1 Introduction

Antje Klitkou, Arne Martin Fevolden and Marco Capasso

Organic waste and other residual materials from bio-based industries and households are of increasing value in today's economy. Substances that have long represented a cost to the economy are now becoming a valuable resource. Exploiting the full potential of these resources requires increased innovation and systemic change as well as better regulation and governance – or, in other words, a transition to a sustainable bioeconomy.

The transition to a sustainable bioeconomy has been on the agenda in policy, academia and business circles worldwide. Developing this sustainable bioeconomy is considered to be critical for several reasons: the need for the sustainable use of resources, the growing demand for food, materials and energy, and the need to decouple economic growth from environmental degradation. However, a sustainable bioeconomy will only emerge when certain challenges are addressed.

First, the entire economy must be involved in the transition process. The sustainable and circular bioeconomy will not only transform traditional bio-industries such as food production and forestry, it will also transform all sectors of the economy. Fossil resources must be replaced by renewable bio-resources in many industries and organic residuals and side-streams must be exploited for sustainable value creation. The transition requires a focus on the circularity of value creation: side-streams and former waste streams can become new input factors for new value circles. The valorisation of waste streams necessitates a higher degree of coordination along and across industries.

Second, a wide range of policy instruments must be employed. Traditional policy instruments, such as generic tax exemptions and R&D funding, are insufficient to foster such a comprehensive transition process and need to be complemented by other types of instruments, such as public procurement, new standards, regional specialisation strategies and entrepreneurship initiatives. In addition, policymakers must take into account the geographic embeddedness of the waste streams and the need for changes in the established rules of the game.

Third, researchers from diverse fields of study must be involved. The transition to a bioeconomy is a complex process and therefore interdisciplinary and transdisciplinary approaches need to be developed in order to facilitate the exchange of knowledge and experience across the established groups of actors and sectors. However, interdisciplinary and transdisciplinary collaborations are challenging, since partners work under different incentive structures and draw on different knowledge bases.

This book addresses these challenges through a holistic approach: (1) analyses of value chains crossing the established sector boundaries, (2) analyses of policy and governance perspective on the transition process and (3) interdisciplinary studies of the bioeconomy.

1.1 Framework

1.1.1 Background

Over the last decade, the notion of grand challenges has emerged as a central issue in policymaking and in academic discourse. The Lund Declaration (2009) stressed the urgency of pursuing solutions to the so-called grand societal challenges, such as climate change, food security, health, industrial restructuring and energy security. All these challenges are persistent problems which require long-term approaches and are highly complex, difficult to manage and characterised by uncertainties (Coenen, Hansen & Rekers, 2015; Schuitmaker, 2012). The concept of a bioeconomy has been introduced as an important pathway for addressing several of these challenges. Replacing fossil-based products with products based on organic waste resources is an important strategy not only for mitigating climate change, but also for fostering industrial restructuring, improving public health and ensuring food and energy security (Ollikainen, 2014; Pülzl, Kleinschmit & Arts, 2014; Richardson, 2012).

However, as Bugge et al. (2016) have pointed out, there seems to be little consensus about what a bioeconomy actually implies. Visions of the bioeconomy range from one that is very closely connected to the increasing use of biotechnology across sectors (e.g. Wield, 2013), to one where the focus is on the use of biological material (e.g. McCormick & Kautto, 2013). Others call for a shift towards locally embedded eco-economies, which use local good practice as the starting point (Marsden, 2012). Thus, describing the bioeconomy, it has been argued that "its meaning still seems in a flux" (Pfau, Hagens, Dankbaar & Smits, 2014; Pülzl et al., 2014, p. 386) and that the knowledge-based bioeconomy can be characterised as a "master narrative" (Levidow, Birch & Papaioannou, 2013, p. 95), which is open to very different interpretations (Bugge et al., 2016, p. 1f.). The different perspectives on the bioeconomy can roughly be aligned into three points of view: (1) the OECD's and the United States' focus on processes that convert raw material into value-added products using biotechnology and life sciences; (2) the European Union's emphasis on the use of biomass resources, such as biological resources and waste, as inputs for food, feed, energy and industrial products; and (3) environmental scientists' and NGOs' concentration on sustainability and planetary boundaries (Kleinschmit et al., 2014).

While the first European bioeconomy strategy had a focus on bioeconomy research and innovation to tackle the grand societal challenges (European Commission, 2012), the updated European bioeconomy strategy (European Commission, 2018) stresses the need for sustainability and circularity of the bioeconomy. A sustainable bioeconomy "can turn bio-waste, residues and discards into valuable resources and can create the innovations and incentives to help retailers and consumers cut food waste by 50% by 2030" (European Commission, 2018, p. 6).

The world's population is expected to increase from seven billion in 2012 to more than nine billion by 2050 (European Commission, 2012). This means that there will be an increased need for food, feed and many other bio-based materials. Reducing and preventing food waste is one important avenue to take. However, not all food waste can be avoided; therefore, we need to exploit this resource for other means of value creation.

Many authors emphasise the need to use new types of resource for producing food, feed and other bio-based materials. These resources require different technological pathways to the traditional bio-processing industry. Such pathways are provided, among others, by biological treatment (biogas production) and biorefining.

Biological treatment with anaerobic digestion is based on different types of feedstock, such as urban organic waste, food waste from the food processing industry and manure. One output is biogas, which can be used in transport as a replacement for fossil fuels. The other output is bio-digest, which can be used as a replacement for artificial fertiliser. This returns nutrients back into the soil. Lantz et al. have discussed the potential incentives and barriers for an expansion of biogas technology in the Swedish context, including the complete biogas chain from feedstock production to the final utilisation of biogas and the digested residues (Lantz, Svensson, Bjornsson & Borjesson, 2007). They distinguish between barriers to the production of biogas and barriers to the utilisation of biogas and digestate, and use a life cycle assessment (LCA) in order to estimate the potential for biogas production from waste resources found in different sectors and sources. Their scientific contribution resulted in a lively debate in Sweden about the agricultural use of sewage sludge from wastewater treatment plants; the debate in turn originated from frequent alarming reports of the possible presence of undesirable substances in the sludge. To ensure the quality of the digestate, a set of rules and voluntary agreements are used. Manure, being a by-product which does not require any additional handling by the farmer, is often considerably more easily available to the biogas producer, and its use is especially profitable if transportation costs are covered.

Another pathway is provided by biorefineries. Biorefineries can be classified in different ways (Parajuli et al., 2015) based on the types of raw material input used for the process, such as straw and stover from plant production, residues from food processing, sludge from wastewater treatment, residues from fish processing, aquaculture and residues from forestry and forest-based industries. A further classification is based on the applied technology: biochemical or thermochemical (based on gasification and/or pyrolysis). A third classification distinguishes between the main intermediate products produced in the biorefinery, such as syngas, sugar and lignin. Biorefineries must be optimised for the efficient use of bio-resources, energy use and recovery of valuable compounds, such as proteins and phosphorus. In the Scandinavian context, all these resource streams are valuable, but straw and stover might, due to the structure of the Danish agricultural sector, be more important for Denmark than for Norway and Sweden. Forestry residues have been exploited by biorefinery companies, such as Borregaard in Norway and Domsjö in Sweden. Biorefineries not only enable the replacement of fossil resources with renewable, organic resources in the production of materials and chemicals, but also allow for the production of new types of materials with different qualities to those of fossil-based materials.

When assessing the sustainability of biological treatment and biorefining *processes*, there are several elements to consider: (1) the mobilisation of waste and residue streams from the agricultural, forestry and food sectors; (2) technological options for converting biomass into biomaterials and bioenergy; and (3) the sustainability of bio-based products compared to traditional products (Kretschmer, Buckwell, Smith, Watkins & Allen, 2013). Food waste, crop and forest residues have significant potential as bio-resources since they offer a range of potential energy outputs from 1.55 to 5.56 EJ per year. The majority (over 90%) of this potential energy output is offered by crop and forest residues. The extent of biomass-based products on the market is influenced by three factors: feedstock availability and its price, market demand and investment decisions, which again are influenced by the maturity of the chosen technology and its economic viability.

When assessing the sustainability of bio-based *products*, Kretschmer et al. (2013) stress two issues for analysis: efficient use of biomass resources, incl. residues and waste, and greenhouse gas emission effects. LCAs can provide an evaluation of the sustainability of bio-based products. When analysing the effects of greenhouse gas emission, the consequences of diverting residues from previous uses (straw and forest residues) must be considered. While the replacement of fossil fuels by first-generation biofuels can be assessed as unsustainable, the massive deployment of advanced biofuels from forestry and agricultural residues can also have unintended environmental consequences and lead to new path dependencies. A resource-efficient use of biomass is not only related to replacing energy crops by using agricultural and forestry residues, but also to the *cascading use* of these bio-resources, which implies a shift from high volumes towards lower volumes, and from low added value to high added value.

1.1.2 Defining the concepts – waste valorisation, circularity, sustainable business models and the bioeconomy

This book explores how streams of organic waste and residues can be transformed into valuable products and thus foster a transition towards a sustainable and circular bioeconomy. When investigating this subject, some questions immediately arise: what is the bioeconomy, what is the circular bioeconomy and why is it sustainable? And, last but not least, what is organic waste and what are valorisation pathways?

A number of different definitions of "bioeconomy" exist (Bugge et al., 2016; Schmid, Padel & Levidov, 2012). In this book, we define bioeconomy as the set of economic activities related to the sustainable production and use of renewable biological feedstock and processes to generate economic outputs in the form of bio-based food, feed, energy, materials or chemicals. A bioeconomy is "sustainable" as far as it is maintaining our environment and protecting food quality and biodiversity. A "circular" bioeconomy means that the existing renewable bio-resources are used in an efficient way, which means that organic waste, co-products and by-products are treated as resources for the bioeconomy. Strategies to achieve this circularity include the following processes: prevention and reduction of organic waste streams, finding new highly valued bio-products based on the re-use of organic by-products, co-products, residues and waste streams, recycling of organic waste and residues, and recovering of the energy content of organic waste streams.

The cascading use of biomass and waste resources has become an important way in which to improve resource efficiency. This principle implies that burning such resources should be the last option, to be adopted only when no other use can be envisioned (de Besi & McCormick, 2015). Biomass resources have been extensively used for energy production, both for heat and power, as well as in relation to waste-to-energy processes. However, following the principles of cascading use of bio-resources, other renewable energy resources should instead be used for energy production (Knauf, 2015; Suominen, Kunttu, Jasinevicius, Tuomasjukka & Lindner, 2017).

These processes often cross existing sectoral borders in the bioeconomy: waste streams and by-products from agriculture or forestry might become a resource for aquaculture or biochemical industry, or vice versa. Urban organic waste can be transformed into biogas for transport and into fertiliser, replacing artificial fertiliser or peat-based compost. Different waste streams can be combined to produce new types of products, not just biogas and fertiliser, but also new feed sources. However, the expression "circular bioeconomy" can be seen as something of an idealised concept, since some materials will always be lost or degraded as they move along supply chains.

What is organic waste? There have been several attempts to define organic waste streams by providing important inclusion and exclusion criteria. The United Nations Statistics Division distinguishes *waste* from other residues in the following way: waste includes materials which are not prime products and the generator has no further use for these resources and discards them, or intends or is required to discard them. This means that the definition of waste is dynamic: (1) since the generator can change the production process and can introduce new processes which exploit the former waste streams, (2) the regulator might change the requirements for what should be discarded and (3) the generator might identify a demand for the resource from other firms and start trading the materials as a good. On the other hand, waste streams, by definition, exclude residuals which are directly recycled or reused at the place of generation, as well as waste materials which are directly discharged into ambient water or air. The latter means that resource streams which are discharged from fisheries and offshore aquaculture into the oceans are under-reported, which might contribute to the increased pollution of the oceans. In this book, we address the valorisation of both organic waste streams and side-streams. We distinguish between residues which have no economic value and side-streams which already have a value.

Waste valorisation means adding value to residues and side-streams through changes in markets and/or in the physical properties of these materials. Valorisation requires both technological and institutional innovation. When analysing valorisation pathways for organic waste and side-streams we can distinguish between different groups of technologies which are applied for organic waste valorisation: (1) more conventional technologies that have been used in the management and treatment of those streams of resources, such as animal feeding, composting, anaerobic digestion, incineration and landfill disposal, and (2) alternative, biorefinery technologies aiming at the extraction and recovery of high-value compounds and the production of chemicals, materials and fuels (Maina, Kachrimanidou & Koutinas, 2017). However, the choice of technology is not the only and most important dimension of valorisation. Valorisation pathways are the trajectories through which such values are created and distributed by and among actors from the private sector, policy, research, civil society and households. Valorisation pathways may even constitute so-called transitions pathways which involve changed technologies, institutions and regulations, infrastructures, production systems, business models and consumption patterns (Turnheim et al., 2015).

Sustainable business models address different ways in which firms can combine an improved customer value with societal, environmental and economic benefits (Boons, Montalvo, Quist & Wagner, 2013). They can target innovative value propositions, value creation and delivery, and mechanisms to capture value (Bocken, Short, Rana, & Evans, 2014, p. 43f.). As Lozano has pointed out, value includes flows of material resources and energy as inputs and products and services as outputs, but also economic value, human resources and, last but not least, environmental value (Lozano, 2018, p. 6). The concept of sustainable business models can be linked to the discourse about the sustainable transition of socio-technical systems (Boons et al., 2013; Geels, 2002; Schot & Steinmueller, 2018).

1.1.3 Methodological approaches

Different methodologies are applied throughout the book to analyse the emerging circular bioeconomy and the valorisation of waste streams. Given the breadth and diversity of the subject, the research goals have been pursued using a variety of research tools belonging to both the qualitative and quantitative spheres.

The studies of the sectors of origin of the residuals combine transition theory, innovation theory and global value chain analysis. Data sources are here principally represented by interviews, workshops, event history analyses and document analyses, all related to case studies of ongoing and emerging valorisation processes. Additional quantitative data, such as national and regional accounts of waste streams, complement the technical foundation of the study.

Cross-sectoral perspectives are centred on quantitative methods. An analysis of the curricula vitae of experts involved in Norwegian research and development projects, funded by the Research Council of Norway and explicitly addressing the bioeconomy, will shed light on the knowledge base of the Norwegian bioeconomy. In addition, an analysis of research and development (R&D) statistics, firm-level data and surveys will provide an insight into the actors and their roles in the bioeconomy.

The book's chapters, pertaining to scientific reviews and scoping reflections, are based on theoretical reasoning on the previous academic literature, supported by bibliometric inferences. When making policy suggestions, semi-structured interviews and expert workshops have been accompanied by document analyses of the regulatory framework for valorisation processes. LCA methods have also been explored, to allow for a more direct response to governance-related questions.

1.2 Important themes addressed in the book

In the following we explain some of the main thematic issues addressed in the book, such as circularity, regional embedding and geographical context of waste valorisation, resource ownership and inter-firm governance, and policy and regulations of waste valorisation.

1.2.1 Circularity across established sectors

When analysing processes in the bioeconomy, the literature has often applied a sectoral approach, i.e. analysing developments in forestry, agriculture, aquaculture, etc., and has largely focused on the primary production of organic products. Instead, when analysing the circular bioeconomy, we have decided to also consider value creation, which crosses the traditionally defined sectors. Cross-sectoral connections are difficult to establish, since the economic actors would need to understand the properties of waste streams in unfamiliar sectors, and to relate them to new processes or new products. Sometimes a bioeconomic improvement may even need the combination of several different waste streams.

Such cross-cutting relations across the sectors can emerge at several stages of the "value circle". We prefer to adopt the expression "value circle", rather than the more common "value chain", which is connected to a more traditional linear model of value creation: production of primary goods – processing – distribution – consumption – disposal. Instead, our focus here is on a more circular approach, where value creation can occur at any stage, and discarded products can still potentially be used for value creation.

Figure 1.1 attempts to visualise such an approach. This figure is generic and can be applied to many nature-based value creation processes.

A next step in the development is from individual value circles to a network of circles and sharing resources in cascades from high to lower resource qualities, culminating in industrial symbiosis. Industrial symbiosis requires coordination and co-location in a regional setting and aims at turning waste outputs from one production process into a feedstock for another production process. The circularity of the bioeconomy is strongly related to the *sustainable* valorisation of biological resources. However, the valorisation of residues is not automatically sustainable. Assessing the sustainability of such valorisation is one of the tasks of LCAs. Crossing sectoral boundaries for valorising biological resources can be challenging for performing LCAs, especially because the boundaries of the systems change if one compares a valorisation path inside one sector, such as wooden residues exploited for

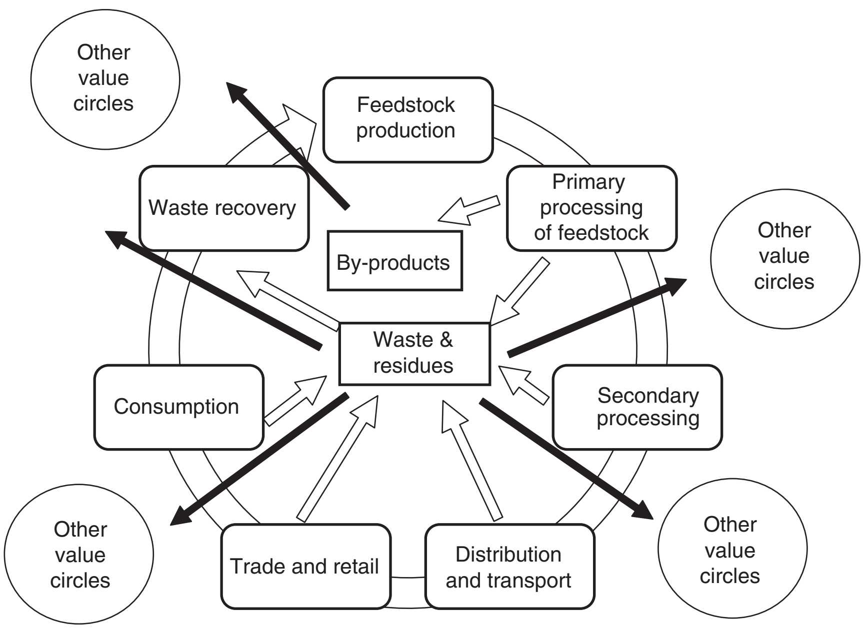

Figure 1.1 Value circles and valorisation of waste and residues.

wooden construction elements, with a path including different sectors, such as wooden residues used as feedstock for animals. However, LCAs focus on tracing the sustainability of new products across sectoral boundaries.

In this book we will study examples of value creation crossing sectoral boundaries. We will also discuss to what extent these are really more sustainable than established alternatives. Another important issue is how circularity across sector boundaries is dependent on cooperation with and knowledge of actors in other sectors. In particular, we target the need for addressing the specific geographic context to achieve such circularity across sector boundaries, as the next subsection, in particular, thematises.

1.2.2 Regional embedding and geographies of innovation

Making the economy "more circular", and adding value to resources that are currently unexploited, requires some form of innovation. The most direct and visible form of innovation would touch the existing value circles, and would prominently involve bridging across existing value circles: if some form of waste is generated at some level of one existing value circle, innovation may allow such waste to become an input within a different value circle.

In some cases, what is currently being wasted in a value circle could be technically ready to be an input in a different circle, but the bridge between the two circles cannot be easily crossed when the circles are not situated in the same geographic area. Innovation might then be required to allow easier transportation of waste: for instance, wood chips can be treated to not absorb humidity during transportation, and thus be introduced into geographically distant value circles.

In other cases, what is currently being wasted can become an input only after a chemical or mechanical transformation: for instance, food waste can be transformed into biofuel. If the type of waste cannot be transported easily or cheaply, the chemical/mechanical transformation (and the innovation connected to it) must occur in the same location where the waste is produced.

However, innovation may also occur on the consumption side. The creation of car models which employ biofuel is an example of the coordination of different value circles which intersect only at the consumption side. Innovations that are more consumption-based, and less technological, may involve the development of new business models. In these cases, the geographic dimension is also relevant. For instance, when local gardening is used to promote bio-foods, trust may be required by the consumer to buy a product which looks or tastes differently than usual, and such trust needs to be created at a local level. Even more evident is the case of public procurement, where the consumption stimulated by the public sector, for instance in the case of a municipality acquiring buses fuelled by bio-methane, may have a politically clear local origin.

It should also be kept in mind that the innovation process itself can depend on locational attributes, and not only because of value circle considerations and institutional setting. Every location provides a particular knowledge set associated with the firms already present in the location. A progressive valorisation of waste is more likely when the current capabilities of a location allow it, and such capabilities, or "competency mix", are associated not only with the firm producing waste, but also with the other firms present in the same location. Knowledge from different economic sectors, all present in a location, could be recombined to generate the desired innovation. However, in order to assess whether a location can provide the right "embedding" for waste valorisation, it is important to understand at which geographical range the location should be considered. A new technology may relate to some competences built at country level, to some competences built at regional level, and to some competences built at firm level. For instance, exploiting knowledge from a technologically contiguous production process, currently present in the country but not in the region, may not be possible when the knowledge transmission requires a frequent interaction: in this case, a country-level analysis of the competence mix would fail in identifying the possibilities of a region. On the other hand, knowledge transmission requiring a less frequent interaction would be neglected by a region-level analysis of the competency mix which excludes knowledge spillovers from region to region. The competency mix which waste valorisation can draw upon can thus be assessed only by considering the recent economic history of the firm, of the region and of the country where waste valorisation is expected to occur.

To sum up, innovation can alter the ways in which value circles operate and intersect. The geographic scale on which the intersection takes place always plays an essential role in the innovation process. As a consequence, the geographic dimension constitutes an essential element to consider when planning new circular economies which valorise waste streams.

1.2.3 Resource ownership and interfirm governance structures

Innovative paths to the bioeconomy are dominated by uncertainty, stemming not only from the unpredictability of scientific and technological evolution, but also from the difficulty of value circles to maintain stability in the face of fluctuations in natural resource availability on the market. An innovative bioeconomic sector may struggle to grow and survive, especially when it needs a constant volume and quality of intermediate goods flowing from upstream producers, to justify a long-term investment. At the same time, ensuring that downstream buyers can guarantee a constant demand can be difficult when the reaction of final consumers to the new bioeconomic products is not predictable, or when the barrier to the entry of other firms into the innovative sector is low. A better coordination along the value circle can be achieved, for instance, by extending the firm boundaries through vertical integration, or by maintaining the existing firm boundaries while securing stability through long-term contracts. An alternative solution to value circle miscoordination may lie in sharing decisional power between firms that are directly connected within the value circle. Formally, an individual could have a seat on both the board of directors of the innovative bioeconomic firm and on the board of directors of an upstream or downstream firm. Such directorate interlocking could guarantee, also in the eyes of potential investors, that the flow of goods along the value circle is sufficiently stable.

Within the bioeconomy, the valorisation of waste streams necessitates an even higher degree of coordination along and across value circles. This is due to the intrinsic properties of waste: both its amount and its production timing are not functional to its future use, but instead depend on the needs of the value circle from which it originates. As a consequence, its availability does not obey the market forces which usually modulate, at least partially, the supply of products in relation to their demand. There are three possible solutions to this "waste puzzle". The first one is technical: altering waste in order not only to make it useful for an economic purpose, but also to improve its properties for storage and transportation so that production amount and timing become less important. The second solution is still technical but goes one step further: processing waste in order to increase its value, up to a point where the demand for it has a similar importance for the firm as the demand for the main product associated with it; at this point, the firm will have an incentive to coordinate the production of the main product and of the "former" waste. The third solution is organisational: if the firm from which the waste originates has a connection, in terms of ownership or of management, to a potential downstream sector for the waste, then the actors in the potential downstream sector can be reassured that the flow of waste will be sufficiently constant, and therefore the incentives for long-term investments will be sufficient to allow waste valorisation in the downstream sector.

1.2.4 Policy and regulation of waste valorisation

Policymakers want to influence the bioeconomy for a wide range of reasons. Among others, they want to ensure that the food we eat is safe and that the methods used to produce it do not harm the environment; they want to make sure that biological resources are used in a way that generates new jobs and economic growth, especially in economically disadvantaged areas; and they want to make sure that biological residual resources (such as organic household waste, wooden residues, brewers' spent grain, animal by-products) are used in a sustainable manner to produce new products and new sources of energy. To accomplish these ambitions, policymakers have a large arsenal of different mechanisms at their disposal, ranging from bans and prohibitions to subsidies, tariffs and quotas and from innovative public procurement to government strategies. The combination of multiple goals and multiple mechanisms makes regulation of the bioeconomy challenging. However, there are also other factors that complicate policymaking.

Policymaking and the regulation of waste streams take place at different levels. Some policies and regulations are developed and implemented at the local level by counties and municipalities. At the local level, policies and regulations are often strongly connected to services that the counties and municipalities are responsible for providing the citizens and might involve such things as encouraging the citizens to sort their waste to facilitate biological treatment and demanding that bus companies which provide public transportation services use biofuels. At a national level, the policies are more broad-based and can affect entire sectors of the bioeconomy. Ministries are sometimes dedicated to the regulation of specific sectors, such as the Ministry of Trade, Industry and Fisheries and the Ministry of Agriculture and Food in Norway. At the supranational level, there are policies that apply for multiple countries and that each country has agreed to adhere to by signing a specific agreement (e.g. the Paris Agreement) or joining a supranational organisation (e.g. the EU or WTO). There might be different levels of compliance with supranational regulations, since these regulations do not necessarily enjoy the same level of popular support as national policies and the supranational organisation might be unable to effectively enforce the regulations. In practice, many sectors of the bioeconomy are at the same time subject to regulation at several levels.

The bioeconomy consists of actors with varying and often conflicting agendas. Some actors own bio-resources and want to exploit these resources commercially. Other actors possess strong technological capabilities and want to introduce new bio-based products or processes. In addition, yet other actors want to protect the environment and mitigate climate change. All these actors want to influence policymaking to further their own agenda. Sometimes, it is possible for policymakers to find solutions that accommodate the wishes of all these actors. Other times, it is impossible for policymakers to find solutions that fit everyone, and they must choose which agenda they want to support. In these cases, they often have to balance between sustainability and economic growth as central principles of the bioeconomy.

In this book, we will try to answer several important questions related to policy and regulation. We want to look at what are the most important policies for improving the sustainability and economic viability of the bioeconomy, what are the main pitfalls that policymakers should be aware of when they regulate the bioeconomy and what kinds of conflicting agendas policymakers face when they want to introduce new regulation.

1.3 An overview of the book

This book is organised into four parts, each exploring different aspects related to the valorisation of organic waste, circularity and the bioeconomy.

Part I discusses the main concepts and approaches applied in the book. Chapter 2 improves our understanding of the bioeconomy by exploring the origins, uptake and use of the term "bioeconomy" in academic literature. It reviews the literature and identifies three kinds of vision for the bioeconomy: the bio-technology vision, the bio-resource vision and the bio-ecology vision. Each of these visions has different origins, represents different sectors and emphasises different underlying values, directions and drivers in the bioeconomy. Together they illustrate the multifaceted nature of this sector of the economy. Chapter 3 develops a theoretical framework for understanding the patterns, drivers and contexts of organic waste valorisation within and across bio-based sectors. The chapter discusses and connects four central concepts into a coherent framework – governance, value creation and capture, technological change, and spatial relatedness and dynamics. These concepts and the related theory serve as the basis for the analysis carried out in the next part.

Part II presents empirical case studies of organic waste valorisation in six bio-based sectors – forestry (Chapter 4), urban waste management (Chapter 5), brewing (Chapter 6), meat processing (Chapter 7), aquaculture (Chapter 8) and dairy (Chapter 9). These sectors are not only important from an environmental and climate perspective, but also in terms of food security, rural employment and economic growth. Although Part II presents six sector studies, all the case studies are cross-sectoral. The sector under consideration is only the starting point of a longer valorisation pathway that spans several sectors. For instance, the case study on urban waste management begins with an analysis of organic household waste, but then focuses on how the waste is valorised into biomethane fuel for buses and fertilisers for farmers. All the case studies draw on the theoretical framework developed in Chapter 3, but emphasise different aspects of this framework.

Part III investigates aspects of the bioeconomy that span across several sectors such as knowledge flow and innovation activity. Chapter 10 investigates what kind of knowledge is required in the bioeconomy. The chapter analyses the CVs of scientific personnel who have received public funding through bioeconomy-focused research programmes in Norway in order to explore which disciplines and institutions are most relevant to the bioeconomy. Chapter 11 investigates activity in the Norwegian bioeconomy by combining and analysing a range of data sources, including patent data and project data, as well as the results from two recent surveys. The chapter aims to provide an overview of the population and actions of actors in the Norwegian bioeconomy.

Part IV investigates valorisation pathways and the bioeconomy from a policy perspective. Chapter 12 explores whether there are conflicting interests and policy rationales shaping the bioeconomy. The chapter analyses submissions to a public hearing on the development of a bioeconomy strategy in Norway to map the actors involved in shaping the new bioeconomy and to analyse their positions within this emerging field. Chapter 13 explores how policies on food waste are developed and implemented. It investigates this topic by analysing the introduction of voluntary targets for food waste reduction in Norway. Chapter 14 presents the LCA method and its use as a policy tool in relation to waste management. The chapter discusses how policymaking can be enriched by LCA, but also raises the potential pitfalls of blindly relying on LCA results. Finally, Chapter 15 concludes the part and the book by articulating suggestions and recommendations for policymakers and companies concerned about the valorisation of various waste streams.

References

Bocken, N. M. P., 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. doi:10.1016/j.jclepro.2013.11.039.

Boons, F., Montalvo, C., Quist, J. & Wagner, M. (2013). Sustainable innovation, business models and economic performance: An overview. *Journal of Cleaner Production*, *45*, 1–8. doi:10.1016/j.jclepro.2012.08.013.

Bugge, M. M., Hansen, T. & Klitkou, A. (2016). What is the bioeconomy? A review of the literature. *Sustainability*, *8*(7), 1–22. doi:10.3390/su8070691.

Coenen, L., Hansen, T. & Rekers, J. V. (2015). Innovation policy for grand challenges: An economic geography perspective. *Geography Compass*, *9*(9), 483–496. doi:10.1111/gec3.12231.

de Besi, M., & McCormick, K. (2015). Towards a bioeconomy in Europe: National, regional and industrial strategies. *Sustainability*, 7(8), 10461–10478. doi:10.3390/su70810461.

European Commission. (2012). *Innovating for sustainable growth: A bioeconomy for Europe*. Brussels: European Commission, Retrieved from http://ec.europa.eu/research/bioeconomy/pdf/official-strategy_en.pdf.

European Commission. (2018). *A sustainable bioeconomy for Europe: Strengthening the connection between economy, society and the environment. Updated Bioeconomy Strategy*. Brussels: European Commission, Retrieved from https://ec.europa.eu/research/bioeconomy/pdf/ec_bioeconomy_strategy_2018.pdf.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274.

Kleinschmit, D., Lindstad, B. H., Thorsen, B. J., Toppinen, A., Roos, A. & Baardsen, S. (2014). Shades of green: A social scientific view on bioeconomy in the forest sector. *Scandinavian Journal of Forest Research*, *29*(4), 402–410. doi:10.1080/02827581.2014.921722.

Knauf, M. (2015). Waste hierarchy revisited: An evaluation of waste wood recycling in the context of EU energy policy and the European market. *Forest Policy and Economics*, *54*, 58–60. doi:10.1016/j.forpol.2014.12.003.

Kretschmer, B., Buckwell, A., Smith, C., Watkins, E. & Allen, B. (2013). *Recycling agricultural, forestry and food wastes and residues for sustainable bioenergy and biomaterials*. Retrieved from Brussels: 978-92-823-4738-6.

Lantz, M., Svensson, M., Bjornsson, L. & Borjesson, P. (2007). The prospects for an expansion of biogas systems in Sweden: Incentives, barriers and potentials. *Energy Policy*, *35*(3), 1830–1843. doi:10.1016/j.enpol.2006.05.017.

Levidow, L., Birch, K. & Papaioannou, T. (2013). Divergent paradigms of European agro-food innovation: The knowledge-based bio-economy (KBBE) as an R&D agenda. *Science, Technology & Human Values*, *38*(1), 94–125. doi:10.1177/0162243912438143.

Lozano, R. (2018). Sustainable business models: Providing a more holistic perspective. *Business Strategy and the Environment*, 8. doi:10.1002/bse.2059.

Lund Declaration. (2009). *Europe must focus on the grand challenges of our time*. Retrieved from https://era.gv.at/object/document/130.

Maina, S., Kachrimanidou, V. & Koutinas, A. (2017). A roadmap towards a circular and sustainable bioeconomy through waste valorization. *Current Opinion in Green and Sustainable Chemistry*, *8*, 18–23. doi:10.1016/j.cogsc.2017.07.007.

Marsden, T. (2012). Towards a real sustainable agri-food security and food policy: Beyond the ecological fallacies? *Political Quarterly*, *83*(1), 139–145. doi:10.1111/j.1467-923X.2012.02242.x.

McCormick, K., & Kautto, N. (2013). The bioeconomy in Europe: An overview. *Sustainability*, *5*(6), 2589–2608.

Ollikainen, M. (2014). Forestry in bioeconomy: Smart green growth for the humankind. *Scandinavian Journal of Forest Research*, *29*(4), 360–366. doi:10.1080/02827581.2014.926392.

Parajuli, R., Dalgaard, T., Jorgensen, U., Adamsen, A. P. S., Knudsen, M. T., Birkved, M., … Schjorring, J. K. (2015). Biorefining in the prevailing energy and materials crisis: A review of sustainable pathways for biorefinery value chains and sustainability assessment methodologies. *Renewable & Sustainable Energy Reviews*, *43*, 244–263. doi:10.1016/j.rser.2014.11.041.

Pfau, S. F., Hagens, J. E., Dankbaar, B. & Smits, A. J. M. (2014). Visions of sustainability in bioeconomy research. *Sustainability*, *6*(3), 1222–1249. doi:10.3390/su6031222.

Pülzl, H., Kleinschmit, D. & Arts, B. (2014). Bioeconomy: An emerging meta-discourse affecting forest discourses? *Scandinavian Journal of Forest Research*, *29*(4), 386–393. doi:10.1080/02827581.2014.920044.

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.

Schmid, O., Padel, S. & Levidov, L. (2012). The bio-economy concept and knowledge base in a public goods and farmer perspective. *Bio-based and Applied Economics*, *1*(1), 47–63.

Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, *47*(9), 1554–1567.

Schuitmaker, T. J. (2012). Identifying and unravelling persistent problems. *Technological Forecasting and Social Change*, *79*(6), 1021–1031. doi:10.1016/j.techfore.2011.11.008.

Suominen, T., Kunttu, J., Jasinevicius, G., Tuomasjukka, D. & Lindner, M. (2017). Trade-offs in sustainability impacts of introducing cascade use of wood. *Scandinavian Journal of Forest Research*, *32*(7), 588–597. doi:10.1080/02827581.2017.1342859.

Turnheim, B., Berkhout, F., Geels, F. W., Hof, A., McMeekin, A., Nykvist, B. & van Vuuren, D. (2015). Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges. *Global Environmental Change*, *35*(November), 239–253. doi:10.1016/j.gloenvcha.2015.08.010.

Wield, D. (2013). Bioeconomy and the global economy: Industrial policies and bio-innovation. *Technology Analysis & Strategic Management*, *25*(10), 1209–1221. doi:10.1080/09537325.2013.843664.