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Pathways to a forest-based bioeconomy in 2060 within policy targets on climate change mitigation and biodiversity protection

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ABSTRACT

While climate change and biodiversity loss have exposed humanity to major systemic risks, policymakers in more than 40 countries have proposed the transition from a fossil-based to a bio-based economy as a solution to curb the risks. In the boreal region, forests have a prominent role in contributing to bioeconomy development; however, forest-based bioeconomy transition pathways towards sustainability and the required actions have not yet been identified. Participatory backcasting was employed in this study to 'negotiate' such pathways among Finnish stakeholders by 2060 in three forest-based value networks: forest biorefineries, fibre-based packaging and wooden multistorey construction. There are many alternative pathways, ranging from incremental to more radical, to a forest-based bioeconomy within a framework of ambitious climate and biodiversity targets. Path dependence can support incremental development on bioeconomy transition pathways, and this should be considered when planning transition towards sustainability. Orchestration of the more radical changes requires actions from legislators, raw material producers, consumers and researchers, because the possibilities for business development vary between different companies and value networks. The envisioned actions between the pathways in and across the networks, such as forest diversification and diverse wood utilisation, can offer co-benefits in climate change mitigation and biodiversity protection.

1. Introduction

Globalization in the form of interactions that enable the continued flow of goods, services, capital, people and information has contributed not only to global economic development but also to environmental degradation and the fragility of the global system (Centeno et al., 2015). This system is also becoming increasingly vulnerable to pervasive risks that originate from changes in key functions of the planetary system (Steffen et al., 2018; Keys et al., 2019). The levels of risk in relation to two ongoing processes, global warming and biodiversity loss, have already transgressed the levels that some authors consider safe for humanity (Rockström et al., 2009; Steffen et al., 2015). Despite their interdependence, policy targets to halt these problems are often formulated separately (Dinerstein et al., 2020). This points to the need to investigate actions to achieve such targets in parallel.

The bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, bio-based products and bioenergy, to facilitate sustainable production that replaces fossil fuels and materials (European Commission, 2012). Recently, the European Union's (EU) bioeconomy strategy was updated to accelerate national-level development and to bring the economy into balance with the living world (European Commission, 2018a). More emphasis was placed on enhancing the resilience of ecosystems and ensuring their

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contribution to climate change mitigation and biodiversity protection (European Commission, 2018a); however, the responsibility of making priorities and mapping interactions between targets lies with national governments. More than 40 governments across the globe have responded by pursuing explicit national strategies to advance their bioeconomy sectors (Dietz et al., 2018).

In northern Europe, like in Finland and Sweden, forests play a dominant role in contributing to bioeconomy development. Large mature and vertically integrated forest industry companies can be described as representatives of organisations, which have traditionally exploited strategies mainly based on economies of scale to enhance their competitiveness (Luhas et al., 2019). The focus of production has thus been on large investments in tangible assets and on bulk products targeted for large industrial buyers rather than valuing new combinations of ideas and capabilities and niche, higher value-added products (Pätäri et al., 2011; Korhonen et al., 2018). Consequently, many forest industry companies have struggled to create and add value (Natural Resources Institute Finland, 2021). To respond to the challenges and changes, there is a need for forest industry companies to transform their strategic orientations. Often, this involves differentiation and a more focused, future-oriented and cross-sectional strategy in which the companies strive for competitive advantage, such as by exploiting economies of scope (e.g. Hetemäki, 2014).

Recently, the transition towards sustainability has received increasing attention from forest industry companies, and typically, the concept of a biorefinery is viewed as a concrete building block of a bioeconomy transition (Näyhä, 2019; Temmes and Peck, 2020). From the perspective of Finland, three major value networks appear significant, i.e. forest biorefineries, fibre-based packaging and wooden multistorey construction. From a broad societal point of view, these three networks are interesting because they all have prominent potential to enhance the development of a sustainable forest-based bioeconomy (Müller et al., 2014; Bauer, 2018; Temmes and Peck, 2020). From a business development perspective, they have new value creation potential, such as through synergies in the simultaneous production of several products made of renewable materials (especially forest biorefineries) (Temmes and Peck, 2020) and substituting products made of non-renewable materials with renewable ones (especially fibre-based packaging and wooden multistorey construction) (Hurmekoski et al., 2018; Pelli and Lähtinen, 2020).

Simultaneously with the potential to contribute to the development of a forest-based bioeconomy and the supply of new products in the markets, the three value networks face different types of sustainability challenges, such as short product lifespans (especially forest biorefineries and packaging), immaturity of innovation systems and highly fragmented actor networks (especially multistorey wood construction) (Diop and Lavoie, 2017; Toppinen et al., 2019); however, through the uptake of new business models (Ulaga and Reinartz, 2011; Parida et al., 2019), forest biorefineries, fibre-based packaging and multistorey wood construction have the potential to change businesses in the value networks of traditional manufacturing industries in line with bioeconomy development needs. For example, in practice, they may offer new value both for business customers and consumers with sustainable product-service solutions through the use of new types of renewable and recycled materials, extensions in the product life-cycles and the accumulation of sustainability-related capabilities among business actors and stakeholders (Diop and Lavoie, 2017; Ranta et al., 2020; Viholainen et al., 2021). Thus, both the opportunities for society and businesses and the sustainability challenges provide the motivation to investigate the network-specific pathways of these businesses as well as the actions that are required to engage them into broader forest-bioeconomy development initiatives.

Recently, participatory processes have emerged as an important avenue to both canvass and address bioeconomy-related sustainability challenges (Kunttu et al., 2020; Näyhä, 2019). More specifically, participatory backcasting has been proposed as a useful approach for revealing stakeholders' priorities and preferences and for 'negotiating' a shared understanding between stakeholders regarding matters such as priorities (Quist and Vergragt, 2006; Näyhä, 2019). Participatory backcasting is a long-term, system-oriented approach including the dynamics of complex socio-technical change that is well-suited for long-term sustainability issues in comparison with the traditional forecasting approaches (Dreborg, 1996; Höjer and Mattsson, 2000; Quist and Vergragt, 2006; Vergragt and Quist, 2011). Backcasting can illustrate and describe how changes can accelerate transitions towards sustainable societies (Neuvonen et al., 2014). Thus, it allows for investigating various sustainability challenges and solutions across the value networks of a forest-based bioeconomy.

Using a participatory backcasting approach, the aim of this study was to understand *how stakeholders in Finland articulate core priorities for envisioned transition pathways towards a forest-based bioeconomy by 2060 when they must organise their preferred actions within policy targets on climate change mitigation and biodiversity protection.* In particular, we build on the perspective drawn from two global drivers of change: climate change and biodiversity loss, which are prominent in the forest-based bioeconomy transition (Heinonen et al., 2017; Eyvindson et al., 2018). Finally, we analyse common characteristics between the three different value chains (i.e. forest biorefineries, fibre-based packaging and wooden multistorey construction) in a forest-based bioeconomy in Finland for the next four decades.

2. Operational framework

The business strategies of Finnish forest-based bioeconomy companies have been characterised as *path-dependent* (Näsi et al., 2001; Poesche and Lilja, 2016; Luhas et al., 2019). Path dependence is a distinctive concept in recent bioeconomy transition literature. Path dependence resulting from economies of scale, learning effects and network effects have cemented a so-called 'techno-institutional lock-in situation' in the conventional wood-based production systems, which has changed the product range in waves (Luhas et al., 2019). Changes in the product range were low from 1970 to 2000, when the robust domestic cluster began to diffuse through mergers and acquisitions and to be replaced with international ownership of companies focusing on Western paper networks and incremental technological improvements (Luhas et al., 2019). The digitalization and path-dependent development pushed the leading corporations to a crisis in the turn of the millennium (Poesche and Lilja, 2016); however, the product range greatly diversified in the 2010s (Näyhä et al., 2014; Luhas et al., 2019). Recently, actors of the forest-based bioeconomy have focused more on the transition towards sustainability and smaller scale 'niche' businesses (Korhonen et al., 2018; Näyhä, 2019).

According to Hurmekoski et al. (2019), an increase in the business diversity of the forest-based bioeconomy is identified as one of the most prominent trends by 2030. The discourse of a bioeconomy transition has already improved the recognition of cross-sectoral collaboration and novel bio-based products and has raised attention regarding the roles of generating new and sharing existing knowledge. It has also highlighted the need for a comprehensive agenda of governmental support to boost the transition (Bauer, 2018; Guerrero and Hansen, 2021); however, the currently dominant bioeconomy discourse has received criticism due to its insufficient differentiation of underlying sustainability requirements, integration of socio-ecological approaches and consideration given to alternative implementation pathways (Priefer et al., 2017). The bioeconomy transition pathways illustrate the complexity of the field with many heterogeneous pathways and value chains as well as uncertainties about sustainability (Purkus et al., 2018). For example, the pathways can follow an incremental change, reconfigure the current regime or aim for a more radical and deep structural renewal (Bauer, 2018; Korhonen et al., 2018). However, the pathways are dependent on the developments in the operating environment, where controversies over the possible pathways to achieve global targets, such as reducing dependence on fossil fuels, mitigating climate change and increasing the use of bio-based resources, have emerged (Priefer et al., 2017; Hurmekoski et al., 2019).

The forest-based bioeconomy has a complex relationship with the climate system and biodiversity, which are key earth system processes (Rockström et al., 2009; Heinonen et al., 2017; Eyvindson et al., 2018). For example, the forest-based bioeconomy and related policy targets may contribute to climate change through changes in forest carbon sequestration and biomass carbon storages and by producing bioproducts that substitute fossil-based materials and energy (Hurmekoski et al., 2020). Moreover, Finnish forest-based bioeconomy companies have focused on mitigating climate change, whereas biodiversity loss has received less attention (Näyhä, 2019); however, concerning climate change mitigation and biodiversity protection based on the targets set at the international and EU levels, the Finnish government has set tightening targets to reduce greenhouse gas (GHG) emissions and to prevent biodiversity loss (Finnish Government, 2019).

The operative framework of the study investigates the bioeconomy transition pathways through the concepts of path dependence and related sustainability challenges. In the operative framework, a concept of path dependence and related sustainability challenges in the forest-based bioeconomy context provide the grounds for the investigation of bioeconomy transition pathways. The path-dependent bioeconomy transition follows a business-as-usual trajectory or an incremental development that either considers partly or excludes policy targets in a bioeconomy transition. The focus of this study was the sustainable bioeconomy transition pathways of three value networks: forest biorefineries, fibre-based packaging and wooden multistorey construction. Policy targets on climate change mitigation and biodiversity protection are used as a precondition for a sustainable bioeconomy transition.

3. Participatory backcasting approach

To study future transition pathways and to avoid path-dependent development, *participatory backcasting* (Quist and Vergragt, 2006; Vergragt and Quist, 2011; Sandström et al., 2016, 2020; de Bruin et al., 2017; Vukasinovic et al., 2019) was applied. The main characteristic of backcasting is a concern with how undesirable futures can be avoided and how desirable futures can be achieved followed by the question "what shall we do today to get there?" (Robinson, 1990; Holmberg and Robert, 2000). A backcasting approach is favoured when major change is needed, the problem affects society, the problem is linked to dominant trends, the problem is mostly related to externalities and there is sufficient time to allow for a considerable scope for deliberate choice (Dreborg, 1996). It allows for the anticipation of conflicts, synergies and trade-offs in environmental policy targets in the early stage of planning and management processes (Budiharta et al., 2018; van der Voorn et al., 2020). Thus, it fits with our aim to study future visions and transition pathways of a forest-based bioeconomy within policy targets. The prominent policy targets in the context of a Finnish forest-based bioeconomy have been identified as climate change and biodiversity loss, and these targets were used as preconditions in the backcasting

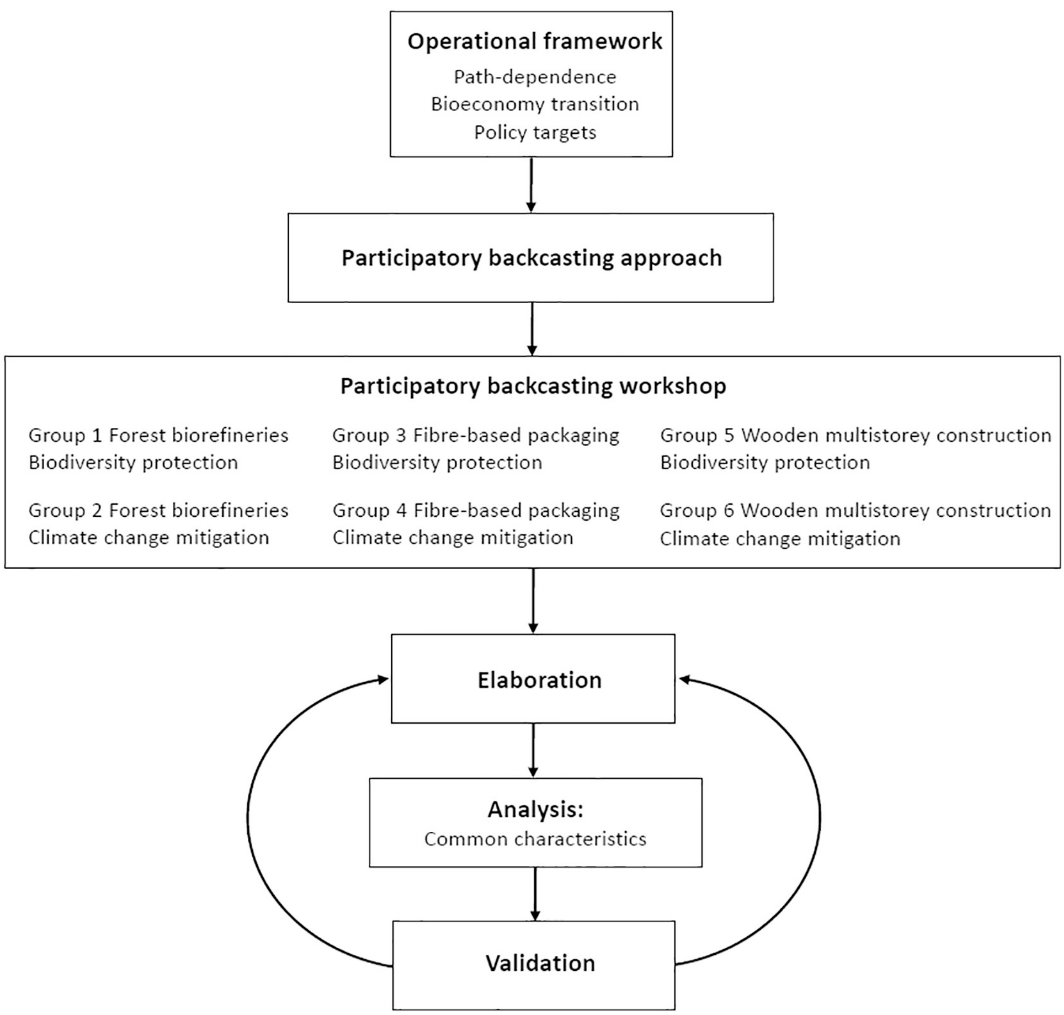

Fig. 1. Research design of the study.

workshop session.

The research design is visually presented in Fig. 1. We organised a joint participatory workshop in January 2020 for the stakeholders, who were invited from four stakeholder groups: companies, researchers, non-governmental organisations (NGO) and lobbying associations. We preferred to recruit participants with various backgrounds, expertise and value orientations (Carlsson-Kanyama et al., 2008), and the invitations were sent to 150 people. The participants were asked to register via e-form in which the participants were asked to state their primary and secondary preferred value networks of the three given options (i.e. forest biorefineries, fibre-based packaging and multistorey wood construction).

In the workshop, two parallel working groups discussed each of the value networks, and thus each group had only one policy target as a precondition: one focusing on climate change mitigation and the other on biodiversity protection. As a result of the organisation of the work, there were altogether six working groups with a chair and secretary affiliated with the project. In all, there were 28 participants, of whom about two-thirds were researchers from various fields (for detailed background information, see Table 1). The participants were assigned to the six working groups based on their own stated preference of a relevant value network and a policy target chosen by the researchers. Some participants were assigned to their secondary preferred groups. Moreover, some participants were reassigned to the groups to balance the number of participants of each group; however, this did not have an impact on workshopping.

The participatory backcasting approach can be generalised into a methodological framework including five steps (Quist and Vergragt, 2006). Accordingly, to facilitate the first step of building a strategic problem orientation, a pre-assignment was sent to the registered participants by e-mail two days prior to the event. The pre-assignment consisted of four questions related to water quality impacts, material substitution, net GHG emissions in the land use sector and wood combustion to describe some topical environmental impacts and challenges related to a forest-based bioeconomy in Finland. In addition, at the beginning of the workshop, two short introductory keynotes were given. The first introductory keynote described the pathway from the past to the present within the forest-based bioeconomy. The second focused on climate change mitigation and biodiversity protection as policy targets of remaining within planetary boundaries.

Accordingly, to facilitate the identified problem, the preconditions for the backcasting workshop were set separately concerning climate change mitigation and biodiversity protection based on the targets set at the international, EU and national levels (see Table 2 for the detailed targets). Related to climate change mitigation, the EU has set progressively tightening targets with respect to reducing GHG emissions, and the international negotiations under the framework of the Convention on Biological Diversity (2018) have set targets related to biodiversity protection.

The preconditions were set separately concerning international, EU and national level targets in 2020, 2030, 2035 and 2050. The time horizon begins from an envisioned situation in 2060 due to several reasons: First, we wanted to go beyond the existing policy targets for 2050. Second, we wanted to build visions without a dependence on the investment cycle and technological pathways (average operating life of a forest industry machine is usually more than 30 years) (Rinkinen, 2020). In addition, we assumed that the implementation of required actions to achieve such a vision takes 10 years. Thus, the time horizon gradually decreases ten years at a time to the near future of the workshop (2060–2050–2040-2030-2020). To feed the group discussion of the second and third step, four thematic dimensions—*policy/legislation, national economy, markets/consumers* and *production*—were drawn from the literature (Newell, 2010; Kivimaa and Kern, 2016). To facilitate these two main steps of the workshop, we provided each working group with a canvas with the sketch of the pathway and policy targets. All six canvases were combined, and they are illustrated in Fig. 2.

The second step was to construct sustainable future visions, and the third step was the actual backcasting. In the third step, stakeholders of the forest sector generated the directions as well as actions necessary to achieve the desired state (Sandström et al., 2020). Each group focused on one of three value networks (forest biorefineries, fibre-based packaging or wooden multistorey construction) and had one of two policy targets (climate change mitigation or biodiversity protection) as an environmental precondition. Each group had 105 min to develop a vision and the required actions to achieve such a vision in collaboration with the chairs leading the group work and the secretaries of the groups making notes on the discussions. The group discussions of the second and third steps were initiated by discussing the preconditions and how they affect the visions and required actions of transition pathways. In general terms, the group discussions were consensus-driven; however, from the viewpoint of policy targets on climate change mitigation and biodiversity protection, some of the participants focused on irrelevant topics, such as healthy living and traditional building. The time used differed between the groups. For example, some groups spent more time

Table 1
Background information of the groups.

Group	Number of participants	Backgrounds of the participants
1. Forest biorefineries, biodiversity protection	4	1 company and 3 researchers (forest economics)
2. Forest biorefineries, climate change mitigation	5	1 company, 1 NGO, 2 researchers (forest economics) and 1 researcher (co-creation)
3. Fibre-based packaging, biodiversity protection	5	1 lobbying association, 1 researcher (sustainability), 1 researcher (strategy and management), 1 researcher (technology) and 1 researcher (environmental economics)
4. Fibre-based packaging, climate change mitigation	5	1 company, 2 lobbying associations and 2 researchers (sustainability)
5. Multistorey construction, biodiversity protection	5	1 lobbying association, 3 researchers (sustainability) and 1 researcher (environmental management)
6. Multistorey construction, climate change mitigation	4	1 NGO, 1 researcher (business economics), 1 researcher (forestry) and 1 researcher (sustainability)

Table 2
The environmental preconditions: climate change mitigation and biodiversity protection targets.

Target year	Climate change mitigation	Biodiversity protection
2020	Finland should cut GHG emissions by 20%, increase the share of renewable energy to 20% and improve energy efficiency by 20%.[a]	Halt the loss of biodiversity.[e]
2030	Finland should reach at least a 40% reduction in GHG emissions from 1990 levels, a 32% share for renewable energy and a 32.5% improvement in energy efficiency.[b]	
2035	Finland's Government Programme in 2019 has set its own target to be carbon neutral.[c]	
2050	It has been suggested to reach a net carbon sink of −32 Mt. CO_2e in the land use, land use-change and forest (LULUCF) sector in Finland.[d]	Biodiversity is conserved and ecosystem services ensured.[e]

[a] European Commission (2009).
[b] European Commission (2018b).
[c] Finnish Government 2019 (2019).
[d] Ollikainen et al. (2019).
[e] Convention on Biological Diversity (2018).

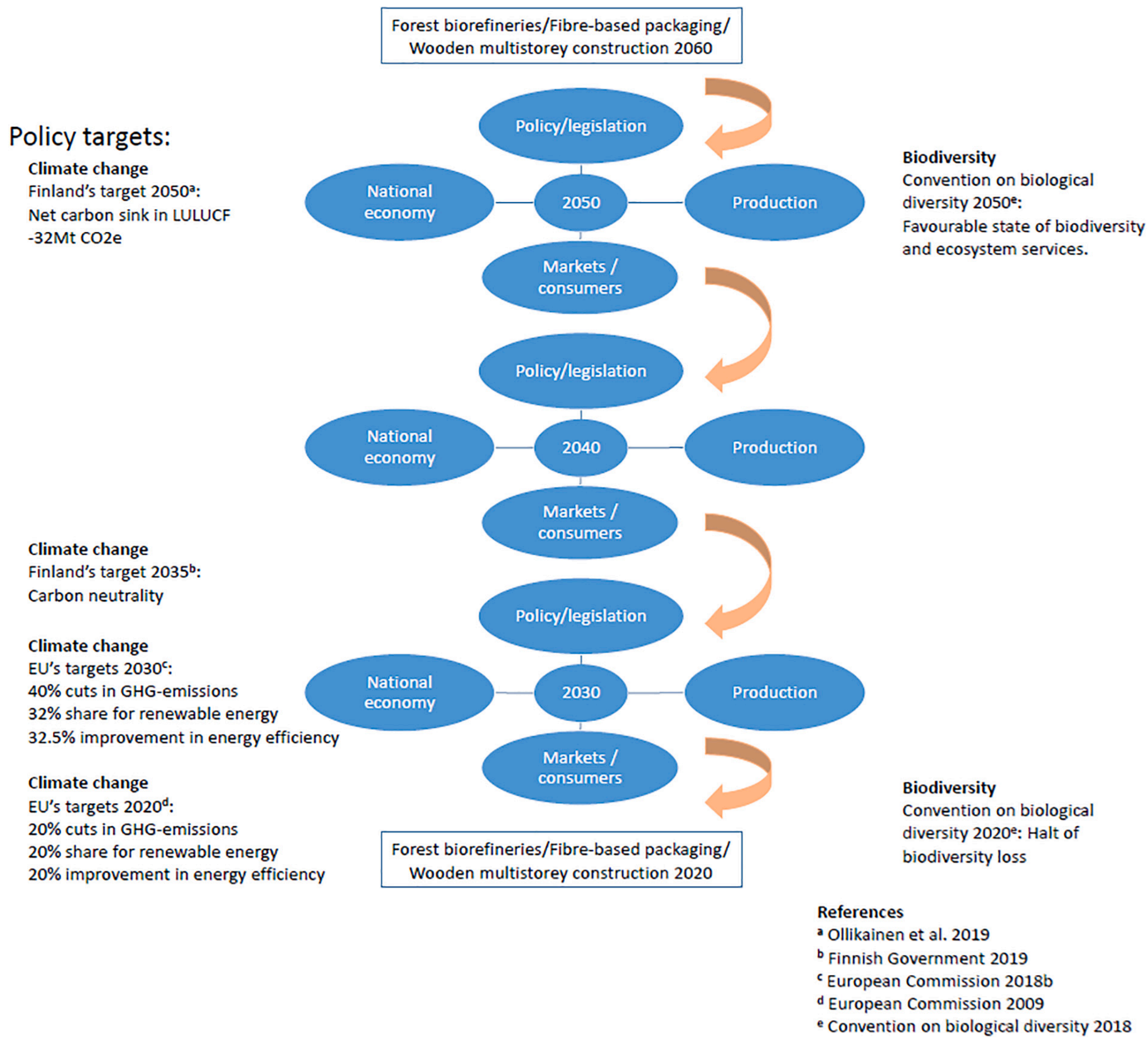

Fig. 2. The canvas for the backcasting workshop.

generating visions than thinking about the required actions. Thus, the emphasis between the visions and the required actions in the timeline varied between the groups.

The fourth step, the elaboration and analysis and the defining of the follow-up and action agenda, was initiated in the joint closing discussion of the workshop and the workshop data collection. All memos were combined and organised into a thematic table. The research materials collected in the workshop included filled canvases with the visions and pathways of each group (6 posters), the notes of each work group (19 pages), photographs of the posters (6) and video materials on the final presentations and closing discussions of visions and pathways (35 min). To analyse the workshop data, a thematic analysis was conducted to recognise common characteristics between the pathways (see also Sandström et al., 2020). We followed the canvas structure, but soon, this stage of analysis revealed that the thematic section *national economy* generated a marginal amount of data. Thus, the themes of the analysis were *policy/legislation, markets/consumers* and *production.*

The fifth step, embedding the results and generating follow-up and implementation, was initiated in the analysis of the research data. An overview of the identified visions was drawn as the analysis that proceeded, detailed in Results chapter, Fig. 3. We conducted a narrative analysis, and we constructed the required actions, imagined events and changes discussed in the workshops as reverse chronological stories as steps of the pathways (Polkinghorne, 1995; Boje, 2001). Finally, the transition pathways were compared. We identified common characteristics between the visions and required actions in and across the pathways, which are shown Results chapter, Table 6.

4. Results

The following section describes the results of the workshop data, which are summarised in Fig. 3. Along with the preconditions, defined as policy targets related to climate change mitigation biodiversity protection, the visions in 2060 and the transition pathways of the three different value networks, *forest biorefineries*, *fibre-based packaging* and *wooden multistorey construction*, are presented. First, sub-section (4.1) describes the identified visions in 2060. Second, sub-section (4.2) describes the transition pathways through required actions. The final sub-section (4.3) discusses the common characteristics.

4.1. The identified visions

With the precondition related to *biodiversity protection* targets reached by 2050, in 2060, diversified biorefining in 'diorefineries' adapt to changes in the markets and raw materials faster in comparison to today's long-term investments with market risks. Such forest

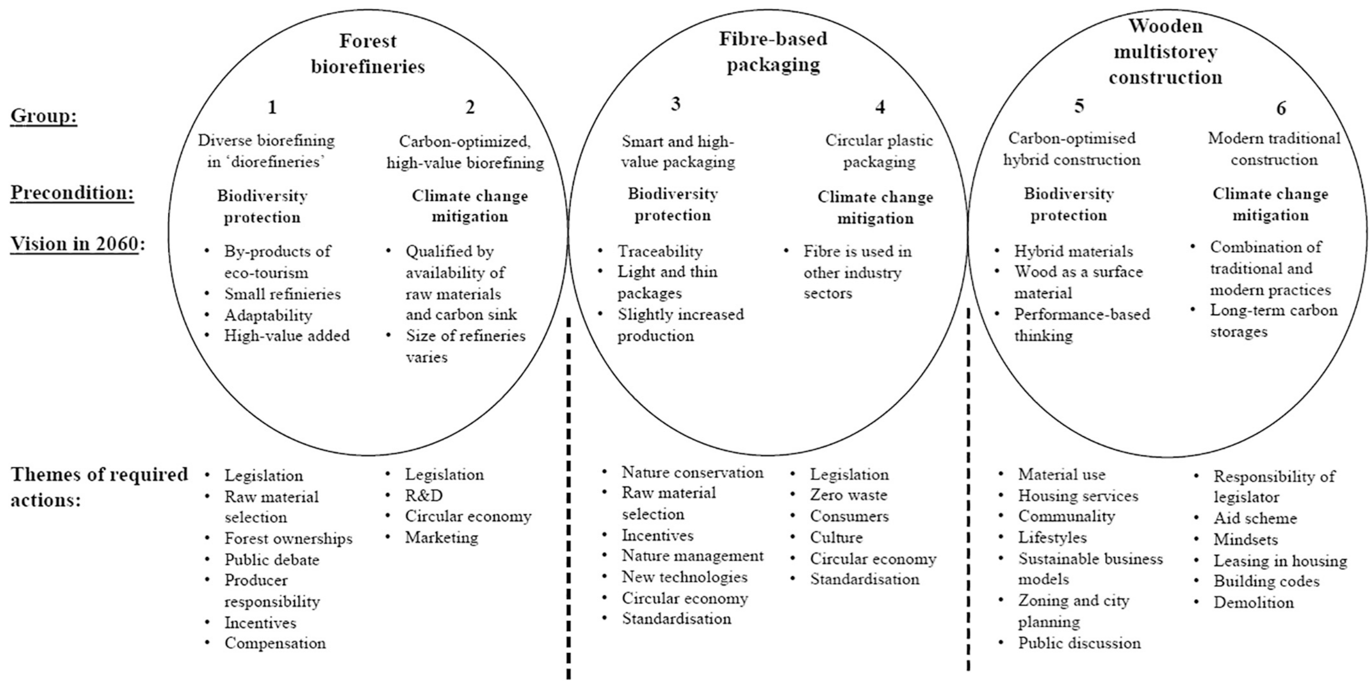

Fig. 3. The identified visions in the forest-based bioeconomy in Finland in 2060.

biorefineries are smaller, modular and possibly movable. High-value chemicals extracted from hemicellulose are the main products of forest biorefineries, but they are also by-products of eco-tourism. The prices of the products include environmental and biodiversity externalities caused by value chains (Fig. 3).

With the precondition related to *climate change mitigation* targets reached by 2050, in 2060, the tightening targets related to carbon sink will affect the availability of raw materials, possibly having an important role in how forest biorefineries are developed. Biorefining responds to demands by fulfilling the basic needs of housing, transportation and nutrition. The sustainability of materials from a climate perspective and carbon capture and related utilisation are mundane. Wood is used in the bioproducts, where its properties are supernal in comparison with other materials, such as toilet paper, textiles and nanocellulose. Both high value-added and carbon storages are achieved in the ideal situation. The size of the forest biorefineries varies. In 2060, the forests are still privately owned. Overall, the importance of the forest-based bioeconomy may decrease in the national economy as the environmental boundaries set limits to the growth of the sector.

With the precondition related to *biodiversity protection* targets reached by 2050, in 2060, the packaging regime is greatly changed: disposable packaging is terminated, and adverse impacts of plastic packages, e.g. impact on the water ecosystem, cause long-term uncertainty of the sustainable production of plastic packaging. Smart and traceable fibre-based packages with high-value added dominate the global packaging markets. Lighter and thinner packages have decreased material demand per unit. The production of fibre-based packaging is slightly increased in Finland due to increased global packaging demand.

With the precondition related to *climate change mitigation* targets reached by 2050, in 2060, the packaging regime is greatly changed: fibre-based packages do not exist, and plastic packages are dominant. Forest-based fibres are used in more valuable solutions, such as in the clothing industry. The circular plastic economy utilises durable, light and versatile plastics from existing materials, i.e. virgin raw oil is not used in the primary production of packages; however, virgin material is needed in some parts of the value chain, such as in the envisioned IT technology, such as drones, which require virgin materials. Circular plastic packaging is beneficial in comparison to disposable fibre packaging due to several considerations: a lot of plastic already exists (1), it is suitable for circular thinking (2) and the termination of raw oil use (3), existing plastic is used anyway (4) and disposable packaging is not in line with the principles of a circular economy (5).

With the precondition related to *biodiversity protection* targets reached by 2050, in 2060, wooden multistorey buildings are made of sustainable hybrid materials. Sustainable performance-based thinking facilitates eliminating black-and-white thinking and competitive positions between different materials. Biodiversity protection is a key value employed in the wooden multistorey construction businesses next to economy-led thinking. Biodiversity is improved in urban environments in addition to the protection of old-growth forests.

With the precondition related to *climate change mitigation* targets reached by 2050, in 2060, a mix of traditional and industrial construction combines old practices with modern technology. The carbon storage of multistorey buildings is longer than one life-cycle of a tree.

4.2. The identified transition pathways

The following section describes the transition pathways through the required actions and follows a chronological structure. First, the pathway is described decade by decade in accordance with the backcasting approach, meaning the story begins by introducing the steps in 2050–2040 and is followed by steps in 2040–2030 and is closed with the first steps in the near future in 2030–2020. More specific details of the identified transition pathways are presented in the Supplementary Material.

To achieve the visions of forest biorefineries in 2060 (Diverse biorefining in 'diorefineries' and Carbon-optimised, high-value biorefining), the envisioned transition pathways are summarised in Table 3. The envisioned transition pathways pose requirements for *policy/legislation, markets/consumers* and *production.* With the precondition related to biodiversity protection, required actions are needed to diversify the value network of forest biorefineries. With the precondition related to climate change mitigation, required actions are needed to facilitate flexible and high-value biorefining.

To achieve the visions of fibre-based packaging in 2060 (Smart and high-value packaging and Circular plastic packaging), the envisioned

Table 3
The envisioned transition pathways of forest biorefineries between 2020 and 2050.

Group	1 Diverse biorefining in 'diorefineries'	2 Carbon-optimised, high-value biorefining
Precondition	Biodiversity protection	Climate change mitigation
Required actions in the 2040s		
Policy/ legislation		• Possibly legislative barriers to limit forest estate sales for foreigners
Markets/ consumers		
Production	• Diversification of raw material selection • Increase in deciduous and mixed forest	• Diverse use of wood • Flexible product portfolio
Required actions in the 2030s		
Policy/ legislation	• Docile and adjustable • Consolidation with biodiversity • New forest law & convention on biological diversity	• Attractive operational environment
Markets/ consumers	• Supply control • Biodiversity in public debate	• Business to consumers marketing
Production	• Larger forest estates • Utilisation of decaying wood • Improvements in compensation system	
Required actions in the 2020s		
Policy/ legislation	• Biodiversity is part of policy • Support to biodiversity-friendly solutions	• R&D funding and skills development
Markets/ consumers	• Avoidance of polarisation development • Information steering	
Production	• Extended producer responsibility • Proactive forest-fire management	• Circular economy

transition pathways are summarised in Table 4. The envisioned transition pathways pose requirements for *policy/legislation*, *markets/consumers* and *production*. With the precondition related to biodiversity protection, required actions are needed to facilitate high-value packaging. With the precondition related to climate change mitigation, required actions are needed to enhance circular plastic packaging.

To achieve visions of wooden multistorey construction in 2060 (Carbon-optimised hybrid construction and Modern traditional construction), the envisioned transition pathways are summarised in Table 5. The envisioned transition pathways pose requirements for *policy/legislation*, *markets/consumers* and *production*. With the precondition related to biodiversity protection, required actions are needed to facilitate optimised material use and housing services of wooden multistorey construction. With the precondition related to climate change mitigation, required actions are needed to facilitate low carbon solutions of wooden multistorey construction.

Overall, the visioned transition pathways of the forest-based bioeconomy can follow three alternative pathways: an incremental pathway (Group 3), transformative pathway (Groups 1, 2, 5 & 6) or more radical pathway (Group 4). The incremental pathway (Group 3) follows slightly increased production and a primarily incumbent bioproduct portfolio; however, the changes in the existing systems, such as improvements in production and policy practices, allow for the required actions to achieve the policy targets. In the transformative pathways (Groups 1,2,5 & 6), the bioproducts have changed remarkably: raw

Table 4
The envisioned transition pathways of fibre-based packaging between 2020 and 2050.

Group	3 Smart and high-value packaging	4 Circular plastic packaging
Precondition	Biodiversity protection	Climate change mitigation
Required actions in the 2040s		
Policy/ legislation	• New nature reserves	
Markets/ consumers		• Zero waste • Could consumers own packages? • Changes in consumer behaviour & culture
Production	• Increase in deciduous forest • Nature management • Hardwood-based technologies • Improvements in fibre recycling	• Packages are designed to be recyclable • Standardization • IT
Required actions in the 2030s		
Policy/ legislation		• Legislation for standardization
Markets/ consumers		• Easy and accurate recycling
Production	• Geographic information of biodiversity in forest management • Global and unified standardization	• Investments to plastic recycling
Required actions in the 2020s		
Policy/ legislation	• Biodiversity incentives for forest owners	• Plastic standardization summit
Markets/ consumers	• Environmental awareness	
Production	• Investments • Realization of new technologies	

material selection and bioproduct portfolios have diversified. In the more radical pathway (Group 4), the industry sector has been driven to a turnaround, and the incumbent production is replaced by alternative solutions.

4.3. Common characteristics

Based on the above analysis, common characteristics between the envisioned transition pathways in Finland for 2020–2060 were identified from the group discussions (Table 6). First, common characteristics were analysed between the two alternative policy targets (climate change mitigation and biodiversity protection) in each sector: forest biorefineries, fibre-based packaging and wooden multistorey construction. We analysed common characteristics between the visions and the required actions. The biodiversity protection targets reached by 2050 was set as an environmental precondition for groups 1, 3 and 5. For groups 2, 4 and 6, the precondition was that by 2050, Finland has committed to reach a net carbon sink of −32 Mt. CO_2e in the land use, land use-change and forest (LULUCF) sector. Second, common characteristics between the visions and the required actions were examined across the sectors.

In Table 6, the first heading, *sector*, describes the analysed value networks (forest biorefineries, fibre-based packaging, wooden multistorey construction and cross-sectoral). The heading *cross-sectoral* describes the comparison across the value networks, such as forest biorefineries and biodiversity protection (Group 1) and wooden multistorey construction and biodiversity protection (Group 5). The second paragraph, *groups*[x)], describes the compared groups, which are explained following the table. The third heading, *common characteristics*,

Table 5
The envisioned transition pathways of wooden multistorey construction between 2020 and 2050.

Group	5 Carbon-optimised hybrid construction	6 Modern traditional construction
Precondition	Biodiversity protection	Climate change mitigation
Required actions in the 2040s		
Policy/ legislation		• Flexible and descriptive policy • Automation of decision-making • Explicit information label of used materials
Markets/ consumers	• Ecosystem services as a part of housing service	• Leasing in housing • Low-cost low carbon apartments
Production	• Transparent value chain • Optimised material use	• Diversification of forestry and value-chains • Simple materials • Easy demolition
Required actions in the 2030s		
Policy/ legislation		• Increased responsibility of legislators
Markets/ consumers	• Flexibility • Communality • Housing cooperatives	
Production	• Small apartments • Servitization of housing	
Required actions in the 2020s		
Policy/ legislation	• Knowledge in environmental impacts of sustainable business models • Zoning and city planning	• Aid scheme to minimise risks and support pilots • Changes in building codes
Markets/ consumers	• Public discussion regarding biodiversity • Living in one apartment • Tackling of traditional concerns	• Lock-out path-dependencies
Production	• High-quality buildings • High buildings	• Changes in conservative mindsets

Table 6
Summary of common characteristics between the envisioned transition pathways in the forest-based bioeconomy in Finland for 2020–2060.

Sector	Groups[a]	Common characteristics
Forest biorefineries	1,2	Forest diversification
	1,2	Diverse wood utilisation
	1,2	Various size of forest biorefineries
	1,2	Flexibility and adaptability
	1,2	High-value products
Fibre-based packaging	3,4	Investments
	3,4	Termination of disposable packaging
	3,4	Unified standardization system
Wooden multistorey construction	5,6	Diversification in housing
Cross-sectoral	1,2,3,6	Forest diversification
	1,2,3	Diverse wood utilisation
	1,5	Assessment of biodiversity impacts of products
	1,5	Ecological compensation
	1,2,3	High-value products
	1,6	Aid scheme
	2,3	Incentives

[a] Group 1 = forest biorefineries & biodiversity protection; group 2 = forest biorefineries & climate change mitigation; group 3 = fibre-based packaging & biodiversity protection; group 4 = fibre-based packaging & climate change mitigation; group 5 = wooden multistorey construction & biodiversity protection; group 6 = wooden multistorey construction & climate change mitigation.

describes the analysed content.

The raw material selection of future forest biorefineries is diversified due to an increase in the mixed and deciduous forests and diverse and specialised forestry practices in the envisioned transition pathways (Groups 1 and 2). Forest biorefineries are diverse in terms of physical size and resilience. In addition to large-scale units, smaller, modular and possibly movable units are common. Improved flexibility and adaptability due to the diverse use of wood allows for the adaptation to changes in the markets and raw materials, including an increased amount of decaying wood in markets due to weather extremes. High-value bioproducts, such as chemicals, textiles and nanocellulose, are the main products of forest biorefineries' value network; however, a detailed and specific demand that supports high value being added is needed.

The termination of disposable packages is viewed as desirable in the future of envisioned fibre-based packaging pathways. Unified standardization systems in forest management, such as a combination of the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC), as well as in the recycling of plastic packages are important. Investments are needed for both fibre-based packaging machines and plastic recycling. Consumer roles vary between the envisioned pathways, but the most notable contrast was identified for fibre-based packaging. On the one hand, the consumer role is marginal with the precondition of biodiversity protection (Group 3), where improvement in environmental awareness is only a consumer-related action. On the other hand, consumer role is essential with the precondition of climate change mitigation (Group 4), where changes in consumer behaviour and culture and following a 'zero waste lifestyle' are important.

Future wooden multistorey construction conforms to lifestyle changes and diversifies housing markets in the envisioned pathways (Groups 5 and 6). The empowerment of the housing services of wooden multistorey construction facilitates migration and moves the business environment towards the service sector by preferring housing cooperatives (in which the property is owned by a cooperation or corporation and is sold as shares for residents). The production of high-quality, low-cost, low carbon apartments and new housing services, such as leasing, diversifies markets. Furthermore, housing services take ecosystem services into account, such as through biodiversity compensation and personal nature reserves.

Forest diversification received great attention in the envisioned transition pathways (Groups 1, 2, 3 and 6). An increase in mixed and deciduous forest as well as diverse and specialised forest management can be supported by a new forest law and increases in the sizes of forest estates. Furthermore, the growth characteristics of deciduous trees in warmer climates and pest resistance can substitute for increasing damages of the boreal coniferous forest. Forest diversification allows for diversification in raw material selection for the forest industry. Thus, forest diversification facilitates more diverse wood utilisation, allowing new business opportunities to emerge (Groups 1,2 and 3). Changes in the value-chain and diverse wood utilisation, such as using hardwood-based technologies, can create more flexible product portfolios.

Biodiversity protection benefits from the assessment of products' biodiversity and ecosystem services' impacts on the envisioned bioeconomy transition pathways (Groups 1 and 5). Products' biodiversity impacts should be part of policy and decision making to achieve a transparent value-chain in the forest-based bioeconomy. The prices of the forest-based products include environmental and biodiversity externalities caused by value-chains, such as through compensation and personal nature reserves.

High-value products, such as chemicals, textiles, nanocellulose and packaging, are considered important in the envisioned pathways (Groups 1, 2 and 3). Interestingly, high-value products are not part of the visions or the required actions of the wooden multistorey construction pathways (Groups 5 and 6).

Changes in the aid scheme are needed in the envisioned bioeconomy transition pathways (Groups 1 and 6). New aid schemes and political support not only minimise risks of new businesses but also facilitate a faster implementation of new technologies and practices.

Incentives are considered important in both the upstream and downstream value-chains in the envisioned bioeconomy transition pathways (Groups 2 and 3). There is a need for incentives for forest owners to improve biodiversity as well as investments.

5. Discussion

The main contribution of this study is employing the participatory backcasting approach to studying pathways for systemic change in a forest-based bioeconomy. The study focus was two policy targets from the viewpoint of three forest-based value networks, and the backcasting workshop technique was applied to create visions beyond the near-future defined by existing political commitments and business investments. Our results offer insights into bioeconomy transition studies and related sustainability development by contributing to required actions within the environmental policy targets on climate change mitigation and biodiversity protection. Furthermore, our study contributes to the bioeconomy discourse by investigating the sustainability requirements of forest-based bioeconomy and the implementation of transformative pathways. On the one hand, the analysis of the envisioned transition pathways showed common characteristics, but on the other hand, the pathways were positioned differently in their degree of path dependence.

A high degree of path dependence of the envisioned incremental pathway (Group 3) resonates with dominating narratives of a bioeconomy transition (Bauer, 2018), the 'more of everything' pathway of the Finnish and Swedish forest policy strategies (Kröger and Raitio, 2017; Beland Lindahl et al., 2017) and the business-as-usual pathway of bioeconomy networks (Korhonen et al., 2018). However, the key aspects and drivers of the actors (Korhonen et al., 2018) and the envisioned more radical pathway (Group 4) with a low degree of path dependence support the possibility of a more radical change. This change is led by technology and legislation, where the consumer role is essential. Insights from scientific research and knowledge of raw material producers to diversify the network structure and open opportunities for 'niche businesses' are required (Priefer et al., 2017; Korhonen et al., 2018). Hence, the more radical pathway of a forest-based bioeconomy is driven by legislators, research, raw material producers and consumers as essential players rather than incumbent industries; however, company-level, cross-sectoral collaboration and clustering can enhance the development of new businesses and thus support product diversification (Luhas et al., 2019; Guerrero and Hansen, 2021). Thus far, bioeconomy related narratives indicate that the transition pathways to different bioeconomies are still open (Bauer, 2018).

The envisioned required actions of *policy/legislation*, *markets/consumers* and *production* in forest biorefineries, fibre-based packaging and wooden multistorey construction can have co-benefits in the policy targets regarding climate change mitigation and biodiversity protection. The majority of co-beneficial actions contributes to *policy/legislation* and *production*, such as land use strategies (Cowie et al., 2007), deforestation and degradation (Phelps et al., 2012) and conservation (Iwamura et al., 2013; Dinerstein et al., 2020); however, the robustness of co-benefits varies, such as among conservation priorities (Iwamura et al., 2013). Thus far, co-beneficial actions contributing to *markets/consumers*, such as ecological compensation and personal nature reserves, have received marginal attention in the context of a forest-based bioeconomy transition, and further analysis of the connection of actions is needed.

To grasp the systemic and complex interdependencies in the forest sector and to analyse alternative pathways, the backcasting method, which is an increasingly used research method, has been employed. Our study has allowed for envisioning and analysing future pathways that consider policy targets. Although we encourage future researchers to develop similar methodological approaches, our study revealed four major development areas to be considered in future studies. Dealing with complex issues in a limited timeframe of group discussions is challenging in practice. Our first suggestion for further methodological development deals with efficient time management. A clear structure for scheduling could help to dedicate sufficient time to discuss all the decade-specific steps in similar depth. The second key issue relates to the participants and group dynamics. In a small working group, the most radical or braking voices may be stronger than the consensus-driven ones, and the results may not reflect differences caused by the guiding environmental policy targets but rather compromises and strong individual views. Furthermore, we encourage providing instructions related to group discussions for the chair and the secretary to fulfil sufficient discussions and to prevent irrelevant topics. Thus, ideally, the groups should have 4–6 discussants. To involve participants with various backgrounds, expertise and value orientations (Carlsson-Kanyama et al., 2008) and thus to increase the diversity of participants, we encourage the use of remote access to ease the accessibility to participate.

Partly due to the aforementioned limitations, our third suggestion is to continue the assessment and to further develop the pathways after the initial workshop. This type of backcasting workshop initiates the process well, but it could be fruitful to add views of other stakeholder groups. For example, consumer and citizen roles were marginal in the envisioned transition pathways; however, consumer roles would be greater if non-expert users, such as citizens, are involved in the processes (Robinson, 2003). Moreover, this study considered only two environmental policy targets. In the development process of the visions, one could assess the visions from the viewpoint of the other environmental policy targets. Thus, further studies are encouraged to continue the assessment of the feasibility and possibilities of co-created stakeholder visions.

6. Conclusions

The participatory backcasting approach enables discovering bioeconomy transition pathways within environmental policy targets on climate change mitigation and biodiversity protection. Common characteristics can be identified from among the required actions of the value networks to achieve such targets. Furthermore, path dependence can support incremental development on bioeconomy transition pathways, and this should be considered when planning transition towards sustainability.

In the future, the forest-based bioeconomy value networks will be diversified. In connection with forests and forestry, entities composed of technologies and services will gain more attention. Adding value through sustainability will become more important, and a greater degree of value will be embedded in services connected either directly to natural ecosystems (e.g. eco-tourism in the forests) or processes of manufacturing industries (e.g. technological solutions to enhance the usability, longevity and recyclability of products). New businesses following sustainability logics may integrate into the traditional value networks and transform their views on businesses to support the fulfilment of the policy targets on climate change mitigation, biodiversity protection and securing the availability of forest-based biomass. However, the possibilities for business development (e.g. the potential to seek new solutions through changes in the use of materials and technologies, or co-operation with businesses, consumers or other stakeholders) vary between different companies because of the complex and characterised nature of value networks and their path dependencies.

Some similarities can be identified, especially with other Nordic countries, even though certain specific characteristics of the addressed value networks may limit the larger generalisation of this study. Future forest policy as well as researchers and companies should consider the interdependence of actions related to climate change mitigation and biodiversity protection in a forest-based bioeconomy. Future research could investigate the required actions to create value in transition pathways, co-beneficial actions (in the market and consumer sector in particular) and forest diversification to promote more diverse wood utilisation and high value forest-based businesses.

Declaration of Competing Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Appendix A. Supplementary data

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References

Bauer, F., 2018. Narratives of biorefinery innovation for the bioeconomy: conflict, consensus or confusion? Environ. Innov. Soc. Transitions 28, 96–107. https://doi.org/10.1016/j.eist.2018.01.005.

Boje, D.M., 2001. Narrative Methods for Organizational & Communication Research. Sage, London.

Budiharta, S., Meijaard, E., Gaveau, D.L.A., Struebig, M.J., Wilting, A., Kramer-Schadt, S., Niedballa, J., Raes, N., Maron, M., Wilson, K.A., 2018. Restoration to offset the impacts of developments at a landscape scale reveals opportunities, challenges and tough choices. Glob. Environ. Chang. 52, 152–161. https://doi.org/10.1016/j.gloenvcha.2018.07.008.

Carlsson-Kanyama, A., Dreborg, K.H., Moll, H.C., Padovan, D., 2008. Participative backcasting: a tool for involving stakeholders in local sustainability planning. Futures 40, 34–46. https://doi.org/10.1016/j.futures.2007.06.001.

Centeno, M.A., Nag, M., Patterson, T.S., Shaver, A., Windawi, A.J., 2015. The emergence of global systemic risk. Annu. Rev. Sociol. 41, 65–85. https://doi.org/10.1146/annurev-soc-073014-112317.

Convention on Biological Diversity, 2018. Key Elements of the Strategic Plan 2011–2020, Including Aichi Biodiversity Targets. https://www.cbd.int/sp/elements/.

Cowie, A., Schneider, U.A., Montanarella, L., 2007. Potential synergies between existing multilateral environmental agreements in the implementation of land use, land-use change and forestry activities. Environ. Sci. Pol. 10, 335–352. https://doi.org/10.1016/j.envsci.2007.03.002.

de Bruin, J.O., Kok, K., Hoogstra-Klein, M.A., 2017. Exploring the potential of combining participative backcasting and exploratory scenarios for robust strategies: insights from the Dutch forest sector. For. Policy Econ. 85, 269–282. https://doi.org/10.1016/j.forpol.2017.06.007.

Dietz, T., Börner, J., Förster, J., von Braun, J., 2018. Governance of the bioeconomy: a global comparative study of national bioeconomy strategies. Sustainability 10, 3190. https://doi.org/10.3390/su10093190.

Dinerstein, E., Joshi, A.R., Vynne, C., Lee, A.T.L., Pharand-Deschênes, F., França, M., Fernando, S., Birch, T., Burkart, K., Asner, G.P., Olson, D., 2020. A "global safety net" to reverse biodiversity loss and stabilize Earth's climate. Sci. Adv. 6, eabb2824 https://doi.org/10.1126/sciadv.abb2824.

Diop, Chérif Ibrahima Khalil, Lavoie, Jean-Michel, 2017. Isolation of nanocrystalline cellulose: a technological route for valorizing recycled tetra pak aseptic multilayered food packaging wastes. Waste Biomass Valorization 8 (1), 41–56.

Dreborg, K.H., 1996. Essence of backcasting. Futures 28, 813–828. https://doi.org/10.1016/s0016-3287(96)00044-4.

European Commission, 2009. 2020 Climate and Energy Package. Available online. https://ec.europa.eu/clima/policies/strategies_en.

European Commission, 2012. Innovating for Sustainable Growth: A Bioeconomy for Europe. Available online. https://op.europa.eu/en/publication-detail/-/publication/1f0d8515-8dc0-4435-ba53-9570e47dbd51.

European Commission, 2018a. A Sustainable Bioeconomy Strategy for Europe: Strengthening the Connection between Economy, Society and the Environment. Updated bioeconomy strategy. Available online. https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b69001aa75ed71a1/language-en/format-PDF/source-search.

European Commission, 2018b. 2030 Climate and Energy Framework. Available online. https://ec.europa.eu/clima/policies/strategies/2030_en.

Eyvindson, K., Repo, A., Mönkkönen, M., 2018. Mitigating forest biodiversity and ecosystem service losses in the era of bio-based economy. For. Policy Econ. 92, 119–127. https://doi.org/10.1016/j.forpol.2018.04.009.

Finnish Government 2019, 2019. Pääministeri Sanna Marinin Hallituksen Ohjelma 10.12.2019. Osallistuva ja Osaava Suomi – Sosiaalisesti, Taloudellisesti ja Ekologisesti Kestävä Yhteiskunta. Valtioneuvoston Julkaisuja, 31. http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161931/VN_2019_31.pdf?sequence=1&isAllowed=y.

Guerrero, J.E., Hansen, E., 2021. Company-level cross-sector collaborations in transition to the bioeconomy: a multi-case study. Forest Policy Econ. 123, 102355.

Heinonen, T., Pukkala, T., Mehtätalo, L., Asikainen, A., Kangas, J., Peltola, H., 2017. Scenario analyses for the effects of harvesting intensity on development of forest resources, timber supply, carbon balance and biodiversity of Finnish forestry. For. Policy Econ. 80, 80–98. https://doi.org/10.1016/j.forpol.2017.03.011.

Future of the European Forest-based sector: structural changes towards BE. In: Hetemäki, L. (Ed.), 2014. What Science Can Tell Us, 6. European Forest Institute.

Höjer, M., Mattsson, L.-G., 2000. Determinism and backcasting in future studies. Futures 32, 613–634. https://doi.org/10.1016/s0016-3287(00)00012-4.

Holmberg, J., Robert, K.-H., 2000. Backcasting - a framework for strategic planning. Int. J. Sustain. Dev. World Ecol. 7, 291–308. https://doi.org/10.1080/13504500009470049.

Hurmekoski, E., Jonsson, R., Korhonen, J., Jänis, J., Mäkinen, M., Leskinen, P., Hetemäki, L., 2018. Diversification of the forest industries: role of new wood-based products. Can. J. For. Res. 48 (12), 1417–1432.

Hurmekoski, E., Lovrić, M., Lovrić, N., Hetemäki, L., Winkel, G., 2019. Frontiers of the forest-based bioeconomy {\textendash} a European Delphi study. For. Policy Econ. 102, 86–99. https://doi.org/10.1016/j.forpol.2019.03.008.

Hurmekoski, E., Myllyviita, T., Seppälä, J., Heinonen, T., Kilpeläinen, A., Pukkala, T., Mattila, T., Hetemäki, L., Asikainen, A., Peltola, H., 2020. Impact of structural changes in wood-using industries on net carbon emissions in Finland. J. Ind. Ecol. 24, 899–912. https://doi.org/10.1111/jiec.12981.

Iwamura, T., Guisan, A., Wilson, K.A., Possingham, H.P., 2013. How robust are global conservation priorities to climate change? Glob. Environ. Chang. 23, 1277–1284. https://doi.org/10.1016/j.gloenvcha.2013.07.016.

Keys, P.W., Galaz, V., Dyer, M., Matthews, N., Folke, C., Nyström, M., Cornell, S.E., 2019. Anthropocene risk. Nat. Sustain. 2, 667–673. https://doi.org/10.1038/s41893-019-0327-x.

Kivimaa, P., Kern, F., 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. Res. Policy 45 (1), 205–217.

Korhonen, J., Giurca, A., Brockhaus, M., Toppinen, A., 2018. Actors and politics in Finland's forest-based bioeconomy network. Sustainability 10, 3785. https://doi.org/10.3390/su10103785.

Kröger, M., Raitio, K., 2017. Finnish forest policy in the era of bioeconomy: a pathway to sustainability? For. Policy Econ. 77, 6–15. https://doi.org/10.1016/j.forpol.2016.12.003.

Kunttu, Janni, et al., 2020. Preferable utilisation patterns of wood product industries' by-products in Finland. For. Policy Econ. 110, 101946.

Lindahl, K.B., Sténs, A., Sandström, C., Johansson, J., Lidskog, R., Ranius, T., Roberge, J. M., 2017. The Swedish forestry model: more of everything? For. Policy Econ. 77, 44–55. https://doi.org/10.1016/j.forpol.2015.10.012.

Luhas, J., Mikkilä, M., Uusitalo, V., Linnanen, L., 2019. Product diversification in sustainability transition: the forest-based bioeconomy in Finland. Sustainability 11, 3293. https://doi.org/10.3390/su11123293.

Müller, G., Hanecker, E., Blasius, K., Seidemann, C., Tempel, L., Sadocco, P., Pozo, B.F., Boulougouris, G., Lozo, B., Jamnicki, S., Bobu, E., 2014. End-of-life solutions for fibre and bio-based packaging materials in Europe. Packag. Technol. Sci. 27, 1–15. https://doi.org/10.1002/pts.2006.

Näsi, J., Lamberg, J.-A., Ojala, J., Sajasalo, P., 2001. Metsäteollisuusyritysten strategiset kehityspolut: kilpailu, keskittyminen ja kasvu pitkällä aikavälillä. Helsinki, Tekes.

Natural Resources Institute Finland, 2021. Statistics Database. Available online. http://statdb.luke.fi/PXWeb/pxweb/fi/LUKE/LUKE_04Metsa/?rrxid=37351054-dec1-4d3a-9964-7e4fad7f285c (accessed on 17 February 2021).

Näyhä, A., 2019. Transition in the Finnish forest-based sector: company perspectives on the bioeconomy, circular economy and sustainability. J. Clean. Prod. 209, 1294–1306. https://doi.org/10.1016/j.jclepro.2018.10.260.

Näyhä, A., Hetemäki, L., Stern, T., 2014. New products outlook. What Sci. Can Tell Us 6.

Neuvonen, A., Kaskinen, T., Leppänen, J., Lähteenoja, S., Mokka, R., Ritola, M., 2014. Low-carbon futures and sustainable lifestyles: a backcasting scenario approach. Futures 58, 66–76. https://doi.org/10.1016/j.futures.2014.01.004.

Newell, R.G., 2010. The role of markets and policies in delivering innovation for climate change mitigation. Oxf. Rev. Econ. Policy 26 (2), 253–269.

Ollikainen, M., Weaver, S., Seppälä, J., 2019. An approach to nationally determined contributions consistent with the Paris Climate Agreement and climate science: Application to Finland and the EU. In: The Finnish Climate Change Panel Report 7/2019. https://www.ilmastopaneeli.fi/wpcontent/uploads/2019/10/Finlands-globally-responsible-contribution_final.pdf.

Parida, V., Burström, T., Visnjic, I., Wincenta, J., 2019. Orchestrating industrial ecosystem in circular economy: a two-stage transformation model for large manufacturing companies. J. Bus. Res. 101, 715–725.

Pätäri, S., Kyläheiko, K., Sandström, J., 2011. Opening up new strategic options in the pulp and paper industry: case biorefineries. Forest Policy Econ. 13 (6), 456–464. https://doi.org/10.1016/j.forpol.2011.06.003.

Pelli, P., Lähtinen, K., 2020. Servitization and bioeconomy transitions: insights on prefabricated wooden elements supply networks. J. Clean. Prod. 244, 118711. https://doi.org/10.1016/j.jclepro.2019.118711.

Phelps, J., Webb, E.L., Adams, W.M., 2012. Biodiversity co-benefits of policies to reduce forest-carbon emissions. Nat. Clim. Chang. 2, 497–503.

Poesche, J., Lilja, K., 2016. Path-dependency and the road to off-path: the case of the Finnish forest industry. O Pap. 77, 64–70.

Polkinghorne, D.E., 1995. Narrative configuration in qualitative analysis. Int. J. Qual. Stud. Educ. 8 (1), 5–23.

Priefer, C., Jörissen, J., Frör, O., 2017. Pathways to shape the bioeconomy. Resources 6, 10. https://doi.org/10.3390/resources6010010.

Purkus, A., Hagemann, N., Bedtke, N., Gawel, E., 2018. Towards a sustainable innovation system for the German wood-based bioeconomy: implications for policy design. J. Clean. Prod. 172, 3955–3968. https://doi.org/10.1016/j.jclepro.2017.04.146.

Quist, J., Vergragt, P., 2006. Past and future of backcasting: the shift to stakeholder participation and a proposal for a methodological framework. Futures 38, 1027–1045. https://doi.org/10.1016/j.futures.2006.02.010.

Ranta, V., Keränen, J., Aarikka-Stenroos, L., 2020. How B2B suppliers articulate customer value propositions in the circular economy: four innovation-driven value creation logics. Ind. Mark. Manag. 87, 291–305.

Rinkinen, A., 2020. Imatran Tehtaat Mukana Maailman Muutoksessa. Stora Enso Imatran tehtaat, Iisalmi. ISBN 952-9690-22-3.

Robinson, J., 2003. Future subjunctive: Backcasting as social learning. Futures 35, 839–856. https://doi.org/10.1016/s0016-3287(03)00039-9.

Robinson, J.B., 1990. Futures under glass. Futures 22, 820–842. https://doi.org/10.1016/0016-3287(90)90018-d.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J.A., 2009. A safe operating space for humanity. Nature 461, 472–475. https://doi.org/10.1038/461472a.

Sandström, C., Carlsson-Kanyama, A., Lindahl, K.B., Sonnek, K.M., Mossing, A., Nordin, A., Nordström, E.M., Räty, R., 2016. Understanding consistencies and gaps between desired forest futures: an analysis of visions from stakeholder groups in Sweden. Ambio 45, 100–108. https://doi.org/10.1007/s13280-015-0746-5.

Sandström, C., Kanyama, A.C., Räty, R., Sonnek, K.M., Nordström, E.-M., Mossing, A., Nordin, A., 2020. Policy goals and instruments for achieving a desirable future forest: experiences from backcasting with stakeholders in Sweden. For. Policy Econ. 111, 102051. https://doi.org/10.1016/j.forpol.2019.102051.

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sorlin, S., 2015. Planetary boundaries: guiding human development on a changing planet. Science (80) 347, 1259855. https://doi.org/10.1126/science.1259855.

Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D., Summerhayes, C.P., Barnosky, A.D., Cornell, S.E., Crucifix, M., Donges, J.F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R., Schellnhuber, H.J., 2018. Trajectories of the earth system in the Anthropocene. Proc. Natl. Acad. Sci. 115 https://doi.org/10.1073/pnas.1810141115, 8252 LP-8259.

Temmes, A., Peck, P., 2020. Do forest biorefineries fit with working principles of a circular bioeconomy? A case of Finnish and Swedish initiatives. For. Policy Econ. 110, 101896. https://doi.org/10.1016/j.forpol.2019.03.013.

Toppinen, A., Sauru, M., Pätäri, S., Lähtinen, K., Tuppura, A., 2019. Internal and external factors of competitiveness shaping the future of wooden multistorey construction in Finland and Sweden. Constr. Manag. Econ. 37 (4), 1–16.

Ulaga, W., Reinartz, W.J., 2011. Hybrid offerings: how manufacturing firms combine goods and services successfully. J. Mark. 75, 5–23.

van der Voorn, T., Svenfelt, Å., Björnberg, K.E., Fauré, E., Milestad, R., 2020. Envisioning carbon-free land use futures for Sweden: a scenario study on conflicts and synergies between environmental policy goals. Reg. Environ. Chang. 20, 35. https://doi.org/10.1007/s10113-020-01618-5.

Vergragt, P.J., Quist, J., 2011. Backcasting for sustainability: introduction to the special issue. Technol. Forecast. Soc. Change 78, 747–755. https://doi.org/10.1016/j.techfore.2011.03.010.

Viholainen, N., Kylkilahti, E., Autio, M., Pöyhönen, J., Toppinen, A., 2021. Bringing ecosystem thinking to sustainability-driven wooden construction business. J. Clean. Prod. 292, 1–13.

Vukasinovic, V., Gordic, D., Zivkovic, M., Koncalovic, D., Zivkovic, D., 2019. Long-term planning methodology for improving wood biomass utilization. Energy 175, 818–829. https://doi.org/10.1016/j.energy.2019.03.105.