebro River basin)	122,763	491,050	300,086	409,208	40,921	**1,364,028**
Subregion A (Navarra)	41,162	164,649	100,619	137,207	13,721	**457,357**
Subregion B (Aragón)	19,032	76,128	46,523	63,440	6,344	**211,466**
Subregion C (Cataluña)	62,568	250,274	152,945	208,561	20,856	**695,205**

Table 32: Biomass arisings for Spain value chain 4; Camelina.

	Biomass arising (tDM)			
Region	**Feedstock Value Chain 4: CAMELINA**			
Price per tonne	€700.00			
Fate	Oil production	Animal feed (cake)	Losses	**Total**
Fate %	33	65	2	**100**
Region (Ebro River basin)	-	-	-	**-**
Subregion A (Navarra)	-	-	-	**-**
Subregion B (Aragón)	330	650	20	**1,000**
Subregion C (Cataluña)	-	-	-	**-**

Table 33. Biomass arisings for Spain value chain 5; BSG.

	Biomass arising (tDM)	
Region	Feedstock Value Chain 5: BSG	
Price per tonne	€50.00	
Fate	Animal feed & Landfill (wet BSG)	**Total**
Fate %	100	**100**
Region (Ebro River basin)	151,540	**151,540**
Subregion A (Navarra)	80	**80**
Subregion B (Aragón)	9,395	**9,395**
Subregion C (Cataluña)	142,065	**142,065**

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Table 34. Reference table for the Spain MIP Region biomass arisings.

Source References	
Value Chain	**Reference:**
Value Chain 1	Agricultural census: https://www.aragon.es/documents/20127/1909615/20220505_Comunicado_Censo_agrario_2020.pdf/3c961fbf-67c7-8c86-b698-d5c9c00d0511?t=1651748110837; http://www.navarra.es/home_es/Temas/Ambito+rural/Ganaderia/censo.htm; https://www.idescat.cat/pub/?id=censag&n=16107&lang=es&by=prov Price: https://www.rotecna.com/blog/cuanto-vale-un-metro-cubico-de-purin/
Value Chain 2	Production data: https://uagn.es/la-produccion-de-alfalfa-deshidratada-fue-un-8-inferior-a-la-anterior/ Price: https://www.campogalego.es/el-precio-de-la-alfalfa-sube-un-60-con-respecto-hace-un-ano/ Fate: https://www.alfalfaspain.es/wp-content/uploads/2020/10/2-RESULTADO-ENCUESTA-30.09.20-3.pdf
Value Chain 3	Production data, Price & Fates: https://www.miteco.gob.es/es/biodiversidad/estadisticas/aef2019_completo_estandar_tcm30-534526.pdf
Value Chain 4	Production data: Interview data Price: Interview data Fate: Interview data
Value Chain 5	Production data: https://cerveceros.org/uploads/62cfc9469b35d__InformeSocioeconomico_Cerveza2021.pdf + Data from the main breweries production centres Price: Interview data and prices on market (https://www.poballe.com/alimentacionanimal/productos-proteicos/2-cebadilla-de-cerveza.html) Fate: n/a (no relevant fates for revalorization were described. Only minor fates are used for innovation actions or innovative initiatives)

Biomass Arising and Flow tables from Swedish MIP Region

Table 35. Biomass arisings for Sweden value chain 1; GROT, logging residues.

	Biomass arisings (tDM)
Region	**Feedstock Value Chain 1 (GROT, logging residues)**
Price per tonne	180 SEK (~ €16.06)

Fate	Land	Combined Power and Heating Plant	Total
Fate %	99	1	**100**
Region (Middle Norrland, NUTS2: SE32 and upper Norrland, NUTS2: SE33, Sweden)	1,763,34	17,811	**1,781,156**
Jämtland	492,469	4,974	**497,444**
Västernorrland	409,177	4,133	**413,311**
Västerbotten	473,327	4,781	**478,109**
Norrbotten	388,369	3,923	**392,292**

Table 36.Biomass arisings for Sweden value chain 2; Biosludge.

	Bio sludge from pulp process (tDM)			
Region	**Feedstock Value Chain 2 (BioSludge)**			
Price per tonne	Prices varies between negative value to some value based on heating value			
Fate	Energy recovery after pre-evaoration	Cover material for waste deposit	BioCoal, Compost/soil improvement	Total
Fate %	60	40		100
Region (Middle Norrland, NUTS2: SE32 and upper Norrland, NUTS2: SE33, Sweden)	16,000	10,000	-	26,000
Jämtland	-	-	-	-
Västernorrland	14,000	2,000	-	16,000
Västerbotten		2,000	-	2,000-
Norrbotten	2,000	6,000	-	8,000

Table 37: Biomass arisings for Sweden value chain 3; Fibre sludge.

	Biomass arisings (tDM)				
Region	**Feedstock Value Chain 3 (Fibre sludge/fibre reject)**				
Price per tonne	Prices varies between negative value to some value based on heating value				
Fate	Energy recovery at mill	Energy fuel sold to Combined power and heating plant	Filler in recycled paper	Insulation, nanocellulose and other materials	Total
Fate %	93.4	4.9	1.6	-	100
Region (Middle Norrland, NUTS2: SE32 and upper Norrland, NUTS2: SE33, Sweden)	57,000	3,000	1,000	-	61,000
Jämtland	-	-	-	-	-
Västernorrland	34,000	-	-	-	34,000
Västerbotten	5,000	-	-	-	5,000
Norrbotten	18,000	3,000	1,000	-	22,000

Table 38: Reference table for the Sweden MIP Region biomass arisings

Source References	
Value Chain	**Reference:**
Value Chain 1	Price: The price per branches and treetops are estimated to 180 SEK per raw tonne i.e., the price the landowner can get. However, there also a cost for taking it out from the forest (about 125 SEK/raw tonne), cost for chipping (about 140 SEK/raw tonne) along with transportation cost. Calculation formula for transportation cost (SEK/raw tonne): (12,53*amount of available raw material) + (0,692*transportation distance*amount of available raw material). Production data: Map source for the total amount of GROT: https://forest-energy-atlas.luke.fi/ Fate: Interview data
Value Chain 2	Questionnaire/Company information, www.northswedencleantech.se/sv/nyheter/reststrommar-och-bi-produkter-fran-metsa-board-husum-skapar-etableringsmojligheter/ https://energiforsk.se/program/branslebaserad-el-och-varmeproduktion-sebra/rapporter/biokol-fran-bioslam/ https://www.c-green.se/newsroom/ragn-sells-and-c-green-collaborate-on-circular-sludge-management
Value Chain 3	Interview data/Company information

14.3 Appendix 3 – Data Collection Template

Table 39. Data collection template opening page.

MainstreamBIO:

MAINSTREAMing small-scale BIO-based solutions across rural Europe via regional Multi-actor Innovation Platforms and tailored innovation support

DATABASE OF REGIONAL VALUE CHAIN INFORMBION

T1.3 - Investigation of regional value chains along with available biomass, waste and residue streams	
WP n° and title	WP1 – Analysis of current situation and set-up of regional multi-actor innovation platforms
Date	01/09/2022

Version	1
Country	Specify Country
NUTS 2 Region	Please specify

Task Description: **In Task 1.3, MTU will lead the mapping of the available biomass feedstocks, waste and residue streams, actors, processes, resource flows, and bioeconomy value chains in our focal regions. At first, a preliminary mapping of the existing value chains will be performed via desk research for all focal regions, by MTU (IE) WR (NL), IUNG (PL), FBCD (DK), PROC (SE), AUP (BG) and INNV (ES). The collection of key information regarding the systems' characteristics will be achieved by directly engaging local value chain actors via interviews (5 interviews are expected per region for a total of 35), based on questionnaires and guidance provided by MTU. The results along with the methodology of the mapping process will be summarised in D1.3.**

This Excel file will act as a Database for collecting information on regional value chains.
Please fill in the "Database" sheet the information about the value chains you identify.
The "Back-up" sheet gathers the drop-down lists info of the "Database" sheet (You don't have to fill anything here).

Template Instructions:

1. Complete information in Tab order 1-5 as fields will auto complete corresponding fields in concurrent tabs.

2. Please complete as much information as possible, any information not intially available may be obtained at the interview stage

	3. Any Queries please contact MTU team		
	Database fields		
	Field name	**Expected info**	**Expected format**
Tab 1	**High Level Introduction to National Bioeconomy**	Information to introduce your countries bioeconomy e.g. main bioeconomy feedstocks, activities/projects, strategies / policies etc.	**Long text (150 min - 250 words max)**
Tab 2	**Value Chain #**	Number of the selected value chain (e.g. 1-5)	**A number**
	Sector	Sector to which feedstock is associated (e.g. agriculture, forestry, marine, other, multiple)	**Short text (5-10 words)**
	Feedstock	What is the feedstock of focus (e.g. maize, straw, pig manure, seaweed)	**Short text (1-2 words)**
	Justification Statement for including	**Justification or context for including this feedstock:** Is the sector to which it relates a strong / scaled area for the region? Is the waste produced a problem for the region? Is there information that the by-product may have specific value in bio-based applications? Is the feedstock generated a waste disposal issue? Does the waste produced have the potential to be a high value sidestream?	**Long test(150 min - 250 words max)**

		Can the feedstock be used as an input for another bio-based producer?	
Tab 3	**Fate**	Current different applications that the specific biomass/feedstock/sidestream is currently being used for.	**Short text (1-2 words)**
	Fate%	Percentage of the available biomass is going towards this specific application.	**Data**
	Region	NUTS2 region is considered within the biomass scoping.	**Data**
	Sub Region	List the different sub-regions that exist within the region insofar as you have broken down the biomass by subregional districts.	**Short text(1-5 words)**
	Biomass Arising	List the totals arising of the specific biomass contained within the region, by Fate(based on above), and Sub Region (based on above).	**Data**
	Source References	Link to data sources per Value chain	**Insert Link**
Tab 4	**Value Chain #**	Number of the selected value chain of which the stakeholder organisation is a member (e.g. 1-5)	**One or more numbers**
	Organisation Name	Organisation Name	**Short text(1-5 words)**
	Type of Organisation / Business	What is the type of organisation relevant to the value chain? (e.g. Biomass Producers, Business, Research & Academia inc Pilot demostrations / relevant sector research projects etc., Civil Society and Policy.)	**Short text (1-2 words)**
	Location	Type address e,.g town and city, province	**Short text (1-10 words)**

	Co-Ordinates	Geographic Co-Ordinates - latitude and longitude.	**Data**
Tab 5	**Value Chain #**	Number of the selected value chain of which the stakeholder organisation is a member (e.g. 1-5)	**One or more numbers**
	Technology/Initiative/Service name	What is the name of the technology/initiative/Service	**Short text (1-5 words)**
	Technology owner/developer	What is the name of the technology/service owner/developer	**Short text (1-5 words)**
	Technology/process/service description	Description of the technology/service, explaining the process/aspects involved, feedstocks/resources which can be used, specialized knowledge or infrastructure required	**Long text (200 words max)**
	Products produced or service provided	What product(s) are produced or service is provided	**Short text (1-10 words)**
	Scale of deployment	Farm, community, region	**Short text (1-5 words)**
	Market readiness	Concept, pilot, demonstration, commercial level	**1 number**
	Environmental Considerations	What are some key environmental impacts from the operation e.g. reduce emissions on a farm level	**Short text (1-20 words)**
	Social considerations	What are some of the impacts for society in the region? e.g. creating jobs, reducing dependence on imports, preserving habitats	**Short text (1-20 words)**
	Economic considerations	What are some of the economic or market considerations e.g. new revenue streams, export demand	**Short text (1-20 words)**

	Location	Type of Area at which the initiative is based (e.g. City, Town, Country)	**Short text (1-2 words)**
	Co-Ordinates	Geographic Co-Ordinates - latitude and longitude.	**Data**
	Link	Link to the detailed info of the technology	**Insert Link**
Tab 6	**Guide to Co-Ordinates**	Guide on how to use Goggle Maps to source Co-Ordinates in latitude and longtitude	**Guide**

Table 40. High level introduction section of data collection template.

High Level Introduction to National Bioeconomy	
Country	Please provide some information to introduce your countries bioeconomy e.g. main bioeconomy feedstocks, activities/projects, strategies / policies etc. (150 min – 250 Words Max.)
Ireland	Please provide some information to introduce your countries bioeconomy e.g. main bioeconomy feedstocks, activities/projects, strategies / policies etc. (150 min – 250 Words Max.)

Table 41. Regional value chain data collection template.

Value Chain #	Sector	Feedstock(s)	Justification Statement for including (150min to 250 words max)
List Relevant Value Chain Number	Sector to which feedstock is associated (e.g. agriculture, forestry, marine, other, multiple)(5-10 words)	What is the feedstock of focus (e.g. maize, straw, pig manure, seaweed)	For example - Is the sector to which it relates a strong / scaled area for the region? Is the waste produced a problem for the region? Is there information that the by-product may have specific value in bio-based applications? Is the feedstock generated a waste disposal issue? Does the waste produced have the potential to be a high value sidestream? Can the feedstock be used as an input for another bio-based producer?

Table 42. Regional value chain feedstock fate data collection template.

	Biomass arising (tonnes DM)			
Region	**Feedstock Value Chain 1 (list feedstock on which value chain is based)**			
Price per tonne				
Fate	Fate 1	Fate 2	Fate x	Total
Fate %	Percentage of the available biomass is going towards this specific application. (Data)	Percentage of the available biomass is going towards this specific application. (Data)	Percentage of the available biomass is going towards this specific application. (Data)	100% (sum of all fates)
Region (e.g. Southern Region Ireland, NUTS2)	tDM of specified biomass type going towards fate 1 for NUTS 2 Region	tDM of specified biomass type going towards fate 2 for NUTS 2 Region	tDM of specified biomass type going towards fate 2 for NUTS 2 Region	Total biomass in all fates for NUTS2 Region

Subregion A	Allocation of feedstock to fate 1 at NUTS 2 level to subregion A (e.g., NUTS3, Provincial, County etc.,)	Allocation of feedstock to fate 2 at NUTS 2 level to subregion A (e.g., NUTS3, Provincial, County etc.,)	Allocation of feedstock to fate 3 at NUTS 2 level to subregion A (e.g., NUTS3, Provincial, County etc.,)	Total biomass in all fates for Subregion A
Subregion B	Allocation of feedstock to fate 1 at NUTS 2 level to subregion B (e.g., NUTS3, Provincial, County etc.,)	Allocation of feedstock to fate 2 at NUTS 2 level to subregion B (e.g., NUTS3, Provincial, County etc.,)	Allocation of feedstock to fate 3 at NUTS 2 level to subregion B (e.g., NUTS3, Provincial, County etc.,)	Total biomass in all fates for Subregion B

References	
Value Chain	
Value Chain 1	References for production data
	References for price data
	References for fate data

Table 43. Regional value chain actors data collection template.

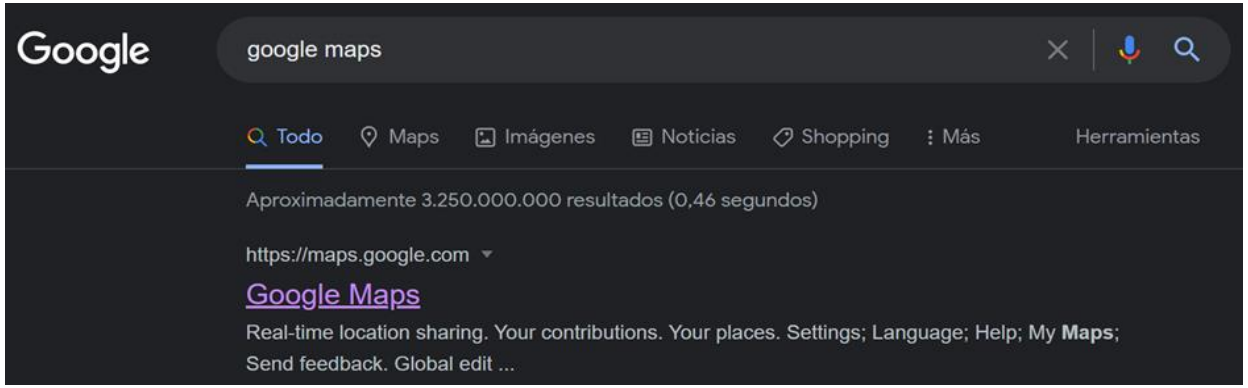
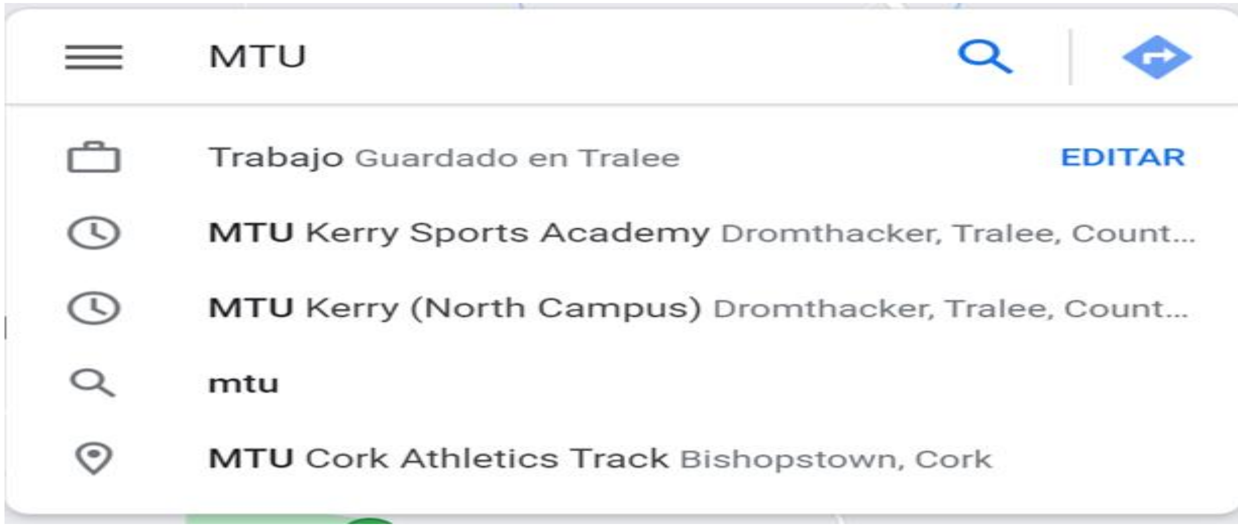
Value Chain #	Organisation Name	Type of Organisation / Business	Location	Co-Ordinates
List relevant value chain number	Name of Organisation	What is the type of organisation relevant to the value chain? (e.g. Biomass Producers, Business, Research & Academia, Civil Society and Policy.)	Type address e,.g town and city, province	Geographic Co-Ordinates - latitude and longitude.

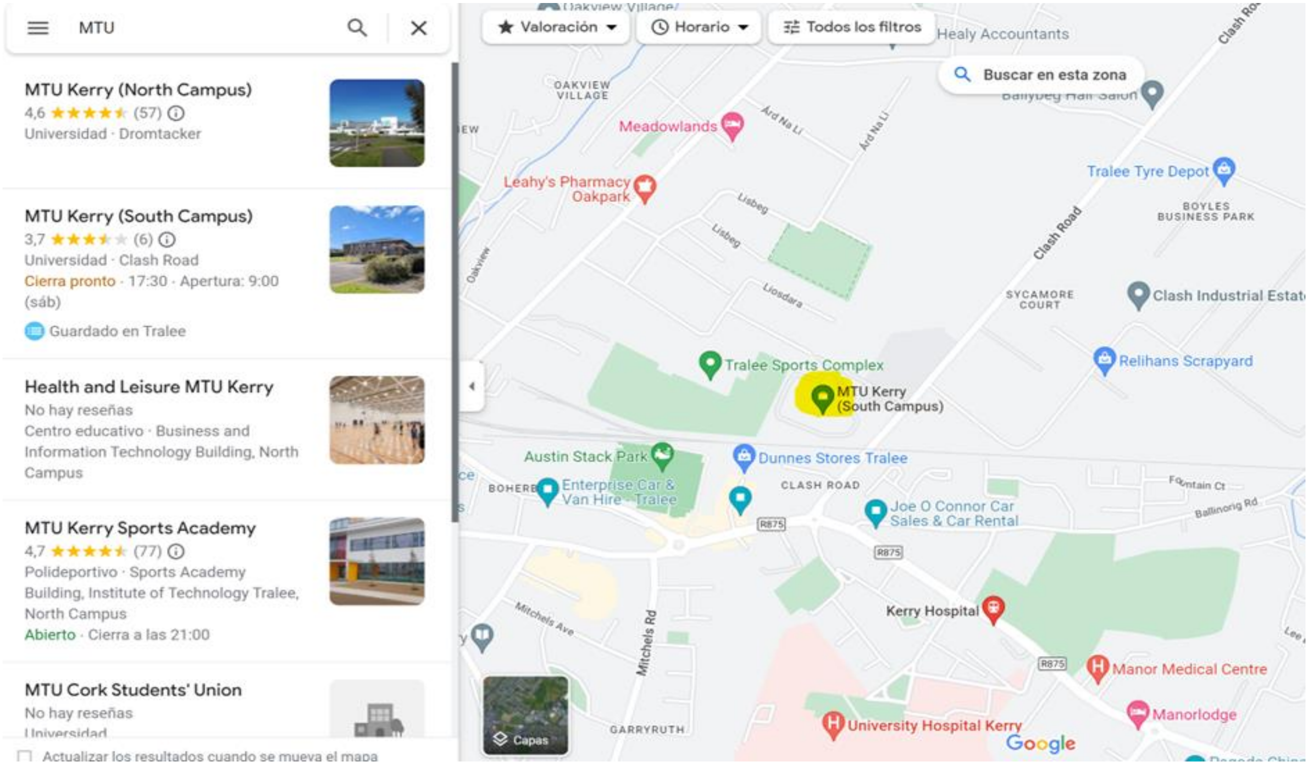
Table 44. Bio-based processes or services data collection template.

Value Chain #	Number of relevant Value Chain	
Technology/ Initiative/ Service name	What is the name of the technology /initiative/ Service	
Technology owner/ developer	What is the name of the technology / service owner/ developer	
Technology / process / service description	Description of the technology/ service, explaining the process/ aspects involved, feedstocks/ resources which can be used, specialized knowledge or infrastructure required	
Products produced or service provided	What product(s) are produced or services is provided	
Scale of Deployment	Farm, community, region	
Market readiness	Concept, pilot, demonstration, commercial level	
Environmental Considerations	What are some key environmental impacts from the operation e.g. reduce emissions on a farm level	
Societal Considerations	What are some of the impacts for society in the region? E.g. creating jobs, reducing dependence on imports, preserving habitats	
Economic considerations	What are some of the economic or market considerations e.g. new revenue streams, export demand	
Location	Type address, town, city, region	
Co-Ordinates	Geographic Co-Ordinates – latitude and longitude	

Web Link	Insert Web Link	

Table 45. Guide to co-ordinates for data collection.

Open Google Maps	
Write your place on the search bar and press Enter	

Find your point on the map	

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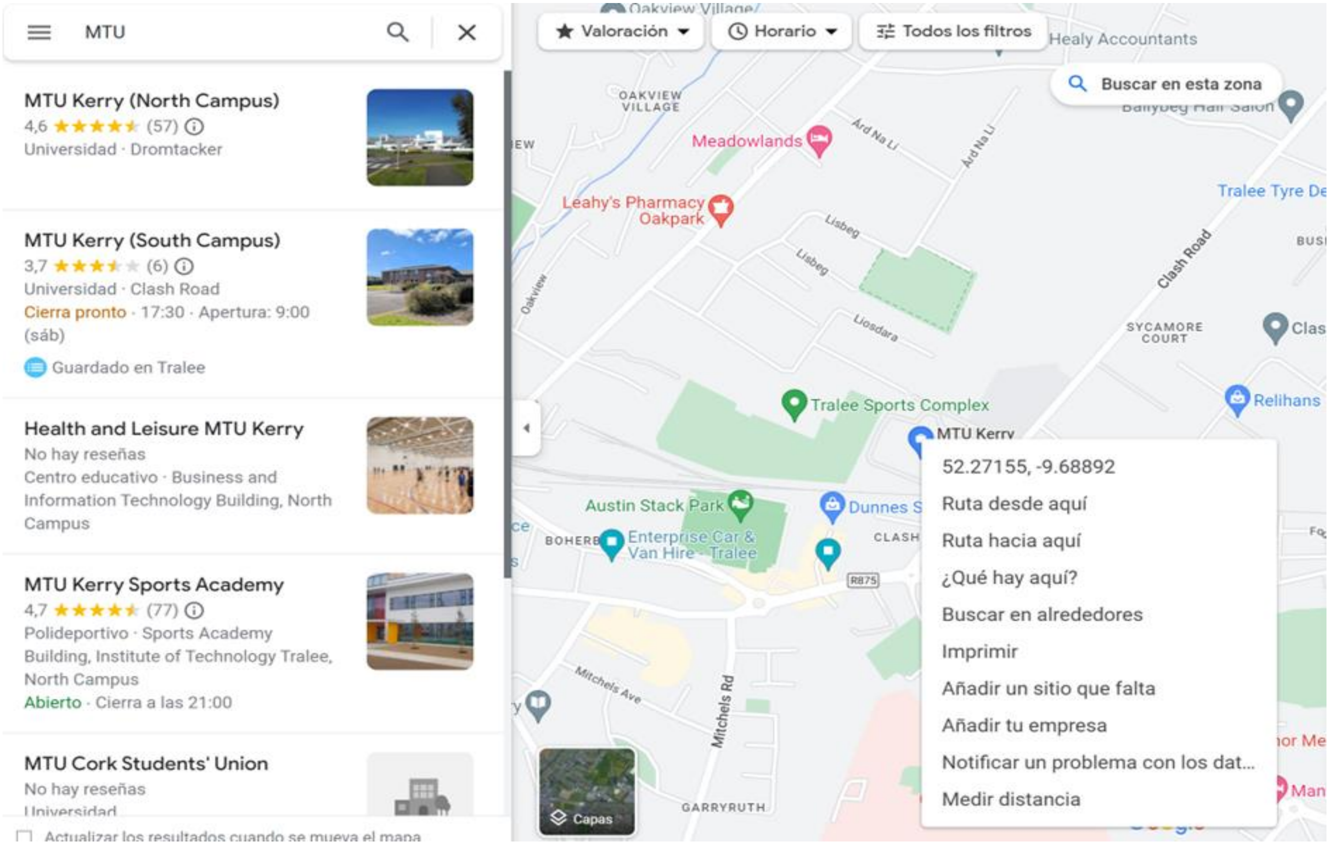
Right click on the point	

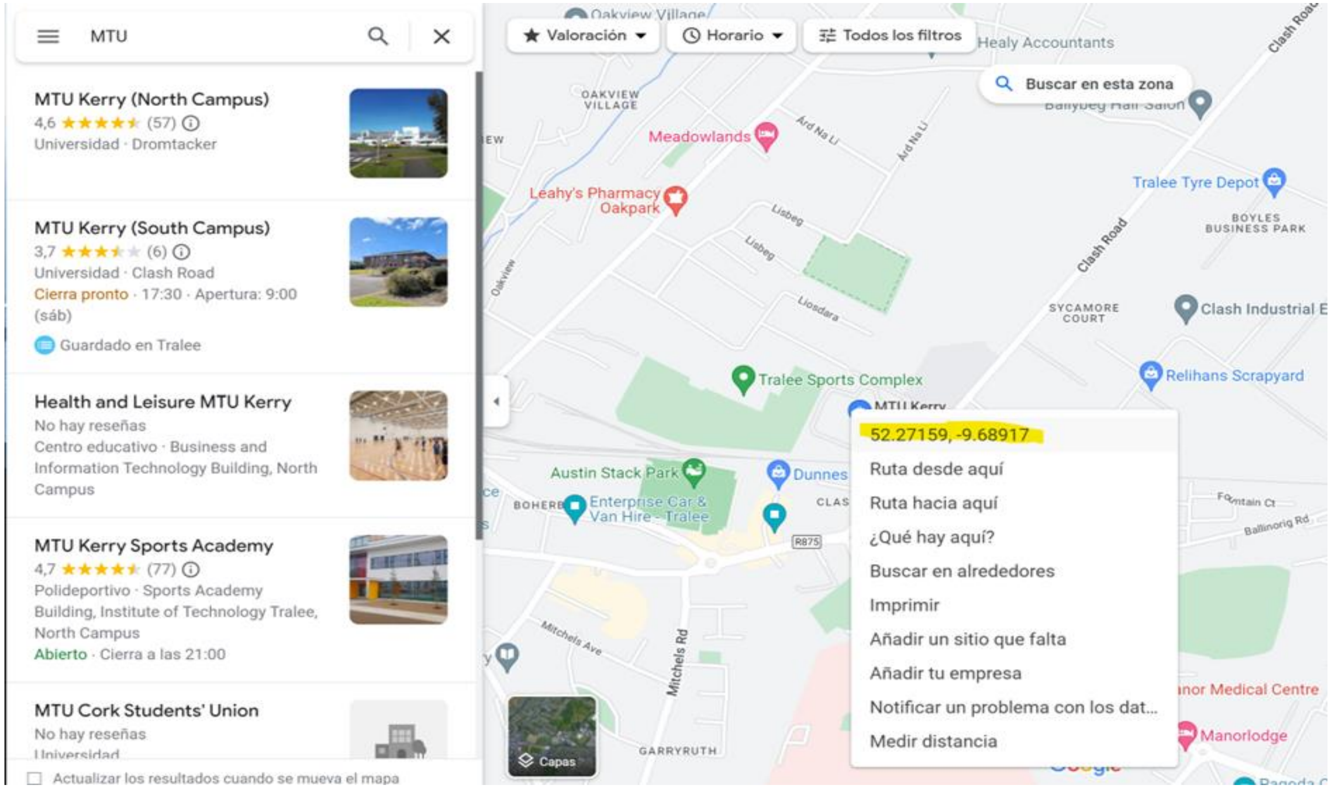
<table>
<tr>
<td>Click on the numbers that appear in the first row</td>
<td>
</td>
</tr>
<tr>
<td colspan="2">And they will automatically copy the numbers to your clipboard for you to paste on the Excel file.</td>
</tr>
</table>

Table 46. Data collection back-up template.

Scale	Stakeholder		Sector	Relevant Value Chain		Feedstocks		Countries	Type of Organisation / Business	Scale of Deployment	Market Readiness
Small-scale	Biomass Producers		Agriculture	Value Chain 1		crop waste streams		Bulgaria	Biomass Producers	Farm	Concept
Large-scale	Business		Forestry	Value Chain 2		grass		Denmark	Business	Community	Pilot
	Research and Academia		Marine	Value Chain 3		animal manure		Ireland	Research and Academia	Regional	Demonstration
	Civil Society		Other	Value Chain 4		human waste		Netherlands	Civil Society		Commercial
	Policy			Value Chain 5		agricultural residues		Poland	Policy		
				Value Chain 6		local crops		Spain			
						livestock		Sweden			
						forage					
						forest residues					
						food processing residues					
						food waste					
						oil					
						medicinal plants					
						winery residues					
						olive oil					
						dairy products					

						Other					

MAINSTREAM BIO
MAINSTREAMING SMALL-SCALE BIO-BASED SOLUTIONS ACROSS RURAL EUROPE

The project

MainstreamBIO is a Horizon Europe EU funded project, which sets out to get small-scale bio-based solutions into mainstream practice across rural Europe, providing a broader range of rural actors with the opportunity to engage in and speed up the development of the bioeconomy. Recognizing the paramount importance of bioeconomy for addressing key global environmental and societal challenges, MainstreamBIO develops regional Multi-actor Innovation Platforms in 7 EU countries (PL, DK, SE, BG, ES, IE & NL). The project aims to enhance cooperation among key rural players towards co-creating sustainable business model pathways in line with regional potentials and policy initiatives. MainstreamBIO supports 35 multiactor partnerships to overcome barriers and get bio-based innovations to market with hands-on innovation support, accelerating the development of over 70 marketable bio-based products and services. Furthermore, the project develops and employs a digital toolkit to better match bio-based technologies, social innovations and good nutrient recycling practices with available biomass and market trends as well as to enhance understanding of the bioeconomy with a suite of educational resources building on existing research results and tools. To achieve these targets, MainstreamBIO involves 10 partners across Europe, coming from various fields. Thus, all partners combine their knowledge and experience to promote the growth of bioeconomy in a sustainable and inclusive manner.

Coordinator: **Q-PLAN INTERNATIONAL ADVISORS PC (Q-PLAN)**

Partner		Short Name
Q-PLAN INTERNATIONAL	Q-PLAN INTERNATIONAL ADVISORS PC	Q-PLAN
MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University	MUNSTER TECHNOLOGICAL UNIVERSITY	MTU
WAGENINGEN UNIVERSITY & RESEARCH	STICHTING WAGENINGEN RESEARCH	WR
IUNG Institute of Soil Science and Plant Cultivation State Research Institute	INSTYTUT UPRAWY NAWOZENIA I GLEBOZNAWSTWA, PANSTWOWY INSTYTUT BADAWCZY	IUNG
RI. SE	RISE PROCESSUM AB	PROC
Agricultural University - Plovdiv	AGRAREN UNIVERSITET - PLOVDIV	AUP
Food & Bio Cluster Denmark	FBCD AS	FBCD
innovarum	EURIZON SL	INNV
DRAXIS ENVIRONMENTAL TECHNOLOGIES	DRAXIS ENVIRONMENTAL SA	DRAXIS
WHITE	WHITE RESEARCH SPRL	WHITE