ESTONIAN UNIVERSITY OF LIFE SCIENCES

Institute of Economics and Social Sciences

Chizuruoke Michael Nnadi

EESTI PÕLLUMAJANDUSETTEVÕTETE BIOENERGIA JA BIO-TOOTE TOOTMISE KAARDITAMISE ANALÜÜS: BALTICBIOMASS4VALUE PROJEKTI JUHTUMIUURING

ANALYSIS OF THE MAPPING OF BIOENERGY AND BIO-PRODUCT PRODUCTION OF ESTONIAN AGRICULTURAL COMPANIES: A CASE STUDY OF THE BALTICBIOMASS4VALUE PROJECT

Master's Thesis

Agri-Food Business Management

Supervisor: Ants-Hannes Viira, PhD

Tartu 2021

ABSTRACT

Estonian University of Life Sciences Kreutzwaldi 1, Tartu 51006		Abstract of Master's	
Author: Chizuruoke Michael Nnadi		Curriculum: Agri-Food Business Management	
Title: Analysis of the mapping of bioenergy and bio-product production of Estonian agricultural companies: a case study of the balticbiomass4value project			
Pages:67	Figures:13	Tables:12	Appendices:4
Institute: The Institute of Economics and Social Sciences Field of Research: Social Geography Supervisor: Ants-Hannes Viira, PhD Place and Date: Tartu 2021			

Abstract: Achieving the global goals of climate change mitigation, food security, and sustainability in economic and environmental parameters has a lot to do with the key players like, farmers, and food producers, that their day-to-day activities and adherence to government and institutional policies plays a vital role. Their knowledge of these global, regional, and national goals is another part of the whole concern. This study assessed the knowledge base of Estonian farmers and food enterprises using a web-based survey sent through the farmers' database to find out what their current links to bio-resources are and what they intend to do in the future. The results show the following,

- Most farmers process manure (25%) , straw (17%) and feed (16%).
- Bio-resources are mainly used for fertilizer (55%) , compost (18%) and feed (12%).
- knowledge of the operational capabilities of transiting to bioeconomy is of more concern to the respondents.
- The number of employees does not affect the adoption of valorization of bio-products.

The thesis can be useful in determining what interventions are needed to achieve a sustainable bioeconomy in different agricultural subsectors.

The data collected can also be used to further analyze biomass concentrations by county and to help design appropriate policies to meet the needs of farmers and food businesses to reduce the negative externalities of their operations and improve their business performance.

Keywords: Biomass, circular economy, valorization, high value products, sustainability

Tartu 2021

ABSTRACT

Eesti Maaülikool Kreutzwaldi 1, Tartu 51006		Magistritöö lühikokkuvõte	
Autor: Chizuruoke Michael Nnadi		Õppekava: Põllumajandus- ja toiduainete juhtimine	
Pealkiri: Eesti põllumajandusettevõtete bioenergia ja bio-toote tootmise kaarditamise analüüs: balticbiomass4value projekti juhtumiuuring			
Lehekülgi:66	Arvud:13	Tabelid:12	Lisad:4
Instituut: majanduse ja sotsiaalteaduste instituut Uurimisvaldkond: sotsiaalgeograafia Juhendaja: PhD Ants-Hannes Viira Koht ja kuupäev: Tartu 2021			
Abstraktne: Kliimamuutuste, toiduga kindlustatuse ja jätkusuutlikkuse ülemaailmsete eesmärkide saavutamisel on palju pistmist võtmeisikute, põllumajandustootjate ja teiste ettevõtjatega, et nende igapäevane tegevus järgiks valitsuse poliitikat. Nende teadmised ülemaailmsetest, piirkondlikest ja riiklikest eesmärkidest on üks osa jätkusuutlikkusega seotus probleemidest. Käesolevas uuringus hinnati Eesti põllumajandustootjate ja toiduettevõtete biomajanduse alaseid teadmisi, kasutades selleks veebipõhist küsitlust, et teada saada, millised on põllumajandustootjate ja toiduettevõtete bioloogilised ressurssid ja mida nad kavatsevad tulevikus nendega teha. Tulemused näitavad järgmist ▪ Enamik põllumajandustootjaid töötleb sõnnikut (25%), põhku (17%) ja sööta (16%). ▪ Bioressursse kasutatakse peamiselt väetise (55%), komposti (18%) ja sööda (12%) jaoks. ▪ Biomajandusse üleminekuks kindluse tundmine on vastajatele rohkem murettekitav. ▪ Töötajate arv ei mõjuta hindamise aktsepteerimistvalmisolekut bioressursside töötlemiseks. Väitekirjast võib olla kasu, et määrata, milliseid sekkumisi on vaja säästva biomajanduse saavutamiseks erinevates põllumajandussektorites. Kogutud andmeid saab kasutada ka bioressursside edasiseks analüüsimiseks, et aidata välja töötada asjakohaseid poliitikameetmeid, et rahuldada põllumajandustootjate ja toiduettevõtete vajadusi, et vähendada nende tegevuse negatiivseid välismõjusid.			
Märksõnad: Biomass, ringmajandus, väärindamine, kõrge väärtusega tooted, jätkusuutlikkus			

Table of Contents

INTRODUCTION

The equitable use of natural resources has always been an issue in the pursuit of sustainable development since the main agenda of sustainable development centers on “safeguarding the needs and rights of future generations” (Franks, 1996; Daly, 2006). On this backdrop, there has been policies enacted by the United Nations and other world, regional and country-specific organizations on how to achieve this sustainability now and in the future, to avert the effects of the rapacious exploitation of both renewable and non-renewable natural resources. Thus, the use of plant and animal by-products has been discovered as a means of increasing the utility derived from these products while saving the exploitation of untouched products to achieve same. This will in turn contribute to the global target of restoring 15% of degraded ecosystems while mitigating climate change (Maes et al, 2014). Most agricultural by-products constitute nuisance as they are difficult to decompose (Briens, Piskorz & Berruti, 2008), and even the ones that can decompose easily produce odiferous smells and can act as breeding grounds for harmful microbes. Houghton, (2008), defined biomass as “the mass of living organisms, including plants, animals, and microorganisms, or from a biochemical perspective, cellulose, lignin, sugars, fats and proteins. Hence in the quest for an environmentally friendly and sustainable options, biomass and bio-resources are of great importance looking at their renewable nature and less carbon dioxide production during combustion and the diversity of their occurrence in nature.

In a country like Estonia that has about 50% of it covered with forests and with very high concentration of biomass and bio-resources (Canales et al, 2020), the research is important to achieve, maintain and sustain the sustainable development goals of the United Nations and the bioeconomy strategy and the Green Deal of the European Union, while creating employment opportunities through development of the rural areas where most of these resources are located (Norden, 2016, Canales et al, 2020). Investments in this field will help the Estonian government to have other alternatives to energy production and reduce the cost of pollution treatment when and where they occur (Gaspard et al, 2013). With more research in this field in Estonian schools and research institutions, it will help create more awareness amongst Estonians on the benefits and opportunities inherent in these practices. This will also help position Estonian Institutions and people as subject matter specialists with the antecedent innovations that accrues from active participation. It will also help to institutionalize the strategic thinking of the Estonian government in pursuit of sustainability and more economic relevance in the Baltic region, Europe, and the world at large. On the long run there are possibilities of these products and services becoming major export items of the country, thereby improving its gross domestic product (GDP), balance of payments among others while improving on the innovations related to their production and use.

To achieve these, it is necessary not only to understand the bio-resources currently being produced by Estonian farms and food processing companies but also to know what they use it for. It is also pertinent to evaluate the knowledge of the farmers on the subject matter and how they perceive the whole concept of bioeconomy, its policies, practices and tools already on ground and how they intend to use them in the future to achieve a seamless and successful transition to bioeconomy bearing in mind the great opportunities inherent in it on the enterprise level for value creation, market expansion and revenue generation and also on the macro level for climate change mitigation. An insight on the intended future use of these bio-resources is very imperative as this will help the government, research companies and even other investors to know where and how to come in in achieving a bioeconomy transition that will benefit all and sundry.

The research aim is to determine the current bio-resources processing situation among Estonian farms and food industries and elicit information on their future bio-resources interest and valorization preferences.

The research questions are,

1. What kind of bio-resources are the farms and food enterprises currently processing (survey data) and for what purpose?
2. What kind of bioresource valorization are the farms and food enterprises interested in and what factors that impact their interest?
3. What business model canvas elements are relevant to the farms and food enterprises and what are the factors hindering them from transiting to these business models?
4. What agricultural sub sectors (animal production, crop production, fishery etc.) in Estonia have adopted valorization of bio-resources more?
5. How does the enterprises' characteristics (size – number of employees) impact the adoption of bioresource valorization?

The use of an online questionnaire sent to Estonian Agricultural and food processing companies using many interfaces like social media, direct mails and personal messages was employed. The questionnaires were sent out starting from the third week of January 2021 and concluded on the second week of April 2021. The data was analyzed using averages, Chi-square test, pivot tables and pivot charts, and percentages were used to analyze the data while, bar charts, pie charts and tables were used for displaying the results.

The data was part of the Baltic Biomass for value project.

The subsequent part of the research is divided into three major headings comprising the following: 1. Literature review 2. Data and methodology and 3. Results and conclusions. 4. References and 5. Appendices.

The literature review explored such topics as, brief history, definition and concept of bioeconomy, classification of biomass and bio-resources, value chains in bioeconomy, Estonian bio-resources, challenges to bioeconomy transition and the bioeconomy business model (which is identified as one of the problems to the transition to bioeconomy).

Acknowledgements

It is my pleasure to recognize the efforts of my wife, Omolabake Nnadi for her support in taking care of the home front while I pursue my master’s degree. My supervisor Mr. Ants-Hannes Viira (Ph.D.) whose wealth of knowledge was never restricted in the writing of this thesis.

This research was supported by European Social Fund’s Dora Plus Programme

European Union
European Regional
Development Fund

Investing
in your future

1. LITERATURE REVIEW

1.1 Brief History, Definition and Concept of Bioeconomy

With the increasing world population and decreasing availability of resources, especially non-renewable resources, a lot of attention has been channeled to the renewable resources in a bid to meet not only the increasing demand but reduce the impact of fossil fuels on the environment, climate and nature.

There has been many arguments to the first proponent of the word “bioeconomics” while some attribute it to British biologist Hermann Reinheimer who published a book in 1913 with the title “Evolution by Co-operation: A study in Bioeconomics” (Beluhova-Uzunova, Shishkova, & Ivanova, 2019, Reinheimer 1913) others say it was Zeman who first used the term in the 1960s to explain the economic order in a biological perspective that binds together all economic activities (Lewandowski, 2018, Bonaiuti 2014, p.54). Before we delve further into this topic, it will be appropriate to clarify on misunderstandings, misuse, and inter-use of the word “bioeconomy” and “bioeconomics”. According to Birner (2018) the use of the term “bioeconomics” differs from the early use of the word “bioeconomy” which refers to “the use of biological knowledge for commercial and industrial uses”. While bioeconomics can be defined as “a progressive branch of social science that seeks to integrate the disciplines of economics and biology for the sole purpose of creating theories that do a better job of explaining economic events using a biological basis and vice versa” (Hargrave, 2019), the European Union defined bioeconomy as “using renewable biological resources from land and sea, like crops, forests, fish, animals and micro-organisms to produce food, materials and energy” (Knierim, Laschewski & Boyarintseva, 2018, European Commission 2012, p.5). Thus while bioeconomics is concerned about the science and theory, bioeconomy deals with the intervention of man in the use of policies, processes and education to achieve the desired goal of sustainable development, solving societal problems of poverty, global warming, fossil fuel depletion and their negative externalities among other environmental, social and economic concerns.

The Convention on Biological Diversity in 1992 by the United Nations (the Earth Summit) can be said to be the first global institutional summit on bio-resources conservation (Grimble

& Laidlaw, 2002). After this was the Millennium Development Goals (signed in year 2000) which was later changed to Sustainable Development goals in 2016 (Batra, Uitto, & Cando-Noordhuizen, 2015). On regional, ethnic and climate differentiated levels, various people of the earth have over time managed their resources in a sustainable way to get the best out of it while limiting the impact of their activities on nature. The various forms of conservation practiced by different people over time is beyond the purview of this research but as earlier custodians their judicious use of these resources bequeathed by nature has led to our having access to them presently although it is on record that many fauna and flora has gone extinct by the activities or inaction of man over time.

There have been various definitions of bioeconomy over time by different people and institutions. Some of the very definitions are presented in the table below with their sources.

Table 1.1 definitions of bioeconomy by different authors

Author/Source	Definition
Enriques and Martinez (1998)	"bioeconomy as an economic activity based on scientific research and implementation focused on understanding the mechanisms and processes at the molecular (genetic) level, with the aim to implement and use it in industrial processes"
EU Bioeconomy strategy (2012)	" The Bioeconomy encompasses those parts of the economy that use renewable biological resources from land and sea to produce food, biomaterials, bio-energy and bio-products."
McCormick and Kautto (2013, p.2589)	"an economy where the basic building blocks for materials, chemicals and energy are derived from renewable biological resources"
SCAR (Standing Committee on Agricultural Research) (2014)	"using biological resources to produce more and better from less oil dependency CO_2 emissions, wastes (agriculture, fisheries, food) and new revenue gains
OECD (2009)	"the exchange of knowledge resulting from the natural sciences to the new, environmentally friendly eco-efficient and competitive products"
European Commission (2018)	"bioeconomy covers all sectors and systems that rely on biological resources –animals, plants, micro-organisms and derived biomass, including organic waste – as well as their functions and principles"

Table 1.1 definitions of bioeconomy by different authors (continued)

Author/Source	**Definition**
Global Bioeconomy Summit (2018)	"the production, utilization and conservation of biological resources, including related knowledge, science, technology, and innovation, to provide information, products, processes and services across all economic sectors aiming toward a sustainable economy"
European Commission (2020)	"the bioeconomy, as a catalyst for systemic change, tackles the economic, social and environmental aspects of the Green Deal, seeking new ways of producing and consuming resources while respecting our planetary boundaries and moving away from a linear economy based on extensive use of fossil and mineral resources"

Compiled by author (2021)

While some definitions focused on defining the relevance of the sources of materials that makes up bioeconomy and their renewable nature (EU bioeconomy strategy, 2012), some others highlighted more on the use of technology using these same plant and animal resources to produce more products with higher utility and economic value (Enriques and Martinez, 1998). In a work published by Bugge, Hansen & Klitkou (2016) they divided the bioeconomy concept into what they called "visions". The visions were the bio-technology vision, the bio-resource vision, and the bio-ecology vision. The bio-technology vision accentuates the importance of bio-technology research and application and commercialization of biotechnology in different sectors of the economy. The bio-resource vision focuses on processing and upgrading of biological raw materials, as well as on the establishment of new value chains. The bio-ecology vision capitalizes on sustainability and ecological processes that optimize the use of energy and nutrients, promote biodiversity, and avoid monocultures and soil degradation (Bugge, Hansen & Klitkou, 2016). Staffas et al (2013) in their narratives opined for a distinction between bioeconomy (BE) and bio-based economy (BBE). Hausknost et al (2017) summarized it that it is technology that drives the bioeconomy while bio-based economy is resource driven as it promotes the transition from fossil-based to bio-based economic system.

It has been believed in some quarters that the transition from a fossil-based to bio-based products and sources of energy will not only address the issues related to climate change but will also lend its weight in finding solution to such pressing global needs as food security, health, energy security and industrial restructuring (Bugge, Hansen & Klitkou, 2016, Ollikainen, 2014, Pülzl, Kleinschmit & Arts, 2014, Richardson, 2012). The definition of the term "bioeconomy can be said to be open to different interpretations based on level of technology, abundance of bio-resources, culture and other factors based on perspectives. For European countries that has over time imbibed the principle of conservation and has abundance of bio-resources, their interest will be geared towards the use of technology to harness these for high value products like medicine and chemicals while for developing countries in Africa and Asia, their concentration will be in ways to make the conservation of bio-resources work while still harnessing the benefits in its very basic forms of energy and food, hence both narratives are pursuing a bioeconomy agenda but on different levels. In their conclusion, Beluhova-Uzunova, Shishkova, & Ivanova (2019) stated that "there is no clear consensus about the definitions of bioeconomy in a global context. The concept of bioeconomy has evolved and has changed to address the emerging world challenges and it is related to the concept of the circular economy and the green economy"

The European Union has been on the forefront on the pursuit and implementation of bioeconomy strategies. In a recent publication by the European commission in November 2020, "It is estimated that the bioeconomy contributes to almost 9% of the EU-27 labour force and 4.7% of the EU-27 GDP. As a concrete operationalization of the bioeconomy, more than 2,300 bio-based plants have been mapped by the Joint Research Centre across Europe" In a similar publication by El-Chickakli et al (2016), the European Union's biology-based industries accounted for 17 million jobs, 8.5% of the work force, and generated 2.2 trillion Euros in GDP. Agriculture created most of the jobs at 9.7million (56%) while non-food products such as paper furniture and textiles generated more profits (480 billion Euros). According to a publication by the European parliament think tank (2017), the EU has invested in various forms to promote and support a "knowledge-based bioeconomy. Some of these are the Horizon 2020 framework aimed at researches. The H2020 societal challenge 2 "Food security, sustainable agriculture and forestry, marine and maritime and inland water research and bioeconomy " is a project aimed at food security, sustainable agriculture and forestry, marine, maritime, and inland water research, and the bioeconomy. The BIOEAST is an initiative of the governments of Central and Eastern Europe (CEE countries) with a vision to develop knowledge and cooperation based circular bio economies to help enhance inclusive growth, create new value-added jobs especially in rural areas while maintaining and strengthening environmental sustainability by the year 2030 (Juhász & Vásáry 2017).

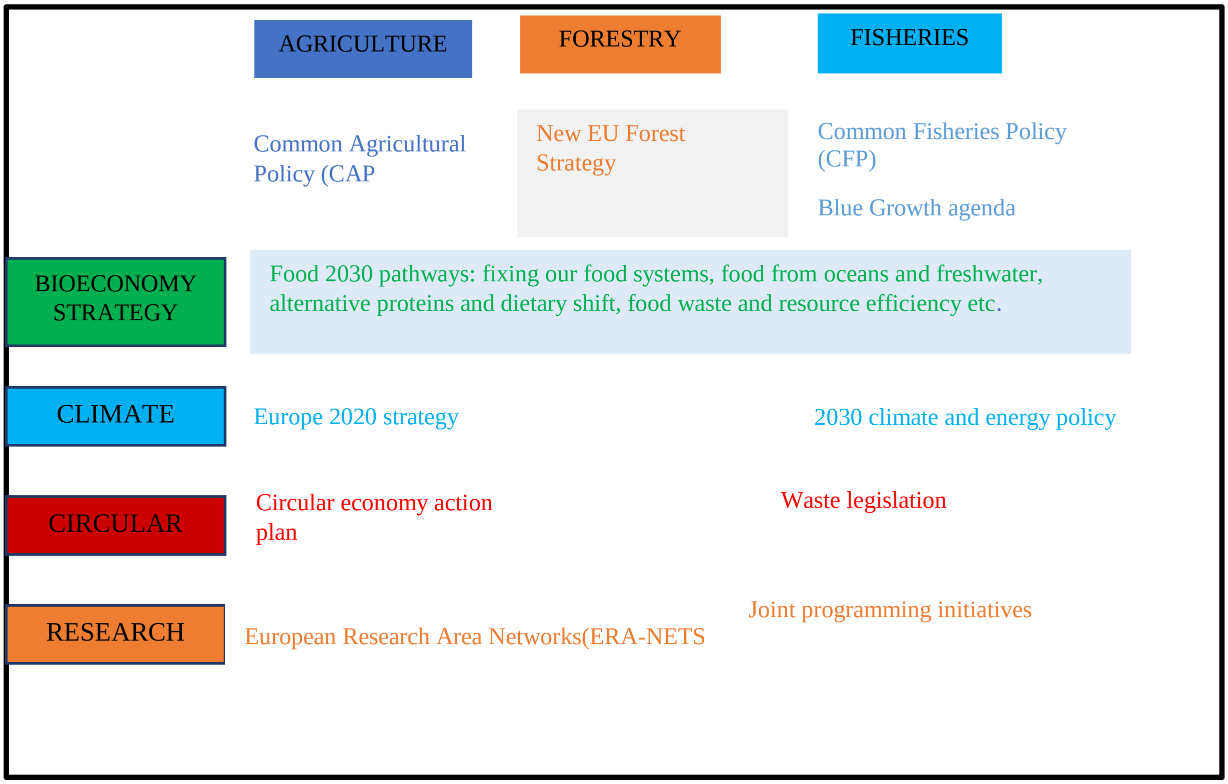

Figure 1. Overview of the main EU policy tools for a bioeconomy (Adopted and modified from EuropeanParliamentary Research Service, 2017)

According to Bourguignon (2017), in his summary of the above bioeconomy interventions by the EU in figure 1:

The Common Agricultural Policy was designed to "to ensure judicious food production, sustainable management of natural resources and climate action, and a balanced territorial development" and has an annual budget of sixty billion Euros.

The EU **Forest Strategy** "provides the framework based on these general principles: sustainable forest management, resource efficiency, rural development and economic growth; sustainable production and consumption of forest products"

The **Common Fisheries Policy** "manages fishing activities by using various policies such as total allowable fishes, restrictions on gear and number of vessels with the intention for a sustainable exploitation of fish stocks".

On **Climate**, "the Europe 2020 strategy has a target of 20% share of renewable energy in the final EU energy mix by 2020".

On **Circular Economy**, "there is an EU action plan aimed at reducing waste to a minimum and it identifies biomass and bio-based products as one of the five priority sectors".

On **Research and Innovation**, "the EU identified biotechnology as a key enabling technology that strengthens innovation and competitiveness in the EU. The Horizon 2020 Programme funds research and innovation in the knowledge-based bioeconomy"

The **Bioeconomy strategy** is an EU blueprint integrating bioeconomy, sustainability and circularity in order to propel the renewal of EU industries, the modernization of the primary production systems, the protection of the environment and to also enhance biodiversity (European Union, 2018)

The **Food 2030 Pathways for Action** are ten focus of the European Union research and innovation comprising of the following,

1. Governance and systems change
2. Urban food system transformation
3. Food from the oceans and freshwater resources
4. Alternative proteins and dietary shift
5. Halving food waste
6. The microbiome world
7. Healthy, sustainable, and personalized and nutrition
8. Food safety systems of the future
9. Food systems Africa
10. Food Systems and Data

According to Lutzeyer (2019), the food 2030 pathways are research and innovation towards future proofing food systems in Europe and its priorities are 1. Nutrition for sustainable and healthy diets 2. Climate smart and environmentally sustainable food systems 3. Circularity and resource efficiency and 4. Innovation and empowerment of communities.

1.2 Classification of biomass and bio-resources

There are various classifications of biomass based on different criteria like source (origin), use, structure etc. Körner (2015) classified it as "virgin primary bio-resources and processed primary bio-resources". On the other hand Paz (2013) classified them as follows, "energy crops, when the plants are grown with the main purpose of being used for energy; by-products, when they are a secondary product of a process; and wastes or residues when they are result of a process and need to be discarded by the initial use". Classification can also be done on basis of economic sector of origination, which include agricultural and forest residues, residue from agro-industries and municipal waste (Paz, 2013, Tursi,2019). There is also classification based on the presence of an important feature in their composition like, lignocellulosic biomass, oil biomass, sugar and starch, and high-moisture biomass (Paz,2013). In a similar classification, Mõtte et al (2019), Zorb & Lewandowski (2017), classified biomass according to the following: (1) origin (plants, animals, and microorganisms), (2) sector (agriculture, fishing, forestry, and waste), (3) their physical conditions (solid, liquid) and (4) the major constituents (starch, sugar, lignocellulose, oil, and protein).

The classification of the biomass and bio-resources helps to determine what it can be used for, either industrial or domestic, energy production or production of biofuels, chemicals, or other high-end variants. It will also help in determining its value chain benefits and the appropriate technology to be employed in its processing relative to other considerations like, uses of its bye-products, location of processing plants etc.

Figure 1 below shows a schematic representation of biomass in terms of its sources (feedstock), processes and products. While the feedstock describes the various forms biomass is used, the processes explains the various forms how these feedstocks are treated to produce the various products. While the most basic product of biomass is used for heat and energy, it can also be used to produce high value products like chemicals and pharmaceuticals.

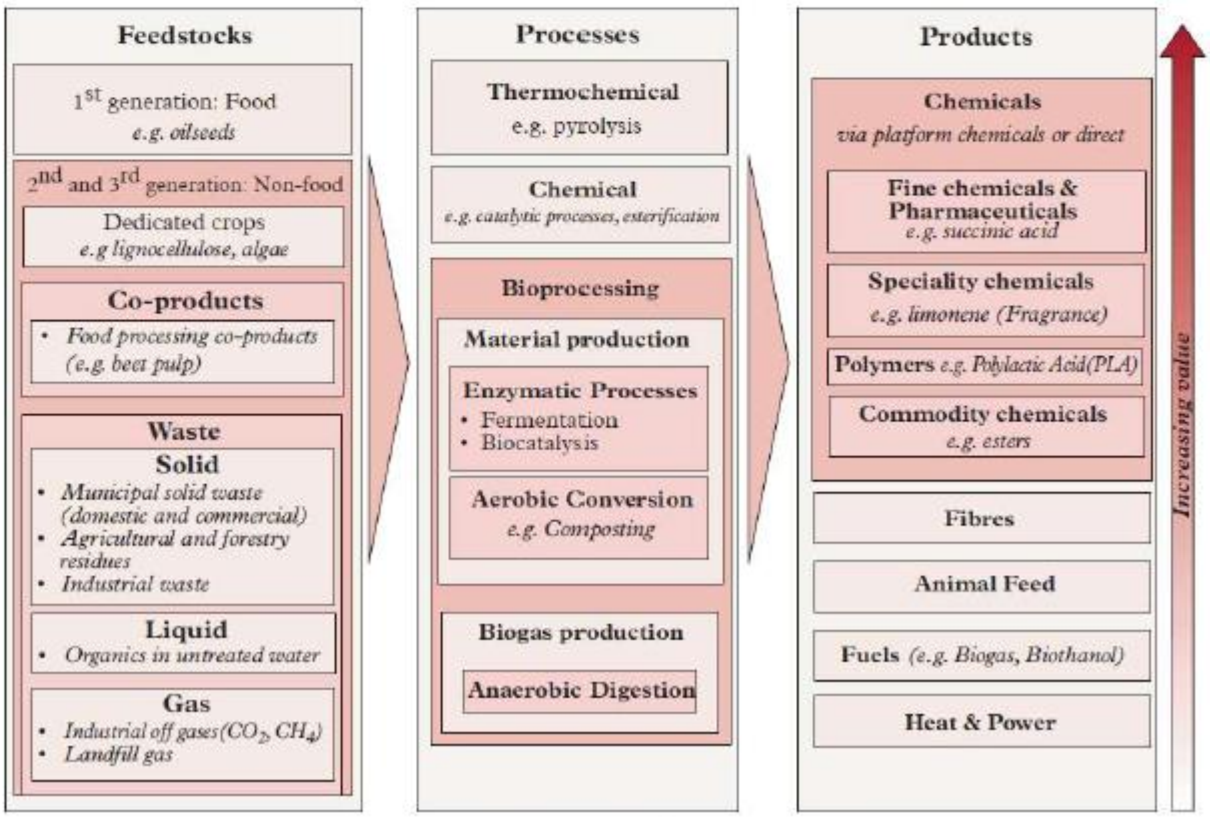

Figure 2. Bio based feedstocks, processes and end products by value added creation (Adopted from House of Lords 2014, chapter 2)

1.3 Value chains in bioeconomy

Value chain as defined by Tardi, 2020 "a business model that details all the activities needed to create a product or service. For good producing companies, a value chain comprises the steps that involve bringing a product from conception to distribution, and everything in between—such as procurement of raw materials, manufacturing activities, and marketing functions". Burns et al., 2002 expatiated it further to include all the technical and organizational steps and processes that make a product acquire value. It is such a processes or activities that makes a product to acquire a value higher than the value possessed in each of the previous stages (Pavone & Goven, 2017, p.150). Thus, moving a raw material from a place of abundance to a place of scarcity as simple as it look is value creation as its demand will be higher where it is scarce and needed.

One of the major challenges and tasks that must be accomplished in the bioeconomy concept is the provision of new and alternative value chains for fossil-based products and raw materials - oil, natural gas, and coal (Kircher, 2020, Ingrao et al., 2018).

In a comparison of stages of value creation between fossil-based and bio-based sources, Kircher (2020) noted that while the fossil-based has three stages of value creation, the bio-based alternatives has 4 stages of value creation as depicted in figures 3 and 4 below.

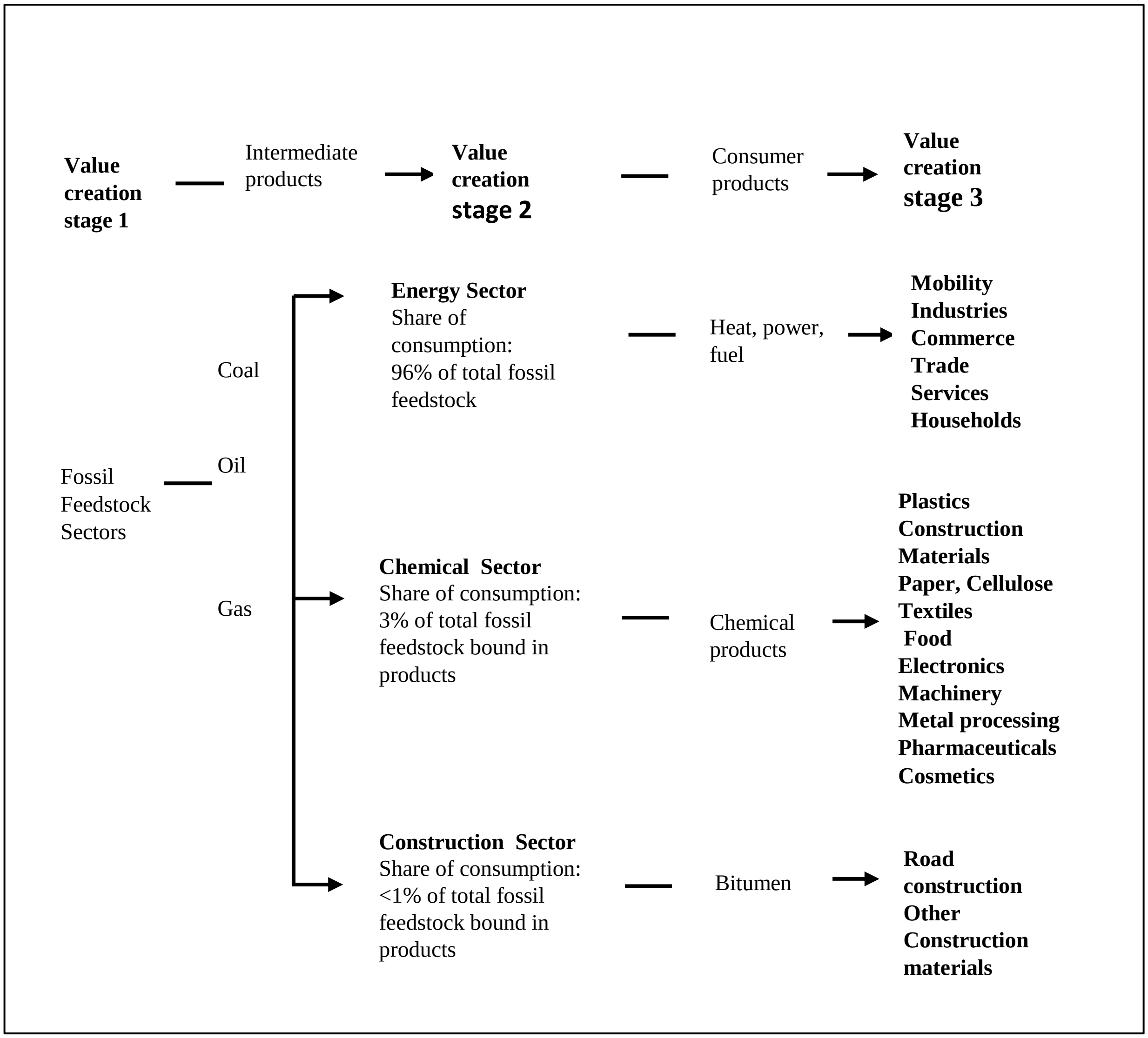

Figure 3. Value chains based on fossil raw materials and their share in consumption (Adopted from Kircher ,2020)

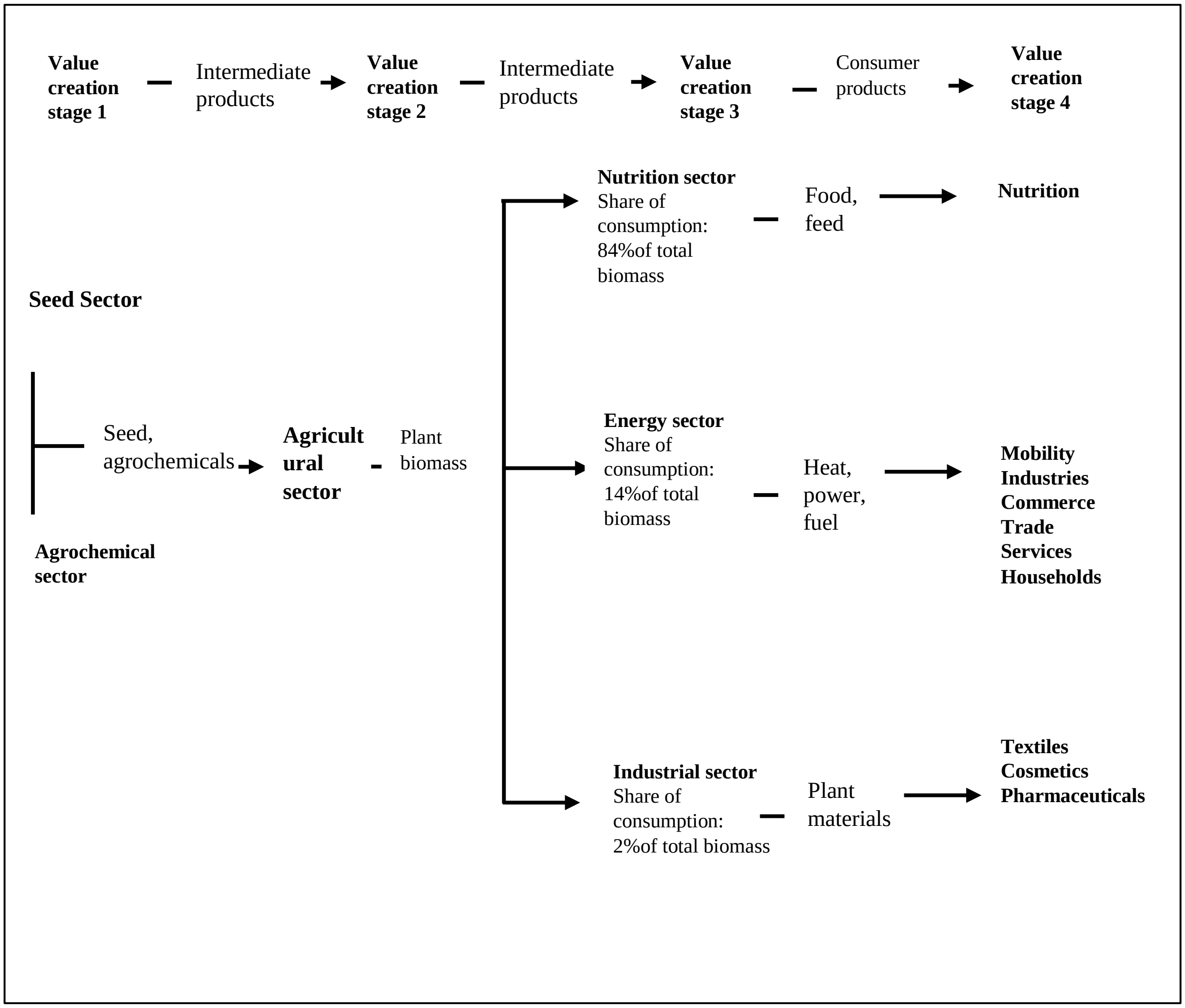

Figure 4. Value chains from agricultural and forest biomass and their share in consumption (Adopted from Kircher, 2020)

Comparing the utilization, catalytic breakdown and efficiency between fossil and bio-based raw materials and products, Kircher (2020) came up with the following.

a. Fossil based sources (crude oil and natural gas) are still more cost-effective in terms of market price
b. They have a robust and well-established global supply infrastructure (pipelines, tankers and vessels)
c. Their products have a higher carbon content (70% to 85%)
d. Oil refinery operates without residual materials because all its components have commercial use in the energy and chemical and building material sectors.

On the other hand the bio-based sector is yet to compete favorably on any of the mentioned areas though it's novel and with prospects of further development but the issue of residual raw materials still remains an area for further research and improvement especially where they tend to negate environmental safety and biodiversity.

Figure 5 below usually called the biomass value cascade (Lange et al., 2016, p.19) reflects the various uses of biomass products in their order of importance. While the products at the top are the products with high value, the ones at the bottom have a low value in terms of meeting human needs. According to Lange et al., (2016) the new focus is that bio-resources should be exploited in a way where the vital products (nutraceuticals, high value metabolites, and feed and food ingredient) are given priority and extracted first, followed by the sugar of the cellulose fibers are used to produce bioenergy.

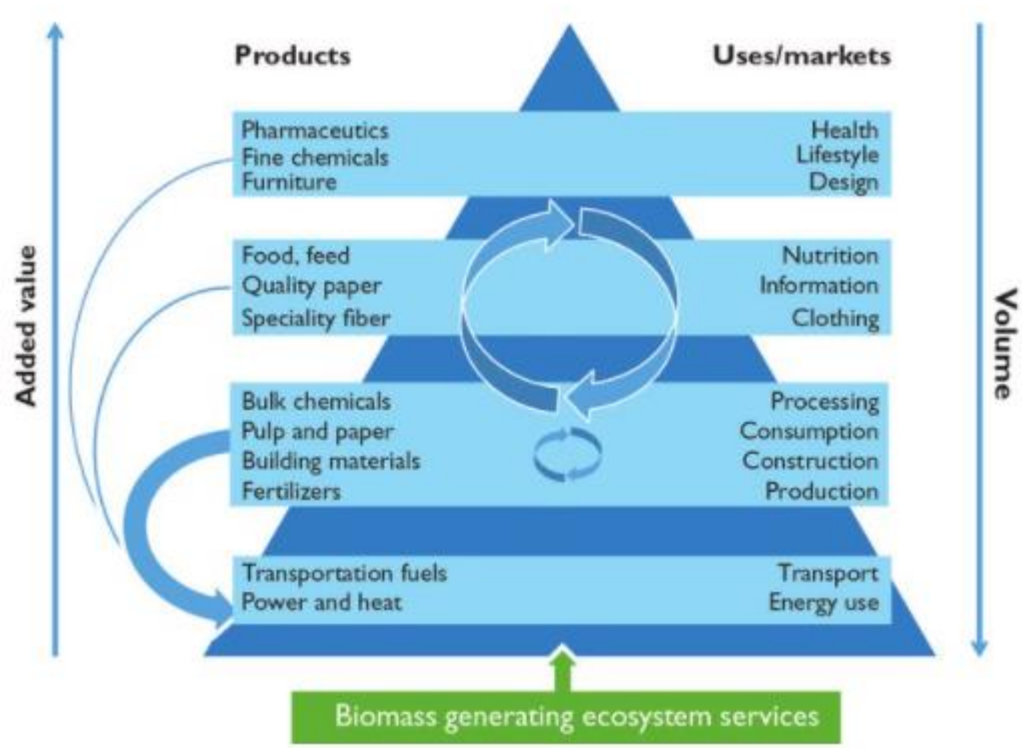

Figure 5. Biomass pyramid for a circular economy (Adopted from Antikainen et al., 2017, p. 20)

Over the years, there has been tremendous developments and discoveries in biomass value chain from different countries across the globe. Lange et al., 2016 captured this in the table 1.2 below.

Table 1.2 Value chains in biomass (Lange et al, 2016)

Biomass	Existing use	New value chain
Blue Biomass: Fish discard and fish waste	Low value animal feed, biogas	Food ingredients, protein rich feed, fish oil for human consumption
Blue Biomass: Macro Algae	Is only sporadically used	Cosmetics, food ingredients, food, health products, polymers
Green Biomass: Grass, Clover and other plants and plant parts	Rough feed, biogas or fertilizer for organic crop cultivation	Extraction of protein (for animal feed) and possibly also high value produce (such as vitamins, food ingredients), utilization of waste rich in fibers
Green Biomass: Alternative protein crops	Animal feed	Protein for, for instance, animal feed from alternative protein crops, such as clover, grass and broad beans
Yellow Biomass: Straw, other cellulosic byproduct	Combustion, deep bedding, ploughing-in	Biorefining, conversion into sugars and lignin, which can be used as raw materials for production of second generation biofuels and biomaterials
Brown Biomass: Wood	The biomass is not produced to its full extent Burning of wood chips	Production of gas, possibly including upgrading of gas to natural gas through gasification of wood in local plants
Waste from meat production	Meat and bone meal, animal feed	Upgrading of meat protein and energy resource
Waste from dairy	Some of the whey is treated as wastewater	Whey protein used for various food products
Unsorted household refuse	Direct burning	Biogas and new materials from household refuse: through the "REnescience" process, a bioliquid is made, which may be used for microbial production of materials or biogas
Protein-rich animal feed	Animal feed	Improved livestock feed/protein absorption by enhancing bio accessibility and specificity of, for instance, protein in the feed

1.4 Estonian Bio-resources

Estonia is a country in northern Europe that has borders with the Baltic sea, Gulf of Finland, Latvia, and Russia. It lies along latitude 58° 35' 50.95" N and longitude 24° 59' 14.12" E. It covers a total land mass of 45,339 square kilometers (Workinestonia, 2019). A description by Bousfield (2011) described Estonia and the other two Baltic countries (Latvia and Lithuania) thus "Outside the cities lie great swathes of unspoiled countryside, with deep, dark pine forests punctuated by stands of silver birch, calm blue lakes and a wealth of bogs and wetlands, all bordered by literally hundreds of kilometers of silvery beach" According to a country report by Bio based industries consortium (2020),it listed agriculture, forest-based and chemical industries as the major drivers of the country's economy. It also stated that wood processing and agriculture as the leaders in terms of production value. Looking at the residual biomass, wood residues are the most abundant at 450 thousand tonnes per year while animal waste comes second at 85 thousand tonnes per year (BIC, 2020). The consortium labelled Estonia as moderate/modest innovator country and Mõtte et al (2019) stated that the GVA (gross value added) of Estonia in the agriculture, forestry and fisheries in 2016 (2.5%) was below the European union average of 2.9%.

In a nutshell, a recent study by Mõtte et al (2019) summarizes the average primary biomass production and value of Estonia between 2014-2016 in the table 1.3 below.

Table 1.3 Biomass production and value 2014–2016 average in Estonia (Mõtte et al, 2019)

Sector	**Commodity**	**Gross production, thousand tonnes; * thousand m^3**	**Production value, million €**	**Share of production value, %**
Agriculture	Cereal	1,244	177	8.6
	Legumes	78	14	0.7
	Technical crops including oil crops	178	54	2.6
	Vegetables, potatoes	185	62	3.0
	Berries and fruits	6	7	0.3
	Fodder roots	0.9	0.1	0.01
	Grazed biomass	3,763	75	3.6

Table 1.3 Biomass production and value 2014–2016 average in Estonia (Mõtte et al, 2019) continued

Sector	**Commodity**	**Gross production,**	**Production**	**Share of**

		thousand tonnes; * thousand m³	value, million €	production value, %
	Sheep and goat meat	0.7	2	0.1
	Poultry	19	30	1.5
	Pork	45	79	3.8
	Beef	13	46	2.2
	Egg	12	14	0.7
	Raw milk	723	229	11.1
Fishery	Ocean fishing	13	44	2.1
	Aquaculture	3	3	0.1
	Baltic sea and inland fishing	64	10	0.5
Agriculture and Fishery	Total	6,348	846	-
Forestry	Fuelwood and falling waste	3,796	73	3.5
	Birch and aspen pulpwood	2,034	71	3.4
	Conifer pulpwood	1,762	64	3.1
	Soft and hard wood log	1,220	91	4.4
	Conifer log	4,745	921	44.6
Forestry	**Total**	**13,557**	**1,220**	
Total		**-**	**2,006**	**100**

In the BIC report (2020) it was stated that in 2014, the total forest area of Estonia was 2.3 million hectares while the total growing stock was 281 million cubic meters. Private owned forests constitute 52% while state-owned forests constitute 48% of the total forest.

A compiled report by BIC report (2020) as sourced from the Estonian statistical institute stated that the aggregate bio-based residue (waste) produced from agriculture within different periods 2013/2014, 2014/2015,2015/2016, 2016/2017 as stated below.

Table 1.4 Aggregate bio-based production from agriculture between 2018-2020 (Bio based industries consortium report, 2020, p.19)

Crop produce	Production (tonnes)	Period
Cereals	1,265,445	2018-2020
Dry pulses	31,433	2013/2014*
Potatoes	102,783	2018-2020
Fresh vegetables	69,707	2018-2020
Fresh fruit	7,663	2018-2020
Oleaginous seeds and fruit	169,306	2018-2020

Note. Updated using 3 years average from statistics Estonian data of 2018 to 2020 official figures *except for dry pulses that data has been discontinued since 2014

Regarding waste generated from agriculture, forestry, and fisheries in the year 2016, the BIC (2020) report as derived from the statistics Estonia website is presented in table 1.5 below.

Table 1.5 Waste generated from agriculture, forestry, and fisheries in Estonia 2016(volume in tonnes)

Sector	Volume, tonnes
Wood wastes (non-hazardous)	2,122
Animal and non-food waste (non-hazardous)	777
Vegetal waste (non-hazardous)	26,214
Animal faeces, urine and manure(non-hazardous)	52,768

Adopted from Bio based industries consortium report (2020, p.19)

Analyzing figure 6 below, it can be deduced that Estonia is a net exporter of biomass (in vegetal biomass equivalents). According to Lupton and Allwood (2017), the width of the Sankey flow diagram shows the quantity of the flow. From the above diagram, it can then be inferred that primary woody biomass has the highest production, followed by crops under the biomass

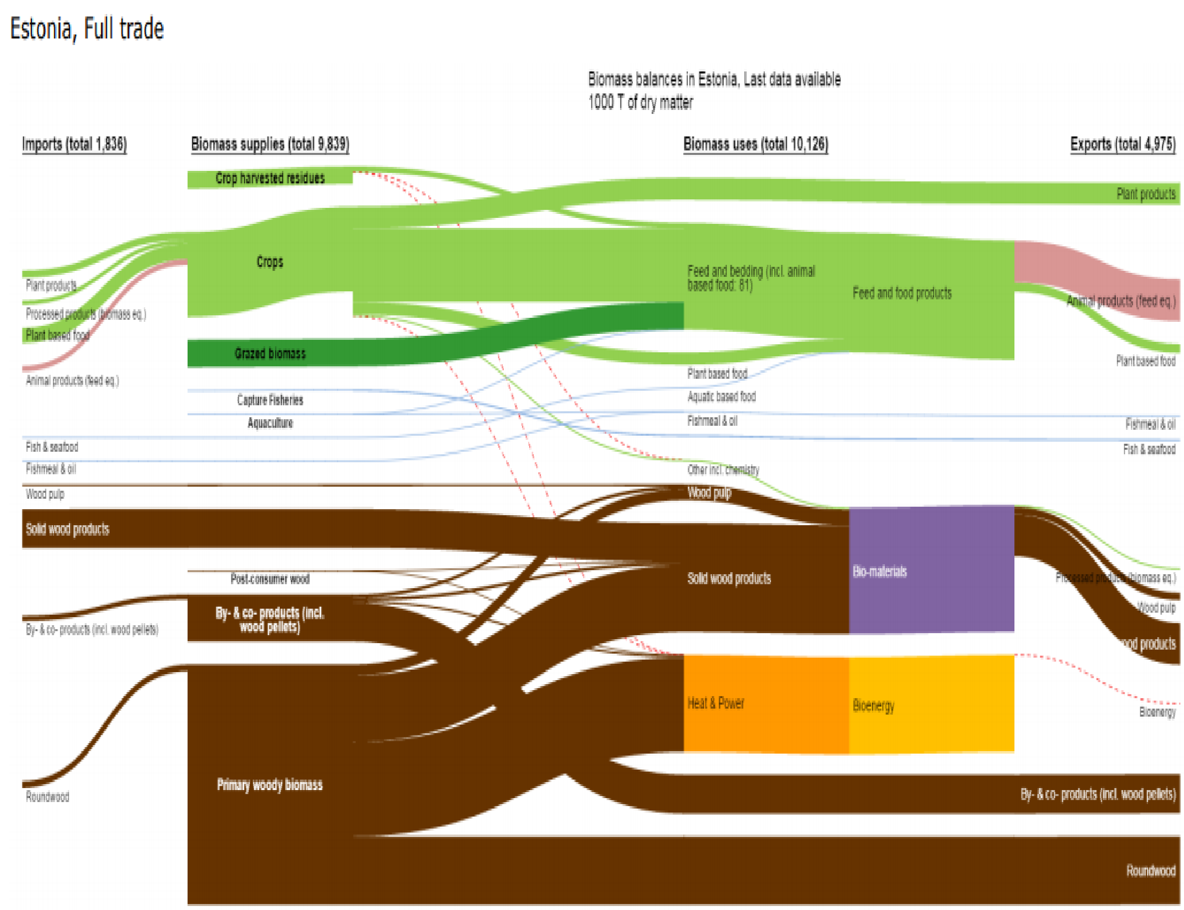

Figure 6. Estonia Biomass flows (2008 to 2017) in 1000 tonnes of dry matter (net trade) (Source: data from the BIOMASS project, European Commission – Joint Research Centre[1])

supplies category which represent biomass produced within the country. Also, the country imports more of solid wood products and exports more of rounded wood. Majority of the

[1] Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated. The data point "Latest available data" corresponds to the latest data available from each sector, which could be different years.

crops, crop harvested residues and grazed biomass are used food and feed products while a higher proportion of the solid wood products, primary wood biomass is used within the country as biomaterials, heat and power and bioenergy. The major exports are rounded wood, by and co products (including wood pellets), and animal products (feed equivalents). The country also exports more of animal products (feed equivalents) more than it imports which signifies that is does a lot of value addition to these class of products to be a net exporter.

Heinsoo et al (2010) in their publication threw more light on the biodiversity of Estonia and carried out their research using data from flood plain meadows, the semi-natural grasslands, and mesic meadows. The semi-natural grasslands which comprises of wooded meadows, coastal meadows, alvars and flood plain meadows are because of human activities majorly grazing and mowing (Heisoo et al, 2010). In their findings (using 2007 data) the flood plain meadows produced the highest biomass yield with 5.7tonnes dry weight per hectare and the highest potential for biomass production among others in the Estonian semi-natural grassland . This is followed by the mesic meadows and the wooded meadows with 2.5 tonnes per hectare and 1.6 tonnes per hectare respectively. Biomass production could also be integrated to the management of semi-natural grasslands

With all this said about the abundance of bio-resources in Estonia, it will be proper to look at how Estonians have fared in the use and transformation of these resources to meet their demands for food, shelter and clothing (the 3 most basic human needs) among other uses. Sõukand and Kalle (2016) stated in their conclusions that “the majority of native edible fruits of trees and shrubs were eaten quite intensively, both fresh and processed….” Thus, it can be said that Estonia has a commendable doze of the blessings of nature which is what bioeconomy is concerned about its sustainable use, conservation, and conversion to other products.

Over the years, the Estonian government has been a proponent of renewable energy in a bid to reduce the dependence on fossil fuels. For example, in 2010, it promulgated the Renewable Energy Action Plan (REAP) according to the Renewable Energy Directive 2009/28 (RED), (Luna-deRisco, Normak and Orupõld, 2011). The target by RED is that by 2020, renewable energy should account for 25% of the total energy consumption in Estonia and the renewable energy share in the 3 major sectors of heating/cooling, electricity and transport is targeted to be 17.6%, 4.8% and 2.7% respectively (Luna-deRisco, Normak and Orupõld, 2011). Estonian renewable energy share is currently 22% (Statistics Estonia, 2021) using 2019 figures and this implies there has been remarkable improvements in meeting this target although it hasn't been met yet. Despite the efforts being made by the government, Estonia still ranks second in European Union in the emission of carbon dioxide due to the mining of shale oil which is used for generation electricity and liquid diesel (Randma, 2018).

In a publication in 2019 on "the challenges of bioeconomy implementation considering environmental aspects in the Baltic states" by Liobikiene and Brizga (2019), in an effort to measure the sustainability impact assessment of bioeconomy in the Baltic states, there were conclusions that out of the 3 Baltic states, Estonia had the lowest biological raw material consumption embedded in production rate of 33% while Latvia and Lithuania had 58% and 52% respectively. This they explained because of the lower share of agricultural land of 23% against that of Latvia and Lithuania which were 30% and 47% respectively.

Table 1.6 Raw material consumption of biological resources embedded in consumption, production, and trade of the Baltic States in 2015 (volume in kt and percentage of biological resources from the total DMI)

	RMC, kt			**The share of biological resources in the total RMC. %**		
	Estonia	Latvia	Lithuania	Estonia	Latvia	Lithuania
Consumption	5,878	10,550	17,990	19	31	31
Imports	3.870	4,720	7,986	24	27	22
Production	9,562	18,725	19,469	33	58	52
Exports	7,553	12,894	9,465	52	86	62

Note. Adopted from Liobikiene & Brizga (2019) based on EXIOBASE 3 database

Comparing the land footprint[2] among the Baltic states, as shown in table 1.7, Estonia's production based land footprint is bigger than the whole country which can be explained that significant part of the land-intensive national production is dedicated to exports (Liobikiene & Brizga, 2019).

[2] Land footprint encompasses the main resources of biomass (cropland, pastures, and forests). This indicator has been defined as the land area used to produce the goods and services dedicated to satisfying the domestic final demand of a country (territory) regardless where this land was used (O'Brien et al., 2017, Liobikiene & Brizga, 2019)

Table 1.7 Land footprint embedded in consumption, production, and trade of the Baltic States in 2015 (km^2)

	Estonia	Latvia	Lithuania
Consumption	21,040	32,172	43,958
Imports	11,884	16,490	19,653
Production	52,263	61,762	56,714
Exports	43,107	46,081	32,410
Country territory	45,227	64,589	65,300

Note. Adopted from Liobikiene & Brizga (2019) based on EXIOBASE 3 database

It is also remarkable to note that in the analysis of Liobikiene & Brizga (2019) only one third of the resources used in national production are bio-resources while Latvia and Lithuania had half of their resources as bio-resources in the analysis of production, consumption and trade based bioresource usage.

1.5 Challenges in Transformation to Bioeconomy

1.5.1 Political, social, economic, and environmental challenges

There have been wide claims that the bioeconomy concept has been more political than anything else (Hausknost et al, 2017) but in all, the objectives are noble relating to the food safety, renewable energy sources, climate mitigation, flourishing local businesses, resources and employment (Biernat, 2019). These objectives though are not automatically sustainable (Gomez San Juan, 2019) as there are conflicting goals to consider on the impact of such goals (von Braun, 2020) whether they will be positive or negative on the long run and the ability to consider and decide on the trade-offs. There have been various schisms among the players in the bioeconomy transition agenda ranging from the government, to the research institutions, private sector, communities, and the consumers. Barry et al, 2015 identified "political struggles and antagonism" as one of the major barriers to seamless transition to bioeconomy. For each of the players in the bioeconomy transition, there are certain requisite conditions that are necessary to achieve the objective either at the global, regional or national level and none can be said to be of less importance than the others. Kircher (2020) stated that the transformation to bioeconomy is not an easy road as it is complex and requires investment in infrastructure, adequate production capabilities, specialized personnel training and engagement of the people for social acceptance. The preconditions for bioeconomy for the different stakeholders as adopted from various authors is presented in table 1.8 below.

Table 1.8 Preconditions for bioeconomy for different players

S/No	State	Enterprise	Research and Development	Education	Public
1	Clear objectives/robust strategies	Availability of skills and labour	Competences	Awareness	Better Engagement
2	Financial capacity for investments and Incentives	Healthy competition	Collaboration with state, enterprises, and education centers	Networks and knowledge	Social acceptance
3	Stable government structures	Robust supply chain and enhancement of markets	Innovations	Use and diffusion on new technologies	Defined communication process
4	Public stakeholder engagement	Availability of biomass and other physical resources	Investment by state and enterprises	Collaboration with other stakeholders	Satisfaction
5	Communication strategy	More value chains	Technology	Improved knowledge	Improved knowledge
6	Supportive policies and regulations	Capacity for scale up	Compliance with standards	Bioeconomy curriculum	Open to dialogue and enlightenment
7	Trust, synergy and cooperation	Trust, synergy and cooperation	Trust, synergy and cooperation	Trust, synergy and cooperation	Trust, synergy and cooperation

Note. Compiled by author 2021[3]

The number one problem with bioeconomy is that it is dependent on the use of biomass and bio-resources which are renewable products produced within a finite resource – the earth (Adejumo & Adejumo, 2018, Boulding, 1966). The use of these resources to produce the best goods and services in terms of quantity and quality has been a debate that humans are yet to

[3] Compiled from publications by: Kircher (2020), Mertens et al (2019), Knierim et al (2018), Grundel & Dahlstrom (2016), Charles et al (2016, p.11-18), Lange et al., (2016,p.23), Lange et al., (2016, p.23), SCAR (2014), Kniūkšta (2009)

come to terms with. While some people support technologies like genetically modified foods for a better products in terms of resistance to draught, nutrient content, resistance to diseases, increase in yield and other qualities as might be incorporated; some others look at it with askance doubting its long term suitability for human consumption without any side effects to the human body system (fear of gene mutations). Thus, there are biases which affect the adoption of bioeconomy or processes and programs that promotes it at individual, cultural and even religious lines.

Though there has been many good sides of bioeconomy and its processes and products, there are different barriers to the acceptance of these products as substitutes (Filho et al, 2018, p.117, Gleim et al 2013). Bio based products have less environmental impact (like bio plastics) than conventional products (Filho et al 2018, p.118) and thus can help solve ecological problems at the same time contributing to a company's growth and a country's economic development (Filho et al 2018, p.118, Beise & Rennings, 2005). One of the major challenges has been the issue of acceptance of bio-based products in the market. On the product acceptance level, a lot of factors has been identified to be responsible for this either based on individual perceptions, group influence, reduced availability, uncertainty of the quality of product or cost associated with buying the product compared to conventional products (Filho et al 2018,p.119, Gleim et al, 2013, Pickett-Baker and Ozaki 2008).

Apart from the challenges associated with product acceptance, a lot of factors are hampering the development of bioeconomy on regional and global frontiers. According to a white paper by the European marine bio-resources consortium (2020), the political, economic, and social and environmental factors were identified as the major predicaments in this arm of bioeconomy in Europe. The political factors are issues related to "lack of clear regulatory framework, loopholes in the current international legislation that gives room to unsustainable activities like overfishing, plastic pollution, etc. The economic factors as narrated by the consortium hinges on lack of incentives which have made the adoption of sustainable practices difficult by the actors. On the social challenges, the consortium asserted that the following social problems would have to be addressed, unemployment, education level, and ageing population.

Right from inception of the bioeconomy agenda, one of the major concerns has been the competition between the use of materials for biomass and food for human consumption (Conforti, 2011). Apart from this land is a source of food and feed among other materials for the bioeconomy but also a source of other ecosystem services (Filho et al 2018, p.45). In a report by World Economic Forum (WEF, 2016), "the biggest recognized global environmental risks comprise of the failure of the climate-change mitigation and adaptation, the loss of biodiversity, ecosystem challenge and global water and food crises". In their analogy, the inability to manage the growing field of bioeconomy can result in negative externalities to biodiversity and the ecosystem that will affect the entire value chain negatively. There is also a growing concern about the demand for land, water and fertilizers for biomass production which may lead to land degradation, and other negative impacts on biodiversity and water (Filho et al, 2018, p.45). There is also the challenge of indirect land use change (iLUC). This is the clearing and use of pristine areas, grass lands and forests and their used for the cultivation of biomaterials (Filho et al, 2018). Although non-food biomass feedstock is channeled to the production of biofuels, their cultivation takes up land that primarily would have been used for food production, thus this poses a problem and challenge to the successful adoption of biomass development in some regions of the world where land, water, fertilizer and labour are scarce. According to a briefing published by the European Parliamentary Research Service authored by Didier Bourguignon (Bourguignon, 2017) this could jeopardize food production and food security. There could also be other competition in the technology used to produce these products resulting in the following competitions: fossil energy versus bioenergy, bioenergy versus bioproducts and bioproducts versus petro-chemical products where one product is given more attention to the other (Bourguignon, 2017) and this can have an unfavorable skew towards the production of the bio-based ones at the detriment of highly in demand fossil-based ones and this can affect sales, revenue and profit considerably in a negative way.

In their review of the challenges posed by biomass and its, commercialization and valorization, Filho et al (2018) classified the demands on the environment into 3 major categories viz: energy, water, and land degradation. On the issues related with energy, they posited that in order to decrease the consumption of energy, in the value chain that the location of the feedstock farming and the production site as well as the end users should be considered for optimum benefits to all stakeholders (Filho et al, 2018,p.46). On the challenges related with water, the water needed for high productivity biomass is 70-400 times higher than that required for fossil energy carriers (Gerbens-Leenes et al, 2009, Filho et al, 2018, p.46). On the issues related to land degradation and nutrient balance, the cultivation of biomass for industrial purposes is done through monocultural cultivation practices that require large amounts of water, fertilizer and pesticides (UNESCO, 2012, p.40, Filho et al, 2018) and this can lead to loss of biodiversity.

There are other technologically related challenges associated with the conversion and valorization of biomass to high end products. Although this seems to be beyond the purview of this research, but they are worth mentioning. One of the most prominent is the decomposition of secondary cell walls of lignocellulosic biomass which are recalcitrant to various conversion strategies and poses the major barriers to the economics of biofuel production (Singhvi and Gokhale, 2019, Himmel et al, 2007).

The BIOEAST Initiative identified five challenges inimical to the transition to bioeconomy which are enumerated below (Juhász & Vásáry 2017).

Research and Innovation deadlock: this refers to poor research and development infrastructure and the inability to put research results into practice and lack of inputs by the practitioners into research and development.

Stalemate in the bio-based value chains: this refers to lack of full exploitation of both the traditional and innovative value chains

Governance impasse: Policies lack proper consultation of the stakeholders (researchers, practitioners, and the society) to come to terms on common principles for sustainable production and consumption.

Societal indifference: Due to lack of knowledge, resources, infrastructure and incentives, the rural communities feel less concerned in the drive to a sustainable circular economy.

Financial barriers: There exists a low-level access to finance and low level of synergies in public-private funds and investments which has hampered research and innovation in Central and Eastern European countries

During a group visit to the Baltic Biometaan factory in Estonia in 2019, one of the board of directors Mr. Ahto Oja stated that the company needed two hundred thousand Euros to help them capture the carbon dioxide produced by the fermentation plant and that the revenue from that will give them another stream of income. In my study of the bioeconomy concept and the negative impact of carbon dioxide to the environment (ozone layer depletion, global warming etc), One can only reminisce and try to know the volume of CO_2 released by the fermentation plant and what are the negative impacts and ask if it's really worth it if there is a net negative impact on the environment?

Based on the above presentations, the major challenges to transition to bioeconomy globally or within regions, countries and cultures can be said to be divided into the following broad categories.

- ✓ Problems associated with acceptance of these products, services, and processes by the public.
- ✓ Problems associated with the social externalities(competition for agricultural land and water resources)
- ✓ Problems associated with the economic externalities(high setup cost because of research and development, competition with investment in other industries and competition between technologies and their use in other processes)
- ✓ Problems associated with the environmental externalities - pollution, greenhouse gases (GHG) release, indirect land use change and land degradation and loss of biodiversity (Filho et al, 2018)

In the light of the above discussions and insights, the successful transition to bioeconomy depends on a multisector analysis which characterizes the sources of, and constraints on, available biomass, the pervasiveness of rival biomass uses and the resource competition that arises from the links with the broader economy (Philippidis et al, 2018).

To make bioeconomy meet the prospects the world demands from it, it must rebuild natural capital and improve the quality of life for a growing population. It should also balance managing common goods such as air, water, and soil with the economic expectations of people (El-Chickakli et at, 2016). There is no better capture of these expectations than those enshrined in the sustainable development goals of the United Nations and these are; to end hunger (SDG 2), to ensure healthy lives (SDG 3), water and sanitation for all (SDG 6), energy for all (SDG 7), sustainable economic growth (SDG 8 and 9), sustainable cities (SDG 11), sustainable consumption (SDG 12, to combat climate change(SDG 13), oceans seas and marine resources (SDG 14), and terrestrial ecosystem (SDG 15) (Calicioglu & Bogdanski 2021, El-Chickakli et al, 2016).

Another challenge that has often been mentioned by some authors is that of the business model for a successful bioeconomy. Salvador et al (2020) stated that development of bioeconomy business model so far can be said to be not enough in comparison to other industries and sectors, hence there is a great need to develop business models that meets the needs of entrepreneurs in the bioeconomy field. In their exposition on conceptual design of sustainable business model innovation in agri-food sector, Bath et al (2017) stated the importance of considering the sustainability concerns in crafting business model innovation. They also opined that regarding value creation, standards, safety and quality, the traceability of products should be incorporated.

1.5.2 The Bioeconomy business model challenge

There are many definitions and narratives of business model but more closely related to the subject at hand is the definition given by Osterwalder and Pigneur, 2010 which defined it as "a business model describes the rationale of how an organization creates, delivers, and captures value". The two major words in the definition to me are "rationale" which states why efforts are made and resources expended and "value" which depicts what is being achieved or simply put – "the objective". Business model is a veritable tool to help navigate the global business landscape rife with uncertainties, aggregating complexity and upsurge of diverse business models and stakeholders (Osterwalder, 2004). It makes the description of the value proposition of a new venture clear and helps the entrepreneurial process to move efficiently and quickly to develop a validated business model (Urban et al, 2018). Bocken et at., 2014 categorized sustainable business models in eight different archetypes[4] as shown in table 1.9 below.

[4] Archetypes are groupings of BMs based on comparison of their similarities and differences (Bocken et al., 2014)

Table 1.9 Sustainable business model archetypes (based on Bocken et al., 2014, p.48-54)

Business model innovation	Archetype of business model	Value proposition	Value creation	Value capture
Technological	Maximization of material and energy efficiency	Products and services using fewer resources to reduce waste, emissions and pollution	More efficient production processes using less resources and reducing waste	Cost reduction from optimized use of resources, reduction of waste and environmental impact
	Creation of value from waste	Eliminating waste by turning waste into input for other production	Recycling of waste and closing of resource loops and making use of under-utilized capacities	Cost reductions from reuse of materials, reduction of waste and virgin material use
	Substitution with renewables and natural processes	Products based on renewables resources and natural processes	Innovative production processes based on renewable resources and energy and natural systems	Revenues from new products, reduction of environmental impact of use of non-renewable resources
Social	Delivery of functionality, rather than ownership	Shift from selling physical products to consumers to providing services for users	Redesign and delivery product/service offerings based on reuse, reparability and upgradability	Revenue for provision of services and increased access for consumers
	Adoption of stewardship role	Products and services for ensuring stakeholders long term well-being	Production and supply systems that deliver the environmental and social benefits	Revenues from the stewardship and benefits from the well-being of the stakeholders
	Encouragement of sufficiency	Product and services aiming to reduce consumption and production	Promotion of less consumption and less waste and more durable products	Revenues from durable products and environmental and social benefits from reuse and less consumption
Organizational	Re-purpose of the business for society/environment	Prioritization of social and environmental benefits over economic profit	Development of products and services with participation and integration with local communities and stakeholders	Environmental and social benefits from locally embedded enterprise
	Development of scale up solutions	Large scale delivery of sustainable solutions	Development of channels and partnerships for scale-up solutions	Revenues for scaling up (e.g., franchising, licensing fees) and benefits from partnerships

Adopted from Viira et al (2021)

The archetypes are divided into three broad categories of innovation model namely, technological, social, and organizational innovation models. The technological innovation includes such practices as efficiency and material maximization, creation of value from waste substitution of inputs with renewable ones and natural processes. Under the social innovation such issues as sufficiency, stewardship, and functionality are more important than ownership. The organizational archetype is delineated along repurpose for society/environment and ability to develop scale up solutions. Every archetype creates value the stakeholders through different business model (Veijonaho, 2018). The value proposition relates to the solution a company brings to its target customers or the competitive advantage it has. The value creation and delivery system outlines company's resources and relationship network to acquire the competitive advantage and to create the value for its customer. The value capture states the streams of revenues and profits (Veijonaho, 2018, Richardson, 2005).

One thing worthy to note in the sustainable business model above is that it is geared towards environmental, society and human welfare in its various levels of value proposition, value creation, and value capture. Thus, it inculcates the base strategies in sustainability management of eco-efficiency, eco-effectiveness and sufficiency as identified by Urban et al., (2018, p.258)

2. DATA AND METHODS

2.1 Research method

Due to the novelty of topic to elicit information on what the farmers understand about biomass valorization and how they have been involved in it in the past and what and how they intend to carry on in the future, the exploratory mixed methods research method was used. According to Leavy (2017, p.9), it entails the collection, analysis, and integration of quantitative and qualitative data in a single project.

2.2 Data collection

The data was collected using structured questionnaire made up of 49 questions categorized as general data, company data, field summary. The link to the questionnaire was sent out by emails to the farmers contained in the farmers data base (https://www.pria.ee/en), containing a total of 1814 farmers and later directly to the farmers and food companies. The questionnaires were sent out starting from the third week of January 2021 and concluded on the second week of April 2021 (approximately 49 days) interval with a total of one hundred and twenty responses received. A total of two hundred and seventy-six responses was received. The data protection caveat was included in the questionnaire and it was stated that the data will be used for study purposes only and in helping to craft better policies that will help entrepreneurs in Estonia understand what is required of them in adopting the bioeconomy business models and knowing where they need help – finance, infrastructure, technical support, product marketing etc.

The questions were divided into 3 major categories general data, company data, field summary. The general data contained questions relating to the respondent's name, email, and phone number, while the company data contained questions detailing the company's' name, ARIB(Agricultural Registers and Information Board) registry code, date of registration. Field summary on the other hand contained details of the company's primary area of production, what type of bioresource being produced, what type of bio-resources the company is interested to valorize, types of manure, greenhouse gas (GHG) emission reduction practices and company's attitude towards environmental requirements among others. The data sought in the questionnaire covered both qualitative and quantitative aspects. Most of the quantitative questions were structured and the qualitative questions were also structured using a Linkert scale of 1-5 where 1 represents "definitely not" and 5 represents "definitely yes". The Linkert scale was used for the questions relating to company attitudes. The data was not collected personally but being used as a secondary data for further analysis. There were also open-ended questions where the respondents were asked to give their opinion or response.

2.3 Data analysis

The data analysis was done after the collation of the responses in an Excel sheet format using descriptive statistics and data visualizations. According to Hui (2019,p.140) descriptive statistics helps to summarize data and shows the distribution of data, central tendency, and dispersion while data visualization presents the data in graphical form for easy comprehension and possibly aesthetics. The data was translated from Estonian language to English language for ease of understanding (by the non-Estonian speaking researcher) using the translate function in Microsoft Excel. Averages, Chi-square test, pivot tables and pivot charts, and percentages were used to analyze the data while, bar charts, pie charts and tables were used for displaying the results.

2.4 Limitations

The data collected shows that either some of the respondents doesn't understand the question or does not want to part with their opinion on the questions and this makes drawing inference and conclusion difficult and maybe of no effect considering the number of respondents (276) compared to the number in the data base (1,814)

A total of one hundred and fourteen (114) respondents out of the 276 recorded above did not answer some key questions like “what type of bioresource is processed and or valued in the enterprise?” and eleven other related field summary questions. Another two hundred and twenty-five did not provide answer on the general data questions.

The translation from Estonia to English using Google translate was a bit not too reliable as some translations didn’t make sense and further consultation had to be made to understand the affected issues.

3. RESULTS

The respondents are mostly farmers and food enterprises in Estonia involved in primary agricultural production of, animal production, crop production, food production, forestry and provision of ancillary services (which include services like hire of equipment) and others which were into one of the following, tourism, nature conservation, veterinary services and excavation services. The percentage distribution of the respondents is shown in figure 7 below. Crop production and animal husbandry tops the list with 40% and 36% of the respondents operating in these fields.

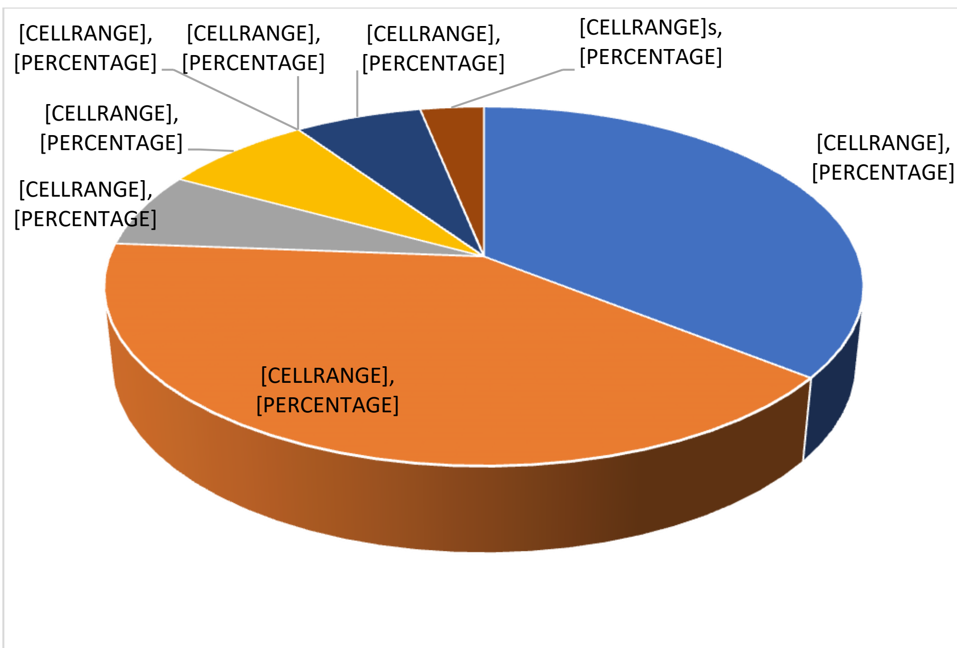

Figure 7. Distribution of respondents by business line (survey data 2021)

The results of the data analyzed in answer to the questions raised in the introduction shows is as presented below.

What kind of bio-resources are the farms and food enterprises currently processing (survey data) and for what purpose?

According to the survey data, the current processing of biomass mass from the farms and food enterprises are as shown in figure 8 with the following rankings: manure (25%), does not deserve/process (20%), straw (13%), feed (10%), and biomass from grasslands at 10% respectively. Although one farmer or food enterprise processes more than one bioresource as shown in appendix **2**.

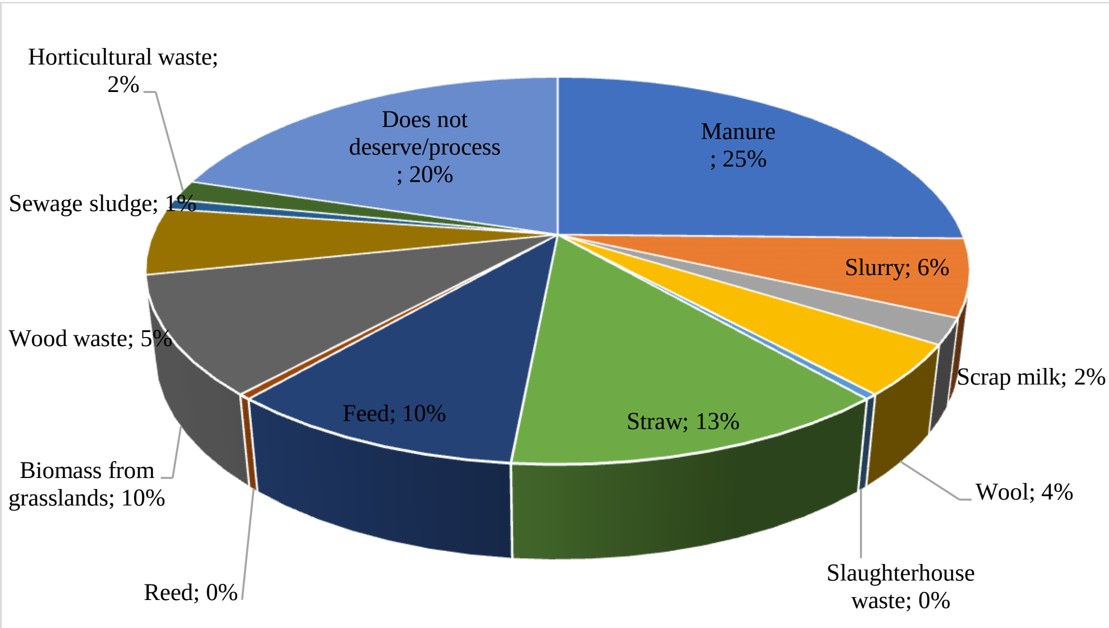

Figure 8. Percentage distribution of type of biomass processed (survey data, 2021)

Results from the survey data shows that 65 of the respondents answered the question on "what type of bioresource is processed and/or valued in the enterprise – please specify in which manner". It shows that more than half of the respondents (55%) indicated that the bio-resources are used for fertilizer related purposes, 18% compost it while 12% use it for feed as shown in figure 9 below. Fertilizer and compost both are used to improve soil nutrients and soil quality.

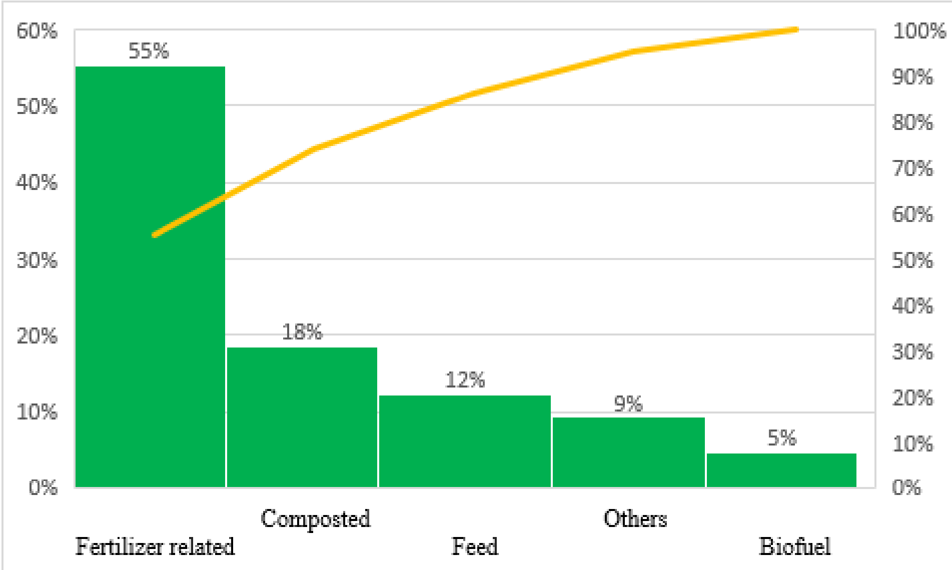

Figure 9. Distribution of uses of bio-resources (survey data, 2021)

The coding of the responses to arrive at the categories used is as contained in appendix 4.

What kind of bioresource valorization are the farms and food enterprises interested in?

Based on the question of bio-resources farmers and enterprises are interested in processing, a percentage of the choices made is presented in figure 8 using a histogram. The result shows that 21% of the respondents are interested in manure, 17% in biomass from grasslands and 13% in straw.

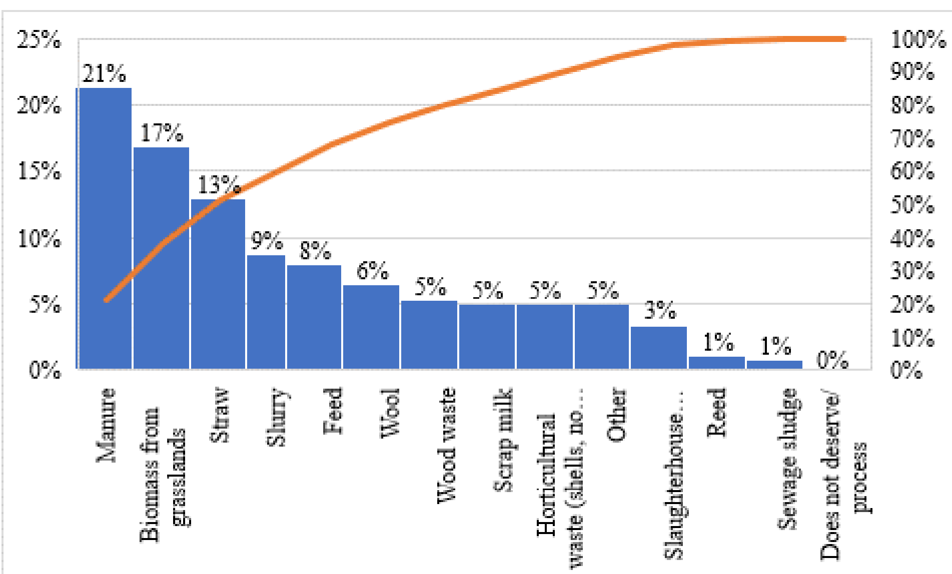

Figure 9. Bio-resources of interest in the future. (survey data, 2021)

On further analysis the correlation of the various bio-resources processed by the enterprises was done using SPSS Pearson correlation statistical tool. The result shows there are positive, and significant correlation between the processing of some of the bio-resources and the others while some showed negative correlation. appendix 3 shows the correlations between the production of the various bio-resources from the survey data. The positive and significant correlation implies that the respondents that indicated that they process one of the bio-resources like manure also indicated they process other bio-resources with a positive significant correlation and vice versa. The ones with green fonts show those with positive significant correlation, the ones with blue font shows positive but not very significant correlation, the ones in black shows positive but not significant correlation while the ones in red fonts shows negative correlation.

What business model canvas elements are relevant to the farms and food enterprises and what are the factors hindering them from transiting to these business models?

Analyzing the responses on question number 15 of the questionnaire ("what topics of interest are you concerned about the processing and/or valorization of a bio-resource? Mark all topics of interest) and integrating it into the business model canvas elements. The questions were categorized into the different business model canvas elements of, value propositions, key partners, key activities, key resources customer relationships, customer segments, distribution channels, cost structure and revenue streams.

Table 3.1 Categorization of topics of interest according to business model canvas elements (survey data 2021)

Survey choices	Count	Percentage	Business model canvas element
Development of new products and services through the use of bio-resources generated by your company	57	6.13%	Value propositions
New business ideas and models related to the processing and/or valorization of bio-resources	58	6.24%	Value propositions
Opportunities for cooperation with R & D institutions for the processing and/or valorization of bio-resources	41	4.41%	Key partners
Cooperation opportunities with other companies to process and/or value their bio-resources and sell them	53	5.70%	Key partners

Cooperation opportunities with KOV for the sale of bioenergy (gas, heat, electricity) bio-resources	39	4.19%	Key partners

Table 3.1 Categorization of topics of interest according to business model canvas elements (continued)

Survey choices	Count	Percentage	Business model canvas element
Possible uses of the enterprise's bioresource for processing and/or valorization	52	5.59%	Key activities
New forms of management of waste from existing production	56	6.02%	Key activities
Overview of activities necessary for the processing and/or valorization process	26	2.80%	Key activities
Technology required for processing and/or valorization	56	6.02%	Key resources
Legislative requirements for the processing and/or valorization of bio-resources	31	3.33%	Key resources
Amount of labour required for processing and/ or valorization	15	1.61%	Key resources
Knowledge and skills for processing and/or valorization	50	5.38%	Key resources
Different types of contracts with customers for the sale of a new product/service	24	2.58%	Customer relationships
Market developments in processed and/or deserved production	32	3.44%	Customer segments
Potential customers of processed and/or valued products	43	4.62%	Customer segments
Sales channels and advertising methods for processed and/or deserved products	30	3.23%	Distribution channels
Assessment of costs related to the processing and/or valorization of bio-resources	38	4.09%	Cost structure
Assessment of the return on investment in the processing and/or valorization of bio-resources	51	5.48%	Revenue streams
Estimation of revenue stemming from processed and/or valued production	42	4.52%	Revenue streams
Possible grants for the processing and/or valorization of a bio-resource	70	7.53%	Revenue streams
Possible sources of investment finance for the processing and/or valorization of bio-resources	62	6.67%	Revenue streams
Other	4	0.43%	Others

Figure 10 below indicates that according to the survey data, the respondents are interested in revenue streams (24%), key resources (16%), key activities (14%) and key partners (14%) more than all other elements. This indicates that finance is the most paramount reason for majority of the respondents followed by the operational components (the trio of key resources, key partners, and key activities) that will make the business a success (Jeffries, August 2018).

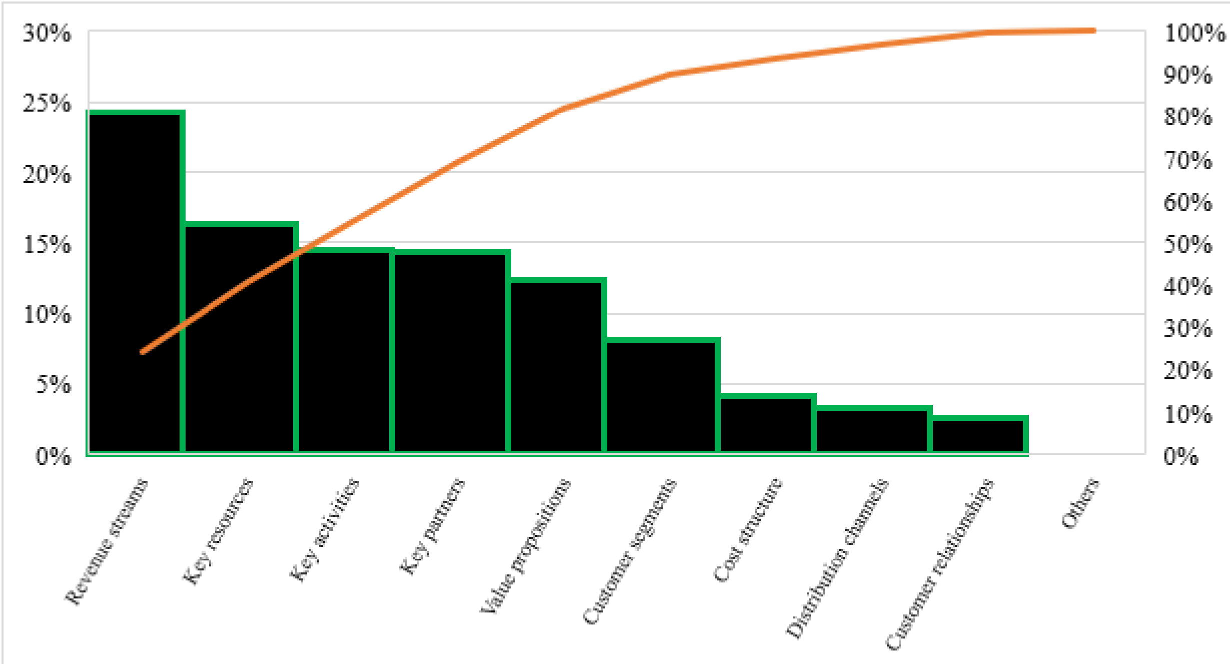

Figure 10. Distribution of respondents according to business model canvas elements of interest (survey data, 2021)

Looking at answers to some questions relating to what inhibits transition to bioeconomy like,

1. Do you consider that there are legal restrictions in Estonia that restrict the introduction of new technologies/processes to value a bioresource? And,

2. For what reasons have you not started producing biogas/biomethane?

A thematic representation of the responses received in answer to question 1 above is shown in the figure 11 below. A total of 15 respondents indicated that there are legal restriction to the valorization of some of the bio-resources in Estonia and 12 of them went further to mention these restriction that is grouped and presented in figure 11. It can be assumed that these respondents are educated and are into farming or food enterprise for economic objectives, hence their ability to note these restrictions.

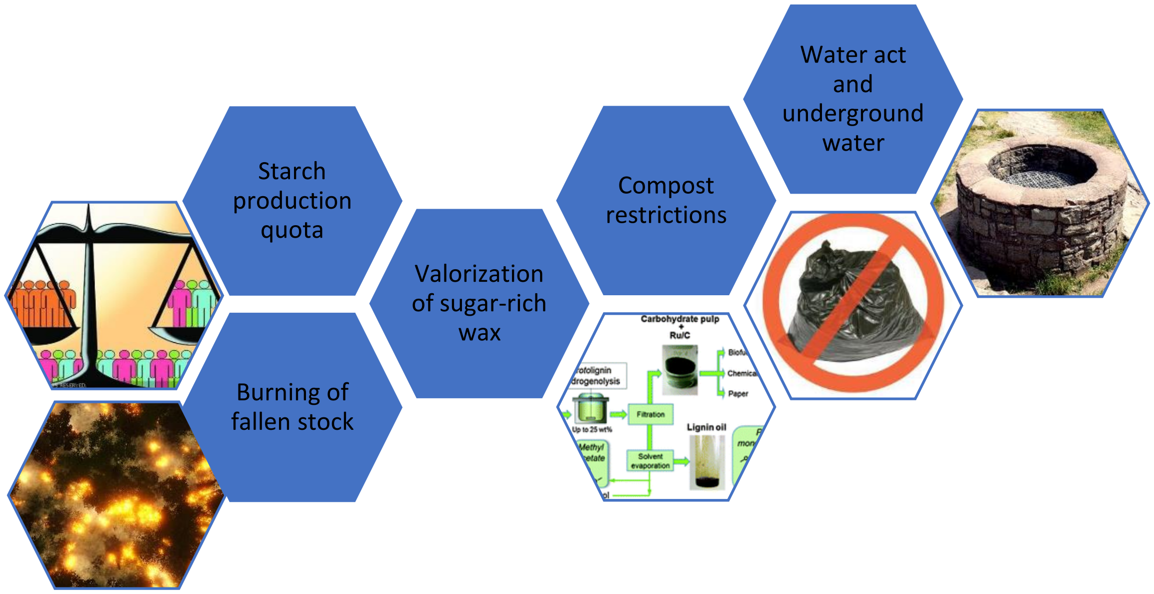

Figure 11. Representation of legal restrictions to processing biomass (survey data, 2021)

Analyzing the reasons why respondents haven't started producing biogas and biomethane, figure 12 below shows that percentage of the reasons according to survey data. The result shows that insufficient animal (farm size, 19%) is the major reason farmers and food enterprises are skeptical of venturing into biogas/biomethane production which is a key product in the valorization of bio-products. Also the percentage of uncertainty as to where to sell biogas/biomethane (6%), unclear future perspective of biomethane (6%) and insufficient knowledge(14%) which related to knowledge gap of the farmers and enterprises presents a great challenge to the transition to bioeconomy and should be addressed through more government enlightenment.

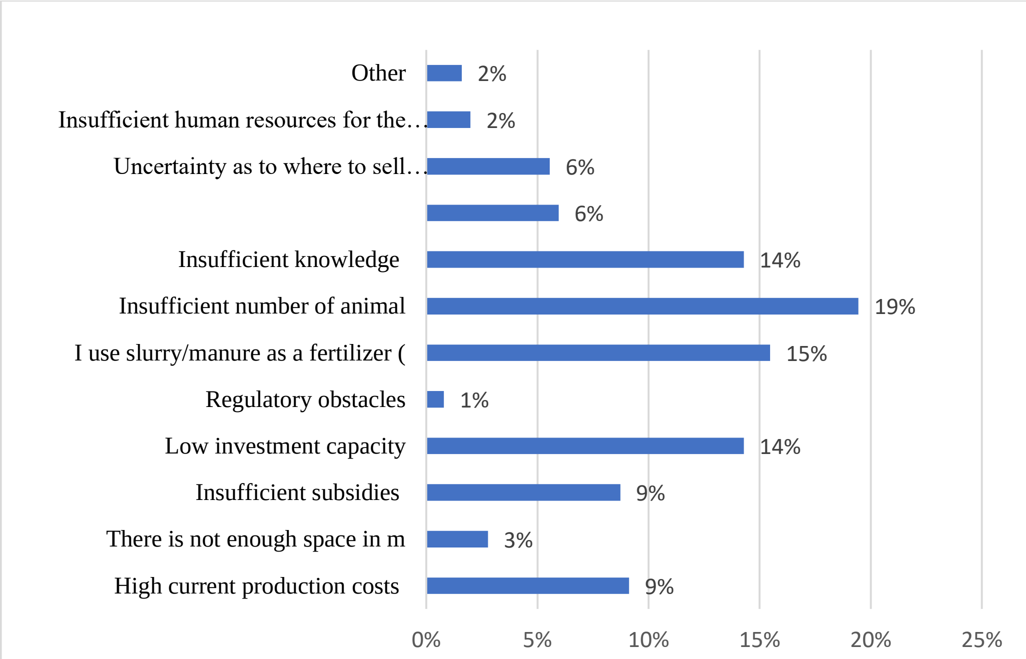

Figure 12. Distribution of reasons restricting biogas/biomethane production (survey data, 2021)

What agricultural sub sectors (animal production, crop production, fishery etc.) in Estonia have adopted valorization more.

Using the clustering method, the sectors were coded by numbers where 1 represents animal husbandry, 2 represents crop production, 3 represents food production, 4 represents forestry, 5 represents Fisheries, 6 represents Aquaculture, and 7 represents ancillary services (e.g. hire of equipment etc.). Valorization in this analysis is any treatment given to waste to either improve its value or make its use easier. On this backdrop, composting is considered as valorization against the spread of the biomass or waste on the farm without any further processing as it has added value if not for economic purposes, it makes its use easier. A total of thirty-three respondents adopted valorization in various forms, from composting to biogas production. To arrive at a statistically correct representation, the data was coded according to the number of subsectors in each column of "subsectors involved" and number of respondents where only one subsector is involved is coded one subsector and where two subsectors are involved is coded two subsectors and so on. By simple sum, animal production and crop production added together has a total of 18 out of the 33 which represents 55% of the total respondents.

Table 3.2. Distribution of valorization adoption by sectors (survey data, 2021)

Subsectors Involved	Number of respondents	List of subsectors	Number of subsectors coding
1	4	Animal husbandry	One subsector
2	3	Crop production	One subsector
3	1	Food production	One subsector
1,2	11	Animal husbandry and crop production	Two subsectors
1,2,3	3	Animal husbandry, crop production and food production	Three subsectors
1,2,3,4	2	Animal husbandry, crop production, food production and forestry	Four subsectors
1,2,3,4,7	0	Animal husbandry, crop production, food production, forestry and ancillary services	Five subsectors
1,2,4	2	Animal husbandry, crop production and forestry	Three subsectors
1,2,4,7	0	Animal husbandry, crop production, forestry, and ancillary services	Four subsectors
1,2,7	2	Animal husbandry, crop production and ancillary services	Three subsectors
1,3	0	Animal husbandry and food production	Two subsectors
1,7	0	Animal husbandry and ancillary services	Two subsectors
2,3	1	Crop production and food production	Two subsectors
2,4	4	Crop production and forestry	Two subsectors
2,4,7	0	Crop production, forestry and ancillary services	Three subsectors
2,7	0	Crop production and ancillary services	Two subsectors

Delving further into the distribution of subsectors, figure 13 below shows the adoption of valorization by number of subsectors the respondents are into. Farms and enterprises that combines two subsectors (mostly animal husbandry and crop production) in their enterprise has the highest adoption rate of 16 companies representing 48% followed by those into a single subsector 8 companies representing 24% and thirdly by those into up-to three subsectors or business lines 7 companies representing 21% of the total respondents to this question.

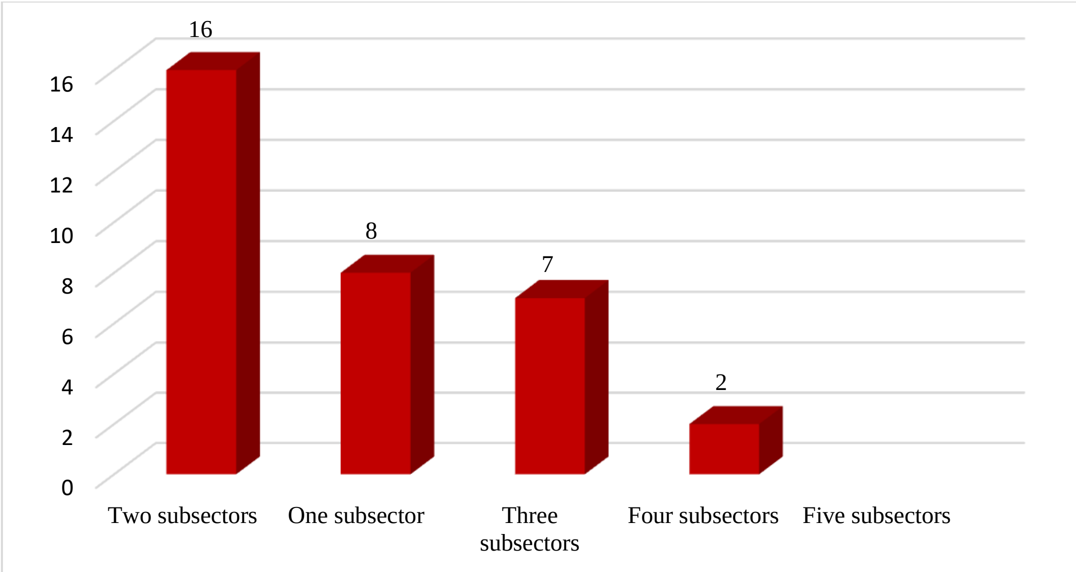

Figure 13. Distribution of valorization according to frequency of number of subsectors (survey data, 2021)

How does the enterprises' characteristics (size – number of employees) impact the adoption of bioresource valorization?

The available data could not be used to make comparison based on the use of the ARIB code and instead, number of employees which is believed to be related to have a proportional relationship to land size or number of animals was used. We employed the use of a one sample Chi-Square test using the number of employees(1-10, 11-50, 51-99) and coding the responses on "What type of bioresource is processed and/or valued in the enterprise?" where all responses where the bio-resources are used without any further processing as "1" and others where there is a further processing (even composting) as "2". A total of 65 responses were gotten under these criteria and the results are as provided in the table below.

The null hypothesis H_0: there is a relationship between company size (number of employees) and adoption of sustainable valorization ideas.

The alternative hypothesis H_a: there is no relationship between company size (number of employees) and adoption of sustainable valorization ideas.

The formula below was used to calculate the Chi-Square value (x^2)of the relationship.

$$x^2 = \sum_{i=1}^{k} \frac{(Oi - Ei)^2}{Ei} \quad \text{------------------------------} \ (1)$$

where,

O_i is the observed frequency

E_i is the expected frequency

k is the number of levels

Using a k-1 degree of freedom where k is the number of levels (3), therefore the degree of freedom is 2, 0.05% level of significance. Using the Chi-Square distribution table, the critical value is **5.99**.

The Chi-Square is calculated in the table below.

Table 2.2 Chi-square calculation table.

Company size	Observed (O)	Expected (E)	Difference (O-E)	(O-E)^2	(O-E)^2/E
1-10	54	21.67	32.33	1045.44	48.25
11-50	8	21.67	-13.67	186.78	8.62
51-99	3	21.67	-18.67	348.44	16.08
Grand Total	**65**	**65**			**72.95**
Number of levels	3				

Since the Chi-square is greater than the critical value, we reject the null hypothesis that there is a relationship between company size (number of employees) and adoption of valorization ideas and accept the alternative hypothesis that there is no relationship between the company size (number of employees) and the adoption of valorization principles by Estonian farmers.

DISCUSSION

The EU bioeconomy strategy is aimed at mitigating the impact of human activities on the environment by reducing fossil fuel production and consumption, achieving a circular bioeconomy, improving share of renewable energy, creating more jobs and wealth among other notable objectives. To this effect, the research was focused on evaluating the bio-resources being processed, what the respondents are interested in processing, the business model canvas elements relevant to them, what agricultural subsectors are pro valorization and how company size affects adoption of valorization. Analyzing the data collected in the survey, the results points to the following.

According to survey results, most the respondents are into crop production (40%) and animal production (36%). It could also be that the population involved in these business lines are very small, do not have access to the internet and thus could not be reached by emails. This calls for further investigation as their participation in such surveys is crucial and this is one of the major ways that the government can know their challenges and proffer solution to them as fish is still an important meal in diets worldwide due to its low cholesterol as compared to other sources of protein.

On the kind of bio-resources being processed by Estonian farms and food enterprises, the survey result shows the following percentages, manure (25%), straw (13%), feed (10%) and biomass from grasslands (10%) as the dominant bio-resources. The results also show that most farmers process more than one bioresource (appendix 2) while only few bio-products (manure, straw, feed, biomass from grasslands, wood waste and sewage sludge) are processed singularly (mono production) by only one farm or enterprise. The correlation matrix in table 2.1 also shows that there are many positive and significant correlation between some of these bio-resources which implies that many farms and enterprises that indicated they produce one bio-resource also chose they produce the others that have a positive significant correlation coefficient. For example, horticultural waste and slurry 0.940**. There is also a negative correlation between “does not deserve process” and other variables in the correlation table. This indicates that fewer respondents chose “does not deserve process”, chose other variables with a negative correlation coefficient.

Comparing the survey results for bio-resources being currently processed and that of interest, there is a slight change considering. While manure remains the most preferred (21%) in both graphs according to survey results, there is a shift from straw (13% in both figures) to biomass from grasslands(from 10% to 17%). The impact of this shift in the future on the micro and macro level should be evaluated to avert any unhealthy socio-economic losses on the industries that use these as raw materials and any other antecedent negative effects. Also, from the responses received under others, some bio-resources were mentioned that were not included in the list provided in the survey which might be very profitable options to consider like, skins, mushroom, and medicinal plants.

On the business model aspect of the survey data, this shows clearly where the respondents need more emphasis to be made and what resources, knowledge or intervention that are paramount in achieving their business objectives in transiting to bioeconomy. Majority of the interest lies on the revenue streams (24%), that is how to generate cash flow by valorizing their bio-resources using technologies and collaborations they are not yet using. The next major areas of interest were the operational areas of (key resources, key activities, and key partners – 16%, 14% and 14% respectively) followed by value proposition (12%) which is what the firms are offering to the customers and needs they are trying to meet. The result speaks volumes as it can be deduced that apart from finances, efforts should be made at drawing up and implementing more stakeholder engagements with the primary actors as they still need more information on how the bioeconomy transition should work and what products they can offer to the people for them to succeed. Also, the identified legal restrictions should be evaluated and addressed while the knowledge gap can be addressed by crafting special startup curriculum for operators in this field as is done in other sectors especially information technology (IT) in Estonia.

Firms that are into crop production (42%) using average adoption according to survey data were shown to be more forward in the adoption of valorization and making efforts to create new products out of their waste according to survey data followed closely by animal husbandry (37%). From the responses this range from manure composting, production of silage and hay to biogas and biofuel production. Although there is a strong relationship between companies that are into crop production and animal production but the data also shows that there are firms are into other fields of agriculture (like forestry and food production) that are also into crop production but are not involved in animal production. According to the survey results it can be argued that the high rate of the respondents being into more than one agricultural product is usually due to the complementing of resources where products or bye-products from one is used in the other for example, manure from animals used as fertilizer for the crops or crop bye-products used as feed for the animals. Looking at factors that inhibit valorization like legal restrictions (institutional) and operational factors as represented in figure 12, there is a lot of work to do in making sure these limitations are taken care of for a successful and sustainable transition to bioeconomy to take place.

The survey results also show that there is no relationship between the enterprise characteristic of number of employees and adoption of valorization. This could be corrected in the future when the campaign for bioeconomy has reached all the farmers and efforts are made to assist them in seeking for ways of adding value to their waste products either as an individual firm or as a collection of several farmers and food enterprises coming together with a common objective to not only adhere to policies and bioeconomy strategy when ready in Estonia but also to seek ways of improving revenue and market reach through product differentiation and value propositions. As stated by Põder et al (2011), farm size is a major determinant of farmers attitude towards the future and the survey result contravenes this if number of employees is extrapolated to be a representation of farm size.

- Further studies should be focused on the relationship between types of biomass and their relationship with types of enterprise, location of enterprise and business model of enterprise to help make more informed decisions on what services and incentives should be provided and their method of allocation.
- The viability and scaling up of some value chains like herbs and mushrooms as mentioned by some respondents should be exploited and mechanisms put in place to bring it to limelight.

CONCLUSION

In line with the previous section, relating it to the topic of the thesis which is “analysis of the mapping of bioenergy and bio-product production of Estonian agricultural companies: a case study of the Baltic biomass for value project” and integrating this with the research problems and research questions, using the results from the survey data, it is hereby inferred that,

Most of the respondents are into crop production (40%) and animal husbandry (36%) processing manure (25%), straw (13%), feed (10%), biomass from grasslands (10%) among other bio-products and survey result shows that 20% bio-products does not need to be processed. The does not need to be processed should be investigated as knowledge limitation on the uses of these bio-products could have made the respondents to tag them as such.

Many of the farmers are involved in more than one line of business and thus the products or bio-products from one is used as raw material for the other(s), thus reducing uncertainties in supply or other concerns germane to them. The correlation results show that there are significant positive relationships between the production of some bio-products and others. This depicts that those that indicated they process these bio-resources also chose that they process the bio-resources that has a significant positive correlation coefficient.

The major bio-products processed according to survey results are manure (25%), straw (13%), feed (10%), biomass from grasslands (10%) and slurry (6%) and these are the major constituents of biogas production plant which Estonia is beginning to be a major producer. In the future this can be broken down into counties in Estonia to determine what bio-products are processed in each county for better planning and distribution of incentives.

The operational factors of key resources (16%), key activities (14%), and key partners (14%) summed up from the survey result has a total of 44% shows to be the most desired segment of interest by the respondents in relation to valorization of their bio-resources and efforts should be made in educating people more even in the rural areas on subjects that can address this.

Although the survey results shows that there is no relationships between company size and adoption of valorization, with improved awareness and necessary infrastructure this situation could be turned around as firms no matter their number will tend to seek for more revenue, market penetration, collaboration with other firms. It could also be to show allegiance to the efforts of the government in achieving their objective of national development by adhering to policies that they are convinced is for the good of all.

Considering the above, the following recommendations are proffered to achieve a seamless, successful, and sustainable transition to bioeconomy in Estonia.

- Massive enlightenment of the actors, especially the farmers on the possibilities and benefits of valorization of their bio-resources. The immediate and future benefits of a bioeconomy transition should also be included as what drive individuals differ. While most people are driven by economic benefits, there are others that are driven by social benefits.
- The government should empower and train entrepreneurs in this segment (agriculture and its related subsectors) who can generate value propositions connecting the farmers and food enterprises and having access their bio-resources to produce high-value products that will benefit all stakeholders.
- The restrictions mooted by some respondents should be evaluated and see how amending or abolishing them will benefit both the people and the government without jeopardizing whatever visions that caused their instatement. Such visions should also be evaluated to see if they have expired with time and the motives behind them are no longer relevant in this period.

REFERENCES

Adejumo, A. V., & Adejumo, O. O. (2018). Sustainable Development: Implications for Energy Policy in Nigeria. In Towards a Sustainable Bioeconomy: Principles, Challenges and Perspectives (pp. 395- 433). Springer, Cham.

Antikainen, R., Dalhammar, C., Hildén, M., Judl, J., Jääskeläinen, T., Kautto, P., ... & Thidell, Å. (2017). Renewal of forest based manufacturing towards a sustainable circular bioeconomy.

Batra, G., Uitto, J. I., & Cando-Noordhuizen, L. (2015). From MDGS to SDGS: Evaluating global environmental benefits. Evaluation Matters, 1(3), 16-23.

Beise, M., & Rennings, K. (2005). Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations. Ecological economics, 52(1), 5-17.

Beluhova-Uzunova, R., Shishkova, M., & Ivanova, B. (2019). CONCEPTS AND KEY SECTORS OF THE BIOECONOMY. Trakia Journal of Sciences, 17(1), 227-233.

Biernat, Krzysztof. "Introductory Chapter: Objectives and Scope of Bioeconomy." Elements of Bioeconomy (2019): 1.

Bio based Industries Consortium (2020) Mapping Estonia's bio based potential country report May 2020. Mapping Estonia's bio-based potential | Bio-Based Industries Consortium (biconsortium.eu)

Birner, R. (2018). Bioeconomy concepts. In Bioeconomy (pp. 17-38). Springer, Cham.

Bocken, N. M., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. Journal of cleaner production, 65, 42-56.

Bonaiuti, M. (2014). The great transition. Routledge.

Boulding, K. (1966). E., 1966, the economics of the coming spaceship earth. New York.

Bourguignon, D. (2017). Bioeconomy Challenges and opportunities. Briefing, EPRS.

Bousfield, J. (2011). The Rough Guide to Estonia, Latvia & Lithuania. Dorling Kindersley Ltd.

Briens, C., Piskorz, J., & Berruti, F. (2008). Biomass valorization for fuel and chemicals production--A review. International Journal of Chemical Reactor Engineering, 6(1).

Calicioglu, Ö., & Bogdanski, A. (2021). Linking the bioeconomy to the 2030 sustainable development agenda: Can SDG indicators be used to monitor progress towards a sustainable bioeconomy? New Biotechnology, 61, 40-49.

Canales, N., Gladkykh, G., Bessonova, E., Fielding, M., Johnson, F. X., & Peterson, K. (2020). Policy dialogue on a bioeconomy for sustainable development in the Baltic Sea region. Stockholm Environment Institute.

Charles, David, Sara Davies, Stephen Miller, Keith Clement, Greet Overbeek, Anne-Charlotte Hoes, Marius Hasenheit, Zoritza Kiresiewa, Stefan Kah, and Chiara Bianchini. "Case studies of regional bioeconomy strategies across Europe." (2016).

Conforti, P. (2011). Looking ahead in world food and agriculture: perspectives to 2050. Food and Agriculture Organization of the United Nations (FAO).

Daly, H. E. (2006). Sustainable development—definitions, principles, policies. In The future of sustainability (pp. 39-53). Springer, Dordrecht.

Franks, T. R. (1996). Managing sustainable development: definitions, paradigms, and dimensions. Sustainable Development, 4(2), 53-60

Gaspard, S., & Ncibi, M. C. (Eds.). (2013). Biomass for sustainable applications: pollution remediation and energy. Royal Society of Chemistry.

Gerbens-Leenes, P. W., Hoekstra, A. Y., & Van der Meer, T. H. (2009). The water footprint of energy from biomass: A quantitative assessment and consequences of an increasing share of bioenergy in energy supply. Ecological economics, 68(4), 1052-1060.

Gleim MR, Smith JS, Andrews D, Cronin JJ (2013) Against the green: a multi-method examination of the barriers to green consumption. J Retail 89(1):44–61

Goldstein EB (2011) Cognitive psychology, 3. ed., international student ed., special ed.

Gomez San Juan, M., Bogdanski, A., & Dubois, O. (2019). Towards sustainable bioeconomy—Lessons learned from case studies. Licence: CC BY-NC-SA, 3, 132.

Wadsworth Cengage Learning, Belmont, Calif

Grimble, R., & Laidlaw, M. (2002). Biological resource management: integrating biodiversity concerns in rural development projects and programs.

Grundel, I., & Dahlström, M. (2016). A quadruple and quintuple helix approach to regional innovation systems in the transformation to a forestry-based bioeconomy. Journal of the Knowledge Economy, 7(4), 963-983.

Hargrave M (2019) Bioeconomics Definition, Investopedia June 25, 2019. https://www.investopedia.com/terms/b/bioeconomics.asp

Hausknost, D., Schriefl, E., Lauk, C., & Kalt, G. (2017). A transition to which bioeconomy? An exploration of diverging techno-political choices. Sustainability, 9(4), 669.

Heinsoo, K., Melts, I., Sammul, M., & Holm, B. (2010). The potential of Estonian semi-natural grasslands for bioenergy production. Agriculture, ecosystems & environment, 137(1-2), 86-92.

Himmel, M. E., Ding, S. Y., Johnson, D. K., Adney, W. S., Nimlos, M. R., Brady, J. W., & Foust, T. D. (2007). Biomass recalcitrance: engineering plants and enzymes for biofuels production. science, 315(5813), 804-807.

Houghton, R. A. (2008). Encyclopedia of Ecology, eds Jorgensen E-CSE, Fath B.

House of Lords (2014). Waste or resource? Stimulating a bioeconomy - Science and Technology Committee. https://publications.parliament.uk/pa/ld201314/ldselect/ldsctech/141/14105.htm

Hui, E. G. M. (2019). Learn R for Applied Statistics. Eric Goh Ming Hui.

Ingrao, C., Bacenetti, J., Bezama, A., Blok, V., Goglio, P., Koukios, E. G., ... & Huisingh, D. (2018). The potential roles of bioeconomy in the transition to equitable, sustainable, post fossil-carbon societies: Findings from this virtual special issue. Journal of Cleaner Production, 204, 471-488.

Jeffries I., (August 2018). How to fill a business model canvas. https://isaacjeffries.com/blog/2018/9/8/how-to-fill-in-a-business-model-canvas

Juhász, A., & Vásáry, V. (2017). BioEast: Central-Eastern European initiative for knowledge-based agriculture, aquaculture and forestry in the bioeconomy. Rural Areas and Development, 14.

Knierim, A., Laschewski, L., & Boyarintseva, O. (2018). Inter-and Trans disciplinarity.

Kniūkšta, B. (2009). preconditions for developing a knowledge-based bioeconomy in Lithuania. Rural Development 2009. Agriculture in Transition towards Sustainable Development, 214-218.

Körner, I. (2015). Civilization biorefineries: efficient utilization of residue-based bio-resources. In Industrial Biorefineries & White Biotechnology (pp. 295-340). Elsevier.

Kumar, P. (Ed.). (2010). The economics of ecosystems and biodiversity: ecological and economic foundations. UNEP/Earthprint.

Leavy, P. (2017). Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches.

Luna-deRisco, M., Normak, A., & Orupõld, K. (2011). Biochemical methane potential of different organic wastes and energy crops from Estonia.

Lupton, R. C., & Allwood, J. M. (2017). Hybrid Sankey diagrams: Visual analysis of multidimensional data for understanding resource use. Resources, Conservation and Recycling, 124, 141-151.

Lutzeyer, H. (2019). Introduction to the bioeconomy strategy: SCAR-CASA workshop. https://scar-europe.org/images/CASA/Events/Portugal_20may2019/presentations/Hans_Joerg.pdf

Maes, J., Teller, A., Erhard, M., Murphy, P., Paracchini, M. L., Barredo, J. I., ... & Lavalle, C. (2014). Mapping and Assessment of Ecosystems and their Services: Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020.

Martinez, J. (1998). Genomies and the world's economy. Science Magazine, 281(5379), 925-926.

Mertens, A., Van Lancker, J., Buysse, J., Lauwers, L., & Van Meensel, J. (2019). Overcoming non-technical challenges in bioeconomy value-chain development: Learning from practice. Journal of cleaner production, 231, 10-20.

Mõtte, M., Lillemets, J., & Värnik, R. (2019). A systematic approach to exploring the role of primary sector in the development of Estonian bioeconomy. Agronomy Research, 17(1), 220-233.

Musard, D. B., Bastioli, C., Bielecki, S., Bunthof, C., Corbey, D., Cudlinova, E., ... & Zinke, H. (2014). Where next for the European bioeconomy? The latest thinking from the European Bioeconomy Panel and the Standing Committee on Agricultural Research Strategic Working Group (SCAR).

Nordic Council of Ministers. Bioeconomy in the Baltic Sea Region. Webpage. http://bsrbioeconomy.net

OECD. Publishing. (2009). The bioeconomy to 2030: designing a policy agenda. Organization for Economic Co-operation and Development.

Ollikainen, M. (2014). Forestry in bioeconomy–smart green growth for the humankind. Scandinavian Journal of Forest Research, 29(4), 360-366.

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

Paz, A. M. (2013). Biological resources for energy.

Pickett-Baker J, Ozaki R (2008) Pro-environmental products: marketing influence on consumer purchase decision. J Consum Market 25(5):281–293

Philippidis, G., Bartelings, H., Helming, J., M'barek, R., Smeets, E., & Van Meijl, H. (2018). The good, the bad and the uncertain: Bioenergy use in the European Union. Energies, 11(10), 2703.

Pülzl, H., Kleinschmit, D., & Arts, B. (2014). Bioeconomy–an emerging meta-discourse affecting forest discourses? Scandinavian Journal of Forest Research, 29(4), 386-393.

Randma. T., (2018). Estonian world: Estonia's dirty secret. July 16, 2018. Teet Randma: Estonia's dirty secret (estonianworld.com)

Reinheimer, H. (1913). Evolution by Co-operation: A Study in Bio-economics. Dutton.

Richardson, J. E. (2005). The business model: an integrative framework for strategy execution. Available at SSRN 932998.

Richardson, B. (2012). From a fossil-fuel to a biobased economy: The politics of industrial biotechnology. Environment and Planning C: Government and Policy, 30(2), 282-296.

Salvador, R., Puglieri, F. N., Halog, A., de Andrade, F. G., Piekarski, C. M., & Antonio, C. (2020). Key aspects for designing business models for a circular bioeconomy. Journal of Cleaner Production, 124341.

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: appropriate use and interpretation. Anesthesia & Analgesia, 126(5), 1763-1768.

Singhvi, M. S., & Gokhale, D. V. (2019). Lignocellulosic biomass: hurdles and challenges in its valorization. Applied microbiology and biotechnology, 103(23), 9305-9320.

Sõukand, R., & Kalle, R. (2016). Perceiving the biodiversity of food at chest-height: Use of the fleshy fruits of wild trees and shrubs in Saaremaa, Estonia. Human Ecology, 44(2), 265-272.

Staffas, L., Gustavsson, M., & McCormick, K. (2013). Strategies and policies for the bioeconomy and bio-based economy: An analysis of official national approaches. Sustainability, 5(6), 2751-2769.

Statistics Estonia (2021). Energy July 17, 2021. https://www.stat.ee/en/find-statistics/statistics-theme/energy-and-transport/energy

Strategy, U. B. (2018). A sustainable bioeconomy for Europe: strengthening the connection between economy, society, and the environment. European Commission.–2018.–URL: https://ec. europa. eu/research/bioeconomy/pdf/ec_bioeconomy_ strategy_2018. pdf (дата обращения 25.02. 2020).

Tardi, C. (2020). Investopedia Value Chain. July 5, 2020. https://www.investopedia.com/terms/v/valuechain.asp

Tursi, A. (2019). A review on biomass: importance, chemistry, classification, and conversion. Biofuel Research Journal, 6(2), 962.

UNESCO, T. (2012). Managing water under uncertainty and risk. The United Nations world water development report, 4.

Urban, K., Schiesari, C., Boysen, O., Hahn, R., Wagner, M., Lewandowski, I., ... & Reyes, C. M. (2018). Markets, Sustainability Management and Entrepreneurship. In Bioeconomy (pp. 231-286). Springer, Cham.

Veijonaho, S. (2018). Forest-based circular bioeconomy business models in Finnish SMEs.

von Braun, J. (2020). Bioeconomy and Its Set of Innovations for Sustainability. Industrial Biotechnology, 16(3), 142-143.

Work in Estonia (2019) Relocation guide to Estonia, https://www.workinestonia.com/wp-content/uploads/2019/01/relocation-guide.pdf

APPENDICES

Appendix 1. Biomass processing distribution table (survey data, 2021)

Types of Biomass Processed	**Manure**	**Slurry**	**scrap milk**	**Wool**	**Slaughterhouse waste**	**Straw**	**Feed**	**Reed**	**Biomass from grasslands**	**Wood waste**	**Sewage sludge**	**Horticultural waste (shells, non-standard production, etc.**	**Does not deserve process**	**Others**	**Total**
Manure	14	15	5	8	1	22	21	0	16	7	1	2	1	2	**115**
Slurry	15	0	3	0	0	10	8	0	4	3	0	0	1	0	**44**
scrap milk	5	3	0	0	0	5	5	0	1	0	1	0	0	1	**21**
Wool	8	0	0	0	1	0	2	0	2	0	0	0	0	1	**14**
Slaughterhouse waste	1	0	0	1	0	0	1	0	1	0	0	0	0	0	**4**
Straw	22	10	5	0	0	4	15	1	11	2	1	1	1	2	**75**
Feed	21	8	5	2	1	15	1	0	10	0	1	1	0	1	**66**
Reed	0	0	0	0	0	1	0	0	0	0	0	0	0	1	**2**
Biomass from grasslands	16	4	1	2	1	11	10	0	3	4	0	1	0	0	**53**
Wood waste	7	3	0	0	0	2	0	0	4	5	0	0	0	0	**21**
Sewage sludge	1	0	1	0	0	1	1	0	0	0	1	0	0	0	**5**
Horticultural waste	2	0	0	0	0	1	1	0	1	0	0	0	0	0	**5**
Does not deserve process	1	1	0	0	0	1	0	0	0	0	0	0	46	0	**49**
others	2	0	1	1	0	2	1	1	0	0	0	0	0	2	**10**
Total	**115**	**44**	**21**	**14**	**4**	**75**	**66**	**2**	**53**	**21**	**5**	**5**	**49**	10	**484**

Appendix 2. Correlation table of bio-resources processed (survey data, 2021)

Bio-resources	Manure	Slurry	Scrap milk	Wool	Slaughter house waste	Straw	Feed	Reed	Biomass from grasslands	Wood waste	Sewage sludge	Horticultural waste	Does not deserve process	others
Manure	1													
Slurry	0.703**	1												
scrap milk	.834**	.818**	1											
Wool	0.336	.764**	.555*	1										
Slaughterhouse waste	0.545	0.505	0.397	.611*	1									
Straw	0.684**	.786**	.760**	.830**	.652*	1								
Feed	0.644*	.807**	.696**	.692**	0.381	.710**	1							
Reed	0.204	0.168	0.308	-0.099	-0.258	-0.149	0.213	1						
Biomass from grasslands	0.783**	.954**	.898**	.731**	0.521	.804**	.789**	0.145	1					
Wood waste	0.473	.630*	.421	.657*	0.350	.655*	.714**	-0.090	.647*	1				
Sewage sludge	0.431	.669**	.636*	0.360	0.189	0.468	.461	0.122	.591*	0.099	1			
Horticultural waste	0.708**	.940**	.794**	.848**	.666**	.858**	.827**	0.096	.901**	.647*	.541*	1		
Does not deserve process	-0.244	-0.111	-0.184	-.0120	-0.174	-0.170	-0.180	-0.104	-0.194	-0.165	-0.196	.-0.144	1	
others	0.330	.588*	.541*	0.434	0.227	0.327	.498	.660*	.544*	0.119	0.455	0.505	-0.236	1

Appendix 3. Categorization of uses of bioresource by purpose (survey data, 2021)

Response	Code - purpose	Purpose Category
Spread in the field as a fertiliser or given to animals	Fertilizer	Fertilizer related
Manure, feed waste and slurry are applied to fields as fertilizer and straw is used for littering animals.	Fertilizer, litter	Fertilizer related
Everything that is transferred to compost, from there goes to the field for food for plants.	Composted	Composted
composted and returned to the field, minced wood and sold to boiler houses. Sort waste and minced wood is also consumed in your boiler house.	Composted	Composted
Manure as a fertilizer. Wood waste in minced form.	Fertilizer, litter	Fertilizer related
As a fertilizer for grasslands	Fertilizer	Fertilizer related
We have transported manure to our fields, where we have grown barley, straws and peas for animal feed, as well as potatoes. We have had the villa processed into yarn in The Villamill and Aade Yarn in OÜ. To a very limited extent, we have been able to use the brush created by the maintenance of the heritage landscapes, because we are located on Kihnu Island and transporting it to the mainland is more expensive than the price to pay.	Fertilizer	Fertilizer related
Silage and dry hay are made from grass	Silage and hay	Feed
goes to the field for fertilizer	Fertilizer	Fertilizer related
Manure and slurry for fertilising fields, wood waste for wood chipping	Fertilizer, litter	Fertilizer related
Manure is composted and fertilized with farmland, we use wood chips for mulch	Composted	Composted
Manure for fertilising fields, biomass from grasslands goes to feed animals	Fertilizer, feed	Fertilizer related
Fertilization in the field	Fertilizer	Fertilizer related
Manure is composted, goes to the field, a small part of the wool is yarn, most of it compost	Composted, yarn	Composted
Goes to the field for fertilizer	Fertilizer	Fertilizer related
Manure will have no choice but to go to the thumb.	Fertilizer	Fertilizer related
Potato processing company	others	Others
We spread manure in the field and the hay is eaten by animals	Fertilizer, feed	Feed
I spread manure in the fields	Fertilizer	Fertilizer related
Hay is made into silage and collected in the field. Used for animal feed.	Feed	Feed
manure goes into fertilizer, straw goes into plant mulks, biomass goes into feed and litter, horticultural waste goes to chickens or compost, and later to greenhouses.	Fertilizer, feed, compost	Fertilizer related
Straw is used to increase my productivity (Crushed and ploughed into the soil	Fertilizer	Fertilizer related
Scrap potatoes go bait, compost or forest.	Composted	Composted
Manure and feed residues, I mix, compost and later spread on the thumb	Composted	Composted
org fertilizer	Fertilizer	Fertilizer related
Extraction	others	Others
manure in the field	Fertilizer	Fertilizer related
The straw is ground into the field and the grassland biomass is hexed into the field	Fertilizer	Fertilizer related
Composting	Composted	Composted

Appendix 3. Categorization of uses of bioresource by purpose (survey data, 2021) continued

Response	**Code - purpose**	**Purpose category**
The straw is not ice, it goes back to the field crushed/deserved.	Fertilizer	Fertilizer related
Manure and slurry are composted	Composted	Composted
Let's take the manure to the field, fertilizer	Fertilizer	Fertilizer related
straw goes down on animals. Manure and slurry are fertilizer, as well as the rest of the feed.	Fertilizer, feed	Feed
will be realised	others	Others
We crush hay, straw and reeds and produce biobriquettes.	Biofuel	Biofuel
in all kinds of	All kinds	Others
Manure goes back to grasslands	Fertilizer	Fertilizer related
Sale and insulation of the house.	Insulation of house	Others
manure, straw, biomass for field ramps. Feed is a deserved biomass	Fertilizer	Fertilizer related
composted for own use	Composted	Composted
we compose and mix manure with bedding with a hole-in-the-hole. The result is compost manure with ha cavlity and, in the future, rammed soil. Gardening surpluses go to sheep-cattle-chickens	Composted	Composted
plough into the ground	Fertilizer	Fertilizer related
We are moving to a biogas plant	Biogas plant	Biofuel
To a small extent, we compose natural hay	Composted	Composted
Manure is used to fertilize fields	Fertilizer	Fertilizer related
manure for fertilizer, straw for apanu, feed that is left in manure	Fertilizer	Fertilizer related
To fertilizer in the field	Fertilizer	Fertilizer related
goes to the field	Fertilizer	Fertilizer related
Increasing soil fertility and feeding cattle.	Fertilizer, feed	Fertilizer related
For fertilizer	Fertilizer	Fertilizer related
The straw goes into the underbelly of the animals, and after that there is manure that goes ramshackle in the field.	Fertilizer, litter	Fertilizer related
Fertilizing the land	Fertilizer	Fertilizer related
Scrub from forestry and ditches is sold as minced wood	Sold	Others
Recycling	Recycled	Fertilizer related
Manure in the field. Straw animal litter. Feed for animals.	Fertilizer, litter	Fertilizer related
Scrub and logging waste-minced wood.	Fertilizer	Fertilizer related
Manure, slurry and straw for fertilizing fields. Straw through animal husbandry for manure / slurry	Fertilizer, litter	Fertilizer related
Goes for animal feed	Feed	Feed
With manure, fertilization of their lands is carried out. Unused fodder grass is sold without ball. Logging waste is marketed to minced companies.	Fertilizer, sold out	Fertilizer related
to stimulate soil fertility.	Fertilizer	Fertilizer related
Manure as fertiliser, wool for yarn, biomass from grasslands for animal feed	Fertilizer, yarn, feed	Feed
Uses dryer, residential buildings, workshop for heating	Heating	Biofuel
Biomass is smoothed for animal feed. Manure is used for fertilizer.	Feed	Feed
Composting in the auna	Composted	Composted
Animal feed	Feed	Feed

Appendix 4. Non-exclusive licence for depositing the final thesis and opening it for the public and the supervisor's (supervisors') confirmation for allowing the thesis for the defence

Hereby I, Chizuruoke Michael Nnadi.

Write your date of birth here (16/02/1977).

1. grant Eesti Maaülikool, the Estonian University of Life Sciences, a free-of-charge non-exclusive licence to store the final thesis titled Write the title of your final thesis here., supervised by Write the name(s) of your supervisor(s) here. for

1.1. preservation.

1.2. depositing a digital copy of the thesis in the archive of DSpace and

1.3. opening it for the public on the Web until the validity of the term of protection of copyright.

2. I am aware that the author retains the same rights as listed in point 1;

3. I confirm that by being issued the CC licence no rights deriving from the Personal Data Protection Act and the Intellectual Property Rights Act have been infringed.

Author of the final thesis ______________________________ signature

In Tartu, 28/05/2021
(Date)

The core supervisor's approval for the final thesis to be allowed for defence

This is to confirm that the final thesis is allowed for defence.

………………………………………………… ………………………………..
Supervisor's name and signature Date

………………………………………………… ………………………………..
Supervisor's name and signature Date