ROSE WOOD 4.0 Sustainable Wood for Europe

NORTHERN HUB ROADMAP

rosewood-network.eu

Northern Hub Roadmap

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862681.

Table of contents

1. Introduction

Modern information and communication technologies (ITC) continue to develop rapidly in all sectors of the economy and society. The forestry sector (compared to agriculture or manufacturing sectors) is however lagging behind in terms of adaptation and spreading of modern ICT solutions. A major challenge is the large variety of ecosystems, forest owner types, supply chain actors and stakeholders, and regional disparities of technological progress. Forest industry 4.0 solutions (including new measurement sensors, high resolution digital maps, forest planning tools, risk monitoring, realtime data exchange and control, logistical optimisation, etc.) are a major field of innovation and future market, which will enable continuous information exchange at all stages in the supply chain, tracking timber flows from forest harvesting to processed wood products and markets. Furthermore, Decision Support Systems (DSS), educational tools and marketing platforms for forest owners are more and more emerging to connect knowledge and practice, and the actors within a region. This will leverage huge benefits for resource efficiency, sustainable use and climate change mitigation. These solutions can however only be exploited to their full potential, if they are more adapted and adopted, disseminated and deployed in the various regional contexts. The need for broader sharing of ITC-driven solutions and best practices is imminent and increasing, to maintain and enhance the competitiveness of Europe's forest industry by transforming it to a forest industry 4.0.

Digitalisation is one of the most powerful drivers of change in all aspects of society. In forestry, it has the potential to enhance the information flows and the relationships between actors (owners, managers, authorities, workers, communities and society) at all steps of the value chain. It has the potential to improve decision-making, empower forest managers and workers to achieve greater sustainability and fulfilment of multi-functionality standards as well as improving efficiency and transparency. However, the adoption of digital solutions is generally slow and very uneven across Europe. Through its Roadmaps, ROSEWOOD4.0 identifies and supports the adoption of close to market solutions and the replication of success cases by stakeholders of the value-chain.

Throughout Europe, the challenges for a sustainable wood mobilisation are diverse and often a lack of specific knowledge leads to non-ideal solutions. However, international and interregional knowledge transfer offers the potential to improve this situation. Against this background, the ROSEWOOD4.0 project has initiated five regional Hubs throughout Europe bringing together 21 partners from 18 countries to steer the interregional knowledge transfer on sustainable wood mobilisation:

- Northern Europe: Finland, Sweden, Norway, Baltic countries, Denmark
- Central-West Europe: Germany, Belgium, France, Switzerland, Austria
- Central-East Europe: Czech Republic, Hungary, Poland, Romania, Slovakia, Ukraine
- Southern-West Europe: Spain, Italy, Portugal and South of France
- Southern-East Europe: Bulgaria, Croatia, Greece, Slovenia

These 5 communities within ROSEWOOD4.0 will facilitate wood mobilisation through mutual learning across European regions. ROSEWOOD4.0 builds on the insights and experience gained in recent research and innovation efforts and will implement specific activities to reinforce digitalisation of the forestry domain with a sharp focus in the most relevant innovation opportunities in the following areas which are highly impacting the sustainable wood mobilisation: (a) Engaging forest owners and overcoming land tenure fragmentation, improved forest planning and risk management, adapted silvicultural measures for increased multifunctionality and biodiversity conservation; (b) Design and maintenance of infrastructures, optimized forest operations and logistics for improved economic and environmental performance; (c) Organisation and transparency of regional wood markets; new business models and market arrangements; (d) Access to finance and business support, including through EAFRD measures and PES (payment for environmental services) type mechanisms; legal and fiscal regimes; (e) Education, training and skills development.

By creating adapted materials and extensively sharing technological and non-technological innovations, best practice cases and RDI results, **ROSEWOOD4.0 multi-stakeholders approach** closes knowledge gaps and creates new opportunities for economic partnerships within the whole wood mobilisation value-chain. ROSEWOOD4.0 focuses on tailored (user- and region-specific) **transfer of know-how and information** that enables and supports **stakeholders of the wood value-chain to exploit innovations and best-practices** and facilitates the capture of innovative ideas enhancing the development of the field. ROSEWOOD4.0 aims also to provide practitioners with development skills (educational and entrepreneurial) and facilitate organisational innovations leading to **novel exploitation actions** leveraging the uptake of new ideas and Best Practices in daily business.

The roadmaps presented here address stakeholders throughout Europe for facilitating the transfer of knowledge and collaboration between partnership regions. The roadmaps represent the collection, the analysis and strategic direction of the results from the five Hub regions including their validation. The main objective of the roadmaps on Hub level is to strengthen the regions through transfer of the gathered knowledge, experiences and circumstances. With the accurate description and assessment of well-functioning best practices and innovations as inputs, there is an active support in strengthening the local wood value-chain development thanks to newly developed digital tools. Further, the roadmaps enhance cooperations by increasing interactions between stakeholders and regions for creating opportunities to initiate further and new developments. Relying on networks , it supports the self-initiative and empowers the forestry to push new actions. For this purpose, the roadmaps highlight best practices and innovations (BPI) that have the potential to serve as tools for prosperous and sustainable wood mobilisation among European regions. ROSEWOOD4.0 has initiated a web-portal for presenting the best practices and innovations to the wider public and stakeholders. This way, new solutions can be incorporated and the transfer of best practices monitored. The roadmaps give readers insights into regional perspectives of wood mobilization, capitalizing on information and cooperation possibilities between European regions. By steering the knowledge transfer between the regions, the roadmaps aim to provide a European perspective on digitilization issues in the forestry domain. In times of structural changes, a changing climate and new technologies, the ROSEWOOD4.0 Hubs can rely on a broad knowledge base from various countries for identifying suitable approaches for their regions. For this purpose, the roadmaps shall pave the road towards more collaboration between the regions, transfer of best practices and innovations meeting the needs of the regions. All this will further develop the ROSEWOOD4.0 network and strengthen the individual regions onto their path towards a sustainable wood mobilization and the transition to a bio-based economy in Europe.

2. Interregional Roadmap for the Northern Hub

2.1 Description of the Northern Hub region

The Northern Hub of the ROSEWOOD4.0 project covers the Northern part of Europe, with a special focus on Finland, Sweden and Norway. The three countries will be briefly introduced in the next paragraphs. Most of the forests in the Northern Hub belong to the boreal forest zone, also referred to as taiga forests. Climate is subarctic with a large temperature range between seasons.

For all three countries considered, conservation of biodiversity is a priority policy issue in both scientific and operational aspects. The Northern model for protecting forest biodiversity is a combination of general conservation considerations in all forest management and the designation of more strictly protected forest areas. Even-aged forestry has been the dominant silvicultural system in Sweden, Finland and Norway since the 1950s. The silvicultural system follows a cyclic harvest-and-regeneration pattern on the stand level. To obtain a long-term sustainable flow of timber from the forest, an even age-class distribution on the regional and national level has been a long-term target in forest policy.

Finland is the most forested country in Europe. Forests cover 75 % of the land surface with 22.8 mio. hectares of forest land. The majority of the Finnish forests (85 %) are PEFC-certified, while another 10 % are FSC-certified. Private, non-industrial owners possess 61 % of the forest area, whereas 25 % is state-forest and 8 % belong to private industries. Statistically, this translates into four hectares per citizen in Finland, while the European average is only 1.3 hectares.

Forest inventories in Finland have a very long tradition, the first nationwide forest inventory was made already in the 1920s. Finland was the first country in the world which completed its national forest inventory (NFI) in 1924. The ongoing NFI cycle is 13th. The results of nationwide national forest inventories are widely used. Planning of national forest policies has been the most important motivation for funding NFIs. The collected information has been used to prepare forest sector Master Plans with an aim to increase the production of timber. In recent decades, these Master Plans or forest strategies have recognized the need for sustainable development, considering economic, ecological, and social aspects, and in recent years increasingly the need for mitigating climate change.

The dominating tree species in Finnish forests are spruce, pine, downy birch and the silver birch, Finland's national tree species. In total, approximately 30 tree species are naturally present in Finland. Most of them are deciduous, with only four conifers: Scots pine, Norway spruce, common juniper and European yew. Some of the tree species – of these conifers, juniper and European yew – often remain bush-like. These species are common throughout Finland, apart from northernmost Lapland and the highest fell areas. Additionally, many non-indigenous species are cultivated in Finland, mainly used for ornamentals, even though they are not significant in timber production. Among these, conifers have been of particular interest for Finland for a long time, due to the limited number of native coniferous tree species.

Paper production in Europe is concentrated in the Northern European countries including Finland, Russia, and Sweden. Finland is among the leading pulp and paper producers in the world, with an annual production of 11.3 mio. tons. Forest-based industry products account for over 20 % of the exported products in Finland (worth 13.1 mio. €).

In order to further increase the economic production of bio-based products, there have been plans of a biofuel factory and 1-2 biorefineries, which would rely on sustainable felling and removal of stem wood. In February 2021, the Metsä Group announced its investment decision to build a bioproduct mill in the South-western part of Lapland, Kemi. The new mill will be the historically largest forest industry investment (1.6 billion €) in Finland.[1]

The region of Finnish Lapland is a highly forested region with 90,700 km² of forestry land, meaning 98 % of the total area is forested land. The region of Lapland comprises seven national parks, 12 wilderness areas, 8 nature parks and around one quarter of the forests are under conservation. Relying on a total standing timber volume of 417 mio. m³ in Lapland, the share of forest-based bio economy in output, employment, added value and investments is much higher than in other parts of Finland. The forestry industry creates a total output of 1.3 billion € per year resulting from a utilization of 5.8 mio. m^3 of wood per year, which is mostly used locally by the forest industry, sawmills etc. Contrary to the national level, only around one third of the forests are owned privately, while the largest share of 60 % is state-owned forest, complemented by companies, parishes etc. owning 7 %. While the average size of a forest estate is 46 hectares, a total of 330,000 hectares belong to forest consolidations.

[1] Metsä Group, Investments, https://www.metsagroup.com/en/about-us/Investments/Pages/default.aspx (31.08.21).

• 90,700 km² of forestry land • Approx. 2.13 million hectares area of private forest holding • 330,000 hectares area of jointly owned forests • 32932 pcs private forests • 417 mio. m³ gross volume of the stand • 12.2 mio. m³ increment of growing stock per year • 6.33 mio. m³ cutting possibilities of commercial timber

Table 1: Facts on Finish Lapland Forestry[2]

Forests	Economic significance
• 75 % of Finland is forest land • Total volume in forest 2 482 million m^3 • The annually growth is 108 million m^3 • The annually felling is 73.3 million m^3 • 85 % of the forest land is in active use • 13 % of the forest land is protected • Forest sector is 4 % of GNP in Finland • Every year, at least 150 million trees are planted in Finland • Over the past 100 years, Finland's forest volume increased by 90 %	• World's 4th largest exporter of pulp, paper and sawn timber • Export value, 2018: € 13.2 billion • 96 % of board, 94 % of paper and 43 % of pulp are exported • Over € 700 million was invested in 2018
Production volumes, 2018	**Energy**
• 8.2 million tons of pulp (of which 4.3 million tonnes market pulp) • 6.7 million tons of paper • 11.8 million m3 of sawn timber • Employment • 41,000 employees in forestry	• 75 % of the heating energy used by the forest industry is wood-based bioenergy • Electricity consumption: 25 % of Finland's total electricity consumption.
Sustainability[3] • The purpose of forest legislation is to promote economically, ecologically, socially and culturally sustainable forest management and use in order that they produce a good output in a sustainable way while their biodiversity is being preserved. • The sustainability of forest management is assessed and monitored on the basis of the Pan-European Criteria and Indicators for Sustainable Forest Management. The National Forest Inventory (NFI), the monitoring system for forests and forest resources, produces diverse information on Finnish forests • The certification systems currently in use in Finland are the PEFC and FSC. Most of the commercial forest area in Finland, about 90 %, is certified under Finland's PEFC scheme, while about 10 % is certified under the FSC standard.	

Table 2: Facts on Finnish forests[4]

[2] https://www.metsakeskus.fi/sites/default/files/infografiikka-lapin-metsat-arktinen-alykas-eng.pdf.
[3] Sustainable forest management - Maa- ja metsätalousministeriö (mmm.fi).
[4] Natural resources Institute Finland.

Two thirds of ***Sweden's*** land surface – or some 28 million hectares – is covered by different types of forests. Of this, some 23 million hectares are considered productive forests. The forest sector's importance to the national economy is significant. More than 300,000 private individuals own forest land themselves. Family-owned forests represent around 50 % of the total forest area and some 60 % of the total annual yield. For many other people, the country's forests are also important – for hunting, for picking berries and mushrooms, for recreation, tourism and contemplation.

Sweden is a forest nation, and the forest industry plays a major role in the Swedish economy. Today, the forest industry accounts for 9-12 % of the Swedish industry's total employment, exports, sales and added value, according to figures from the Swedish Federation of Forest Industries 2014. The forest industry is heavily export-oriented and makes a significant contribution to Sweden's trade balance.

The largest landowner in Sweden is state-owned Sveaskog AB, which owns 3.1 million hectares of forest land, or almost 14 % of the country's forest land. The Swedish Church is also a large forest owner with 990,000 hectares.

The basic idea guiding Swedish forest policy and forestry-model is that forests shall be managed to provide economic, ecologic, as well as social benefits. Efficient and sustainable production of wood for different end-uses shall go hand in hand with the preservation of valuable ecological- and socio-cultural values. In Sweden, the multi-functional role of forests is safeguarded through regulations on the use of forests across the entire forest area. In addition, land with significant ecological - or other values is protected, or the management of such land is adapted.

The forest industry plays an important role for the Swedish economy. It is also heavily export-oriented and makes a significant contribution to Sweden's trade balance. Sweden is the world's second largest exporter of pulp, paper and sawn wood products combined. Of the pulp and paper production, close to 90 % is exported. As for pulp production, around a quarter of the total consumption of pulp within the EU are manufactured in Sweden. Of the Swedish industry's employment, turnover and value added, the forest industry accounts for 10-12 %.

The Region North Middle Sweden consists of three counties: Gävleborg, Dalarna and Värmland. The area borders the Baltic Sea in the east, Norway in the west and extends in a belt across the middle parts of the country and Middle Norrland in the north. The area has rich natural resources, a magnificent and varied environment, with mountainous areas in Dalarna, large areas of forest in Värmland with deep valleys and a long coastal strip in Gävleborg. North Middle Sweden has several joint business development opportunities with great potential in relation to trade and industry. There is a total of 41 municipalities with a population of approximately 826,000, giving a population density of 13 persons per km^2. North Middle Sweden is undergoing a shift from being an industrial community to a knowledge-based community, while the issue of climate change is becoming increasingly significant.

This necessitates an enhanced focus on regional growth efforts. The next Structural Funds programme for North Middle Sweden will therefore focus on renewal and sustainable growth. North Middle Sweden is near expansive growth markets such as the Mälardalen valley and Norway/the Oslo region. This presents opportunities for trade and industry in the shape of important sales markets for products and services. It also makes larger labor market regions possible. The Europe 2020 strategy emphasizes three priorities of key significance for development and growth in Europe over the next 7-year period.

- Smart growth, developing an economy based on knowledge and innovation
- Sustainable growth, promoting a more resource efficient, greener and more competitive economy and increasing the standing timber with 15 %
- Inclusive growth, fostering a high-employment economy delivering social and territorial cohesion
- 5.6 million hectares forest

• 56,000 forest owners • 685 million m^3 standing timber in the forests • 20,5 million m^3 harvested for industry in 2019 • 23,000 employees in the forests

Table 3: Facts on North Middle Sweden

Forests • 70 % of Sweden is forest land • Total volume in forest 3,533 million m^3 • The annually growth is 120 million m^3 • The annually felling is 80 million m^3 • 80 % of the forest land is in active use • Every year, at least 380 million trees are planted in Sweden • Over the past 100 years, Sweden's forest volume increased by 100 %	**Economic significance** • World's 3rd largest exporter of pulp, paper and sawn timber • Export value, 2018: € 14.5 billion • 80 % of the products are exported • A little over € 1.54 billion was invested in 2018
Production volumes, 2018 • 11.9 million tonnes of pulp (of which 4.3 million tonnes market pulp) • 10.1 million tonnes of paper • 18.3 million m^3 of sawn timber • Employment • 70,000 employees in forestry • A further 50,000 one-man businesses active in forestry	**Energy** • 96 % of the heating energy used by the forest industry is bioenergy. • Electricity consumption: 20 TWh per year – just over 15 % of Sweden's total electricity consumption.
Sustainability • Of the country's total greenhouse gas emissions, the forest industry accounts for around 1 %. • Since the start of the 1980s, pulp and paper mills have reduced the organic materials they release into the water system by 90 %. At the same time, pulp production has risen by 30 %. • Since the start of the 1980s, pulp and paper mills have reduced the sulphur compounds they release into the air by 98 %. At the same time, pulp production has risen by 30 %.	

Table 4: Swedish Forests in facts

Almost 38 % of the land area in ***Norway***, or 121,000 km^2 (12.1 mio hectares), in Norway is covered by forest.[5] Of this, around 82,800 km^2 (8.28 mio hectares) is productive forest, which means that it produces enough timber to be economically important. The total standing timber volume in the Norwegian forests is 978 mio m^3, and the annual regrowth is 24.2 mio m^3. The dominant tree species is the Norwegian Spruce with a standing volume of 428.3 mio m^3 and an annual regrowth of 12.8 mio m^3, followed by Scots Pine with 302 mio m^3 standing volume and 5.5 mio m^3 annual regrowth. The annual harvest is about 12 mio m^3, meaning that there are opportunities to increase the harvest without reducing the volume in forests over time. The export of timber increased significantly over the years 2012-2016 and is now about 3.5 mio m^3 annually.

There are more than 125,000 separate forest properties in Norway, and 77 % of the area is owned by private individuals, mainly farmers. 60 % of the properties are 25 hectares or smaller. Each year, there is conducted

[5] Statistics Norway.

harvesting on about 14,000 of the properties. While forestry is a traditional and important industry in Norway over most of the country, the largest forest county is Inland county. Around 25,000 persons are employed in the forest-based value-chain in Norway[6] . Almost all of the Norwegian forests are PEFC- or FSC-certified[7].

The Inland Region is the largest forest region in Norway; approximately 50 % of the region's area – 2.6 million hectares – is forest, and the region accounts for 26 % of both the national productive forest area and timber volume, as well as 40 % of Norway's annual harvest of timber. 37 % of the harvested timber come from properties larger than 500 hectares, 27 % from properties of 100-500 hectares and 36 % from properties smaller than 100 hectares. 87 % of the timber comes from forests owned by private persons and municipalities. 53 % of the standing volume in the forest is spruce, 37 % pine and the rest are various deciduous trees. 43 % of the national value creation in the primary forestry is made in the Inland Region, which employs 2,200 people, and provides a basis for 6,300 employees throughout the value chain. The region comprises 11 national parks and more than 300 nature reserves and other areas protected by law.

• 2,6 million hectares forest • 230 million m^3 standing timber in the forests • 4,6 million m^3 harvested for industry in 2019 • Timber sale worth €200 million • 2200 employees in the forests • 6300 employees throughout the value chain • 18000 km private forest road

Table 5: Facts on the Inland Region

Forests	Economic significance and employment
• Norwegian forests cover an area of 12.1 million hectares – 38 % of the land area • Total volume is 978 million m^3 • Annual cuttings 12 million m^3 • Annual growth 12,8 million m^3 • 43 million trees planted in 2019, the number increases annually	• Almost 6,000 employees in forestry • About 21,000 employees in forestry and wood-based industry • Export value timber and paper, 2019; € 906 million • Average annual income from forestry for forest owners, 2019: € 4,200 • Total production value of timber and wood products through the value chain is approx. € 3.8 billion, or 0.5 % of Norway's total value creation
Production volumes, 2018 • 4.4 million m^3 timber for pulp industry • 5.9 million m^3 sawn timber • Employment • 25,000 employees in the forest-based value chain	
Sustainability • 6 million hectares – 75 % of the productive forest area is PEFC-certified • 0,4 million hectares – about 100 properties – are certified by both PEFC and FSC • 70,000 key biotopes, covering about 75,000 hectares forest, are registered	

Table 6: Norway forest in facts

[6] Regjeringen.
[7] Skogeierforbundet.

2.1.1 Political Targets for Wood Mobilisation and Forestry

Under the scope and aims of the Arctic Council, climate change mitigation and reducing black carbon emissions are sought. The Arctic Council is the leading intergovernmental forum promoting cooperation, coordination and interaction among the Arctic States, Arctic indigenous communities and other Arctic inhabitants on common Arctic issues, in particular on issues of sustainable development and environmental protection in the Arctic.[8] The Ottawa Declaration lists the following countries as Members of the Arctic Council: Canada, Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden and the United States. Climate change and environmental protection are at the core of Arctic cooperation.

Common areas of interest of the Northern Hub include capacity building, risk management, connectivity, cold-climate technologies and services, maritime transport, energy, bio economy, tourism, housing and mining. Putting into practice the commitments of the Paris Climate Agreement will be the most important contribution from the Member States in addressing climate change. At the same time, the implementation of the Arctic Council's "Framework for Action on Enhanced Black Carbon and Methane Emissions Reductions" (2015) will provide an additional measure. Northern Hub countries thus encourage projects and actions aimed at reducing emissions, facilitating adaptation, and raising awareness on climate change.

Maintaining diversity is an important part of current forest management in all Northern countries. In 2020, the European Union has published a biodiversity strategy to turn Europe's biodiversity on a path to recovery by 2030. The strategy is very ambitious, and it will have a great influence on the forest industry.

In *Finland*, forestry policy aims to steer the choices made by forest owners and the use of forests in the direction desired for society. International weightings are increasingly influencing the content of national policies. Forest policy guides forest and natural management, logging and harvesting of wood. The means of forestry policy have traditionally been divided into:

- regulation, such as forest legislation,
- economic guidance such as the Fixed-Term Financing Act for Sustainable Forestry (Kemera) and taxation, as well as
- information guidance, such as forest owners' advice and forest planning.

As the emphasis on the use of forests in society changes, efforts are being made to guide forest owners and the use of forests by changing the above instruments.[9]

In *Sweden*, forest policy equates environmental goals with production goals. Current forest policy has two overarching and equal goals, namely a production goal and an environmental goal.

The production goal means that the forest and forest land must be used efficiently and responsibly so that it provides a sustainable good return. The focus of forest production must give the forest owner the freedom and responsibility to decide for herself/himself on the use of what the forest produces.

From the environmental aspect, the natural production capacity of the forest land must be preserved. Biodiversity and genetic variation in the forest must be ensured. The forest must be farmed so that plant and animal species that naturally belong in the forest can survive under natural conditions and in viable stands. Endangered species and habitats must be protected. The forest's cultural environment values and its aesthetic and social values must be protected.

The five policy focus areas are:

- Sustainable forestry with increased climate benefits

[8] https://arctic-council.org.

[9] www.luke.fi/tietoa-luonnonvaroista/metsa/metsapolitiikka/.

- Multi-use of forests for more jobs and sustainable growth throughout the country
- Innovations and world-class processed forest raw materials
- Sustainable use and conservation of the forest as a profile issue in Swedish internationally
- A knowledge step for the sustainable use and conservation of the forest

Today's Swedish forest policy and forestry model is based on the idea that forests shall be used for multi-functional purposes. That is, forests shall be managed to provide economic, ecologic, as well as social benefits. Efficient and sustainable production of wood for different end uses shall go hand in hand with the preservation of valuable ecological and socio-cultural values. The practical challenge lies in establishing a balance between the different interests in Swedish forests.

The ***Norwegian*** policy aims to ensure a sustainable forestry, both ecologically, economically, socially, and culturally[10], considering the forest's importance in the ecosystems, as recreation area for humans, and as a carbon sink and storage. To be able to reach the goals in the Paris Agreement – as well as the Norwegian Climate Change Act, which states that Norway should reduce its greenhouse gas emissions by 40 % by 2030 and 80-95 % by 2050[11] – Norway must change from a petroleum-dependent economy to a sustainable bioeconomy, and forestry plays an important role in this change[12]. The government seeks to facilitate a better utilisation of the forests, and to support the forestry and forest industry by investing in R&D and infrastructure[13].

To ensure a sustainable and profitable forest-based industry, the government has defined some focus points for their forest policy:

- Develop infrastructure (roads and railways), both public and private
- Profitable use of forestry for employment and value creation
- Increase R&D to improve profitability and climate change mitigation
- Stimulate the demand for green, wood-based products; increase the domestic processing of raw material (reduce export), ensure sustainable forestry, document the properties of the wood, knowledge sharing, standardise and industrialise competitive building systems in wood and develop policy and regulations to strengthen the framework conditions
- Gain knowledge on climate change and climate adaptation within forestry to develop measures to reduce greenhouse gas emissions

The strategy for increased R&D includes creating arenas for collaboration and dialogue e.g. through clusters, collaboration between industry and research institutes, and international cooperation, build the right competence at all levels from vocational education to PhDs, and business-oriented instruments for R&D offered by e.g. Innovation Norway and The Research Council of Norway.[14]

To stimulate the demand for wood-based products, the strategy includes ensuring sustainable forestry, mainly by financial instruments such as forestry funds and grants for environmental measures in the forests, to document the properties and environmental benefits of wood-based products and make guides for the use of wood, to standardise and industrialise the forest-related measures and innovation, sharing of knowledge to

[10] Regjeringen, Meld.St.6 2016-2017.
[11] Lovdata 2020 https://lovdata.no/dokument/NLE/lov/2017-06-16-60.
[12] Green shift, https://www.regjeringen.no/en/topics/climate-and-environment/climate/innsiktsartikler-klima/green-shift/id2076832/.
[13] Regjeringen, Meld.St.1 2020-2021.
[14] The Green Platform Initiative, https://www.forskningsradet.no/en/apply-for-funding/the-green-platform-initiative/.

encourage builders to build with wood, e.g. by using model projects, and the use of political measures and legislations.

Sintef [15] (2018) states that **The Inland region** has the potential to create 25,000 new jobs within the bioeconomy by 2050. The region's county council and County Governor has adopted a Bioeconomy Strategy, which aims to "contribute to greater competitiveness and value creation in the Inland Region"[16] . The vision of the strategy is "The Inland Region – a leading powerhouse for a sustainable bioeconomy in Norway", and it consists of five goals and 13 associated strategies, related to K*nowledge and expertise, Market and competitiveness, Biological resources and return streams, Cooperation*, and *Visibility and communication*. The strategy's action plan will be revised during the winter of 2021. The region has established the project Biovalley to help establishment, investments framework conditions and competence sharing within the bioeconomy sector.

2.1.2 Structures of Decision Making

In ***Finland***, decision-making in forestry is implemented on the federal level. However, nowadays there is a lot of space for individual decisions made by forest companies, forest owners or by forest contractors under the Forestry Act, for instance. Against this background, the government program in Finland, as well as in Sweden and Norway, puts special attention on bioeconomy and wood mobilisation. The current EU strategy "Green Deal" points the way to sustainable development in EU societies, emphasizing reduction in the use of fossil fuels and fostering carbon neutral achievements as well as nature diversity goals. From this basis, Finland's goal is to improve the utilization of renewable natural resources. Forest-based bioeconomy is seen as one of the biggest strengths of Finland. The imported fossil energy shall be replaced with renewable, domestic energy sources.

The above-mentioned actors play a key role for implementing the national and regional forest strategies in Finland. The National Forestry Strategy 2025 implements the UN Agenda 2030 goals for the Finnish forestry. According to its objectives, Finland is a competitive operating environment for forest-based business and activities and their structures are renewed and diversified. Forests are in active, economically, ecologically, socially and culturally sustainable, and diverse use. The strategy is linked to other national strategies and programmes, such as the National Bioeconomy Strategy, the National Biodiversity Programme, the National Energy and Climate Strategy, LULUCF, and the Regional Forestry Programmes.

The current Forestry Act (1093/1996) was adopted in 1997. The latest change in the current Forest Act entered into force in 2015. The new Forest Act significantly increased the freedom of choice and responsibility of forest owners in the use and management of their forests. The purpose of the Forest Act is to promote the economically, ecologically and socially sustainable management and use of forests. The Act on the Financing of Sustainable Forestry promotes forest improvement and environmental management of private forests and the use of wood energy. The act of the Financing Sustainable Forestry will be in force until the end of 2023.

In ***Sweden***, the usage of forests is principally regulated by the Forestry Act which sets out the demands placed upon forest owners by society. These include for example the requirement to notify forest felling to the Forest Agency, to reforest after felling, and to show consideration for natural and cultural values at forestry operations. Apart from the Forestry Act, parts of the Environmental Code, as well as other legislation, is also applicable to the forestry sector. The Forest Agency is responsible for supervising compliance with the Forestry Act and those parts of the Environmental Code applicable to forestry.

[15] SINTEF, 2018 https://www.sintef.no/contentassets/d46b0e74d4284fcd8ec2a038312464f2/gull-i-gronne-skoger.pdf.
[16] Inland Region, 2017 https://www.statsforvalteren.no/siteassets/fm-innlandet/07-landbruk-og-mat/skogbruk/trebruk/biookonomistrategi-for-innlandet_feb18.pdf.

The current forest policy was adopted in 1993 and reinforced through parliamentary decision in 2008. Swedish forest policy builds to a large extent on voluntariness and is often summarized in the wording "freedom with responsibility". This means that forest owners have a liberty of choice regarding the management of forests, within the frames set by the forestry legislation and other relevant legislation. However, with this freedom of choice also come responsibilities. What is referred to as "sectoral responsibility" implies that preservation of valuable natural and cultural environments is regarded as a common responsibility of the forestry sector and concerned authorities. In practice, this is for example evident in considerable areas being set aside voluntarily by forest owners for conservation purposes, without economic compensation by the state. A large number of forest companies and private forest owners have also chosen to certify their forestry to one or both of the two forest certification systems applied in Sweden, the FSC and the PEFC.

For ***Norway***, the Norwegian Forestry Act states that the forest owner must have an overview of environmental values in the forests, and that for these reasons, there may be forestry measures that cannot be implemented. Furthermore, the forest owner must ensure that all measures taken in the forest are in accordance with the legislation, which, among other, includes regulations for *harvest*; pathways and trails, as well as the property's production capacity, should not be damaged or reduced due to the harvest, *rejuvenation* should be ensured that occur within three years, *road construction* requires approval from the municipality, *preventive measures* to prevent insect and fungal infestations.

The purpose of the forestry act is "to ensure a sustainable management of the forest resources in the country, with a view to active local and national value creation, and to ensure biological diversity, consideration for the landscape, outdoor life and the cultural values in the forest", but gives no strict guidelines on how, when, or by whom harvesting or silviculture is to be done – these considerations are left to the forest owner, or the professionals who manage the forest on behalf of the owner. However, it is the forest owner's responsibility to ensure that the legislation is complied with.

Besides adopting legislations, the government, County Governor or municipalities may use financial subsidies and tax systems to influence the forest owner's decisions on measures taken in their forests.

2.1.3 Main actors in forestry in the Northern Hub

The main actors in the forestry sector in partnership countries of the Northern Hub are the following.

Type of Actor	Finland	Sweden	Norway
Forestry companies	Stora Enso, Metsä Group, UPM, VAPO/ bioenergy, Keitele Group, Pölkky, Koskisen, Versowood, CrossLam Kuhmo, CLT Finland, CLT Plant, Kotkamills Group, Valmet, Andritz, HewSaw/Veisto, Heinola Sawmill Solutions, Raute Industries, Ponsse, John Deere, Logset, ProSilva, Sampo Roselew	Stora Enso, SCA Setra Group, Holmen, Södra Skogsägarne, Moelven, Billerud Korsnäs, Karl Hedin, Siljan Timber, Fiskarheden, Martinsson, Norra Skogägarne, Bergs Timber, Komatsu Forest Machines	Moelven Industrier, Bergene Holm, Inntre Kjeldstad, Norske Skog, Borregaard, Forestia, Hunton
Forestry Associations: services for forest owners	Forest Owners Association	Norra Skogsägarne, Mellanskog, Södra Skogsägarne	The Norwegian Forest Owners' Federation (Norges skogeierforbund), Norwegian Forestry Association (Norskog)
State Forest Enterprises	Metsähallitus	Sveaskog	Statskog

Supervisor of the Forest Act, education of forestry professionals, forestry development	Finnish Forest Centre	Skogsstyrelsen	The **Norwegian Agriculture Agency** is the supreme supervisory authority of the Forest Act, but much of the supervisory is delegated to the County Governor and the municipalities. Considering education, the vocational schools are owned by the counties or by private ownership, and the supervisory authority is The **Norwegian Directorate for Education and Training**, while the universities offering higher education within forestry are owned by the state and supervised by **NOKUT** (The Norwegian Agency for Quality Assurance in Education).
Forest Research Centre	Natural Resources Institute Finland (LUKE)	SLU, Skogforsk	NIBIO
Educational Institutes	University of Helsinki (BSc, MSc, PhD), University of Eastern Finland (BSc, MSc, PhD), Lapland university of Applied Sciences (BSc, MSc), Häme University of Applied Sciences (BSc, MSc), South-Eastern Finland University of Applied Sciences (BSc, MSc), Karelia University of Applied Sciences (BSc, MSc), Novia University of Applied Sciences (BSc, MSc), several schools for vocational education	Linne Universitetet, SLU, Umeå University, Luleå University, several schools for vocational education, BsC, MsC, PhD	NBMU and HINN Evenstad (bachelor's and master's degrees, and PhD), several schools for vocational education (e.g. Solør VGS Sønsterud). Skogkurs (The Forestry Extension Insitute) offers shorter courses and training for forest owners and professionals
Clusters	Industry and Circular Economy Cluster, Smart Arctic Forestry Network, Arctic Smart Rural Communities Cluster (renewable energy), Arctic smartness clusters	PaperProvince, Bothnia Bioindustries Cluster, Biofuel Region, Smart Housing	Norwegian Wood Cluster, Wood Works, Circular Packaging Cluster and Heidner Biotech

Table 7: Main actors in the forestry sector in Northern Hub countries

2.2 Main findings

2.2.1 SWOT-analysis

All the three regions were first analyzed in a local SWOT analysis and then merged into one joint SWOT analysis for the Northern Hub. The main points were selected by experts and partners of the Northern Hub and are displayed in table 8.

Strengths	Weaknesses
• Strong forest industry • Developed Digitalization systems in forestry • Multiple and sustainable use of forests • Open and accurate forest inventory data • Developed enterprises for harvesting and logistics Highly mechanized supply chain. • High degree of work safety • Well organized education system for the value chain (vocational schools, technical school, university of applied sciences) and training for all workforce • Very competitive pulp and sawmill industry using new technology	• High amount of small forest owners and decreased interest in forestry • Lack of qualified and local forestry labor, especially for harvesting operations, planting and silviculture • Poor condition of forest road network • Shortages in tending of young forests • Lack of knowledge on recycling and circular business models
Opportunities	**Threats**
• New forest management alternatives for forest owners • Stronger cooperation between forestry and R&D • Forest consolidations and rearranging of forest estates • Increased gender equality/be more attractive for all interested workforce independent of gender • Development of new wood-based products and utilization of side stream • Continous counseling of forest owners • Upgrading of workforce (especially on digital solutions) • Development of the road transport, wood terminals and collecting small amounts of timber	• Urbanization and lack of attractivity for jobs in the value chain and for jobs in rural areas • Climate change (eg. forest damages, pests) • Lack of funding for R&D and efforts to find new opportunities • More national/EU restrictions on harvesting and other use of forests • Aging of forest owners • Social acceptance of forestry

Table 8: Northern Hub Joint SWOT

The Northern Hub regions have a high availability of wood, and especially in Sweden and Finland the forest industry is strong. The main strengths in forestry are based on the intensive, but sustainable silviculture measures. These actions have led to a high and accelerating increase in stem volume. A positive impact of climate change on the growth of Northern forests can also be detected. Forests in all the Northern Hub regions are healthy and a high number of young stands ensures that there will be enough forest resources in the future. However, **shortage in tending of young forests** is a huge weakness in the Northern Hub. Forest subsidies, funds and accurate forest inventory data offer tools for tackling this problem. Forests in all the regions are largely certified and operated under certified environmental management systems.

The Northern Hub regions are equipped with advanced infrastructures for forestry, and all three countries have a dense network of forest roads. Some challenges in Norway vary from the ones in Sweden and Finland. For example, the high costs for infrastructure development (mountains, fjords etc. and low population)

combined with high road/rail taxes and lower loads, result in generally higher logistic costs than elsewhere in northern Europe. In Finland and Sweden, several sawmills, bioenergy power plants, wooden house, and CLT (Cross Laminated Timber), gluelam beam and plywood factories, biorefineries and pulp/paper factories can be found. In addition, several manufactures of logging machines, sawmill technology, and pulp and paper mill technology are located in Finland. In Norway, an area with high-capacity sawmills and industrial production of wood houses can be found, but less pulp and paper industry. Much of the fiber (pulpwood and chips) which is not used for particle boards, fiber board or bioenergy, is mainly exported to Sweden and especially to the Karlstad area. Norway can be considered a pioneer in wood construction, but the use of wood as a building material is growing fast in all the northern countries.

Forest industry generates a wide range of different side streams. By aligning these production side streams and waste utilization for new products, the wooden material is utilized almost entirely. Products from utilization of side streams are e.g. pellet production, bioenergy, pine oil and wood ash. The development of new wood-based products and the utilization of side streams offers huge opportunities for the forest industry and for entrepreneurs in circular economy. For example, biochar production is growing and it also offers business opportunities for entrepreneurs. Concerning the development of new products, there is a need for stronger cooperation between forestry and R&D. In Sweden and Norway, forest industry clusters can be found , but there is a need for developing cluster co-operation in Finland.

Both the weaknesses and threats are related to a **high age, urbanization and continued passiveness of forest owners, and fragmentation of forest estates.** Private forest owners will be a more and more diversified group in the future. The biggest threats will be a higher average age, and a growing share of city-dwellers and distant forest owners. Considering these changes, there should be more ways available to make forestry attractive for a younger age group .

One of the biggest weaknesses in the Northern Hub is **the fragmentation of forest owners and small forest properties.** Opportunities have been identified in forest consolidation, creating collective forests for easier and more efficient forest management. The rearranging of forest estates is also a great opportunity to create larger forest units instead of small-scale ones. With the continuing counseling of forest owners the passiveness of forest owners has partially been addressed, while digitalization might offer further opportunities through interdisciplinary approaches and developments. For private forest owners, there is also a variety of advisory services available. In all the Northern Hub countries, forest owners have their own national unions, which have been organized regionally. Local forestry associations are endorsing forest owners by offering many kinds of services.

Forest education is of high quality and it covers all the Hub regions. With new kinds of implementation utilizing digital connections, education is nowadays more accessible to everyone regardless of the place of living or the life situation. In addition, there are plenty of new short training programs for forestry issues available. High work safety can be highlighted ensured in the Northern forestry, and it is very closely legislated and monitored by the authorities.

Finding skilled workforce is one of the biggest challenges faced by the forest industry at the moment. The forest industry in the Northern Hub area is especially concerned about the sufficiency of forest machine operators and other forest workers, as harvesting volumes increase in the future. The shortage of labor also applies to timber transport. A part of the problem is that the graduated forest machine drivers are not motivated to stay in the forestry field. Transitions to other industry occurs in all sectors, however forest machine training is one of the most challenging allowing employees to move easily to other transportation industries with higher income, better working conditions and other benefits.

Unused-wood potential creates opportunities for forest industry in Finland, Norway and Sweden. However, the increasing harvesting amount is putting more pressure on moving to year-around felling, which underlines the importance of a well-maintained forest road network. There is a crucial need for **better maintenance of the forest road network** and the organization of private road cooperatives. Developing the road transport, wood terminals and collecting small amounts of timber are important opportunities in all Northern regions.

The impacts of **climate change** are a serious problem for forestry as well as they are for the whole planet. Among the potential impacts are forest fires, storms and pest damages. On the other hand, the growing season might extend and lead to increasing growth of forests. Some pest insects cause more damage, and new species can spread to Northern areas. Climate change also results in less ground frost in winter, leading to problems in forest harvesting because of lower bearing capacity of forest soils. Finland already deals with the challenge of forest harvesting on peatlands, and climate warming will deepen this challenge. This means that there isa crucial need for new innovations for harvesting on peatland forests. A large amount of peatland forests is one of the differences between Finland and the other Northern Hub countries.

Social acceptance of forestry is a problem in all Northern countries. Forests are expected to meet a growing number of interests. Not only should the forests be used to produce sustainable products, but also to protect environmental assets, offer tourists exciting experiences and give opportunities for recreation. The discussions about how widely forests should be protected have become even more intense, as well as the fear that regulations from the EU will prevent forest owners from using the forests to their full potential.

The value of forest varies with what is identified as valuable by whom. From a holistic perspective, the forest as a whole has the most value, from an anthroposophical perspective the value is isolated to what benefits human needs. Between a holistic and an anthroposophical view there is the multifunctional aspect of the forest. The multifunctional value of the forest implies that there is a multitude of interests at play at any given time concerning forest use. Serving a wide range of economic, environmental and social purposes, the forest has different significance to different groups of interest. Wood remains the main source of financial revenue and forest biomass represents the most important source of renewable energy in the EU, however there are conflicting interests with regard to the forestry industry. The forest is also home to an intricate web of life and is essential for CO_2 sequestration and as a provider of ecosystem services. To protect and utilize at the same time can be challenging.

Several certification standards have been employed to the forest industry to ensure a wide scope of interests is being maintained in the forest value chain, complicating the forest owner's ability to use theirforests to the full potential, but also reducing the potential for conflict (FSC, PEFS, Levende Skog). Developing sustainable management to balance the economic, ecological and social roles might be a way to mitigate potential future conflicts.

Concerning politics, the challenge in all Northern hub countries is that the government has its own opinions and development goals. The long-term planning is risky and non-existing, since the goals, politics and subsidies are changing with every change of government. This makes forestry less attractive for foreign investors and discouraging for domestic investors. In addition to the national forest politics, the EU forest politics are appearing as confusing and do not encourage making new investments in bio-based renewable energy.

Many of the strengths in the Northern Hub are linked to digitalization. Exploiting digitalization is seen as a vital requirement for improving the productivity, quality and working conditions in the forestry sector and therefore many assets are being directed to the digitalization related to bioeconomy. Interdisciplinary co-operation is required by the funders to continue exploiting all possible benefits of digitalisation.

The growth of the bioeconomy is dependent on forest industry, securing the supply of forests, and the Northern Hub SWOT reflects this. However, for finding solutions to weaknesses and threats, there is a crucial need for a strong co-cooperation between the Northern countries and other Hubs.

2.2.2 Best Practices and innovations identification

There is a strong will in the Northern countries to utilize forest assets as a source of income and for the welfare of local people. Various digital systems including mobile applications have been developed to advance co-operation and engage forest owners to take care of and manage their forests. Forest work productivity is on a high level since the harvesting chain is completely mechanized and digitalized, while stakeholders are granted free access to forest data. The forest road network gives value not only to forestry but enhances recreational utilization of forests and serves for preventing forest fires.

The best practices and innovations (BPI) identified were developed by forestry companies through co-operations in the forestry and IT sector. The main BPI in the Northern Hub mostly answer to the needs and means of forest management as well as harvesting and logistics. The goal is to increase productivity and co-operation in the supply chain. Naturally, the resources of wood are in focus. Environmental aspects are taken into consideration and in addition, the BPI focus on cascading use of wood and design for recycling and value chain(s) for reuse and material recycling (upgrading).

Most of the BPI are implemented in practice by local or international companies, meaning some are specifically adapted to northern conditions. A continuous development process ensures that the BPI target the increase of productivity, e.g. by utilizing digitalization. Some of the BPI were developed decades ago and implemented already some years ago, while being adapted for addressing current forestry needs and changes. Digitalization has brought about some recent modifications boosted by the provision of open big data in Scandinavia. The utilization of production side streams is at a high level, which leads to full utilization of raw wood material and waste for new products. This way, the cascade use of wood material could be organized efficiently leading to an overall high resource efficiency.

As result from the last validation workshop with experts, there were ten best practices from other hubs selected as most promising. These best practices are presented in table 9. The most relevant best practices from Northern hub are presented in table 10. The next step is the implementation of some of these practices to Northern hub region. There were many digital best practices available which represent newest technology, e.g platforms. Similar best practices can be found from several countries, and with very limited information, it is difficult to define suitability. We should be able to study whether these best practices offer anything new to us, compared to those we have in use.

Hub	***BP title***	***Description***
CWE Austria	Festmeter	Festmeter offers vitality analyses about berk beetle detection in conifer forests
CWE Austria	Application of drones for seedling transport in steep terrains/mouintanous areas	Application of drones is used for seedling transport in steep terrains and mountains
CWE Austria	Evergreen - Innovation camp	Evergreen innovation camp is a hackathon for finding innovative solutions for tracing timber
CWE Germany	Virtual forest	The virtual forest is a platform for forestry and timber industry. Decision support tool for forest growth and wood mobilization.
CWE Switzerland	Road condition monitor	The Road condition monitor has an ultrasound center to capture information on road segments
CWE EU	Avatar	Avatar is an advanced virtual aptitude and training application for harvesting
SWE Spain	C.A.F.E	C.A.F.E (Carbon, Aqua, Fire & eco-resilience) is a decision support system for a multiple criteria forest management

SWE Spain	CrossForest	Cross forest is a project aiming to develop Digital Service Infrastructures for combining Forest Inventory Datasets and Forestry Maps to create and integrate models supporting forest management and forest protection.
CEE Poland	ReGap	Regap is a recycling model of used Wood in Germany and Poland.
CEE Poland	Prozel	Prozel forecasting threats to forest ecosystems through the implementation of an innovative electronic system for the recognition of odors

Table 9: Most relevant best practices from other Hubs

Country	***BP title***	***Description***
Norway	FeltGIS	Data collection of production data to cloud services. FeltBoks and FeltLogg transfer maps and data from harvester and forwarder to ensure easy access to the forest operations for all collaborators.
Norway	The forestry extension institute	The Forestry Extension Institute is a NGO organised as a partnership between 37 forestry organisations and scientific institutions. The main purpose of the institute is to provide continuing education and training in the forestry sector and related fields.
Norway	Women in forestry	Women in Forestry is an independent organisation whose purpose is to motivate and stimulate women of all ages to participate and engage at all levels in the forestry, and emphasize unity and collaboration.
Norway	Forestry Fund	The Forest Fund consists of funds that forest owners are obliged to dispose of in all sales of timber and biofuel. The purpose of the scheme is to secure financing for sustainable management of forest resources.
Norway	Use of drones in vocational education	The vocational school of forestry uses drones in training to plan and control harvesting, thinning and forwarding of timber, as well as filming students while running forestry machines to evaluate their working methods, and making instructions movies for silviculture.
Sweden	HiVision	Operate your crane from inside the truck cabin, without having to step out of the truck. Instead of a crane cab VR-glasses and cameras are used to load the truck. Can load 400 kg more and safer.
Sweden	Arboair	Arboair offers a service that with the help of a 4K camera and IR camera connected to a drone can detect infected or stressed trees.
Sweden	Bark beetle risk map	Digital map of high risk areas for bark beetle where you forest owners can look at thei own forest. Open access for all.
Sweden	Nordluft	The company has developed a proprietary highly advanced drone swarm control system for use in its spreading systems, the Nordluft Ground Control (NGC). The system is built to be easily customizable for other applications.
Sweden	Simulation-based design for off-road driving and driverless machines	By simulating machines and terrain, researchers at Umeå University develop decision support for drivers of forest machines and, in the long run, driverless machines. The research has also resulted in the company Olofsfors starting to experiment with the design of ties for forest machines in a simulation environment.
Finland	Metsään.fi	Metsään.fi provides eServices for forest owners and forestry service providers. The online application shows the silvicultural possibilities of each forest estate and their compartments.
Finland	Kemera	Government subsidies (KEMERA support) are available for safeguarding sustainable wood production, maintenance of forest biodiversity and improvement of the health of forests. The purpose of the Act is to bring to market wood from sites where the profitability of harvesting is poor due to circumstances and the size of the trees.
Finland	Virtual Forest 2.0 innovation	Virtual forest is a 3D application, which can be used in participatory planning of land use, guidance of forest owners and for combining interests of different stakeholder groups concerning utilization of natural resources and areas.
Finland	Forest Finland	Forest Finland is the joint communication project of the Finnish forest sector. The campaign will awaken and raise peoples' interest and encourage discussion about the forests' role in everything we have in Finland. Forest Finland talks about the sustainability of the use of the northern forests and about the solutions the sustainable use of them offers. The forest will be seen on TV and heard on the radio, in outdoor advertising and in social media.
Finland	Simulators in forest machine education	Simulators can be used in forest machine training by speeding up the learning of the technology used in forest machines, and at the same time saving costs by reducing the training time required in terrain for the basic use of the machine.
Finland	Finnish Forest Association	The Finnish Forest Association is a cooperation and communications body dedicated to its members and stakeholders, established in 1877. It supports the promotion of forests, their sustainable and responsible use, and their potential to assist in the development of society. To support its activities, it gathers, refines and publishes information.
Finland	Ash in forest road maintenance	The ashes can be used in a road building among gravel. The use of ash from neighboring heat plants reduces the use of natural aggregates. The use of ash in the construction of the road in Finland has been limited, as it is currently subject to environmental permits.
Sweden	Industry 4.0/DigiWood	The main idea of the digital sawmill project was to enable more efficient and value-creating forest, wood and bioproduct production through digitization.

Table 10: Most relevant best practices from the Northern Hub

2.2.3 Needs Analysis

In *Finland*, **needs of forest owners** are quite concrete and linked to supporting the decision-making processes in forest management. This means guidance from forest professionals and includes presenting different forest management options equally, as well as demonstrating forest management results now and in the future. Guidance should include objective recommendations from forest professionals and arguments for and against different forest management options. Forest guidance discussions should be supported by illustrative examples, calculations and visualizations. In the decision-making process, the forest owners highly value the ease of the process. They prefer to have multiple services to choose from rather than one service provider (guidance, forestry planning, timber trade, harvesting services). They highly value a centralized source of information instead of scattered information, and easy access to information. The roles of different forest-related organizations should be clearer to forest owners in order to identify the right service providers for their requests.

Needs of forestry companies have to do with operational infrastructure and predictable forest policy. Support is needed from the state and the EU, rather than obstacles and restrictions. The decision-making should be more flexible and faster in order to target funding according to changing needs. Infrastructure needs refer to maintenance of forest road networks as well as the higher road network in order to secure wood transportation possibilities. In addition, there is a need to find new tools to activate private forest owners to unlock their wood potentials. The digital systems (Metsään.fi) that are accessible by all the stakeholders should be developed further to include the current and actual status of the forest. Needs of the forest companies in business focus on marketing, technology transfer (e.g. digitalization, new machinery & tools), logistics and product / service development in order of importance.

Regarding the future of the wood market in Europe, companies accentuated the retention of competiveness, currency rates, price (which can be dropped e.g. by storm damages in Europe), expenses of transportation in Scandinavia and logistics in Europe, as well as political stability. Companies consider the impact of climate change prevention for forestry quite prudently. It will depend on how EU decision makers will understand the influence of cuttings and silviculture from the point of view of carbon sinks and storages. FSC certification is more important for the customers in the future.

Needs of the contractor enterprises relate mainly to human resources, business expansion and technology transfer. Financing, service development and cooperation with business partners should also be developed further. Contractors were satisfied with engineer recruitment, but they reported a lack of lumberjacks and skilledl harvester and forwarder drivers. Climate change might affect the harvesting conditions. If winters will be milder in future, it will weaken the carrying capacity in peatlands and cause more difficulties for machinery operations. According to contractors, the incentives needed to encourage the mobilisation are taxation politics, dissemination of information and obligation of proper silviculture to forest owners, more price to pulpwood, better reputation of forestry, professional labor force and more women to forestry.

In the *Swedish* forest industry, two main needs have been highlighted:

1. Access to raw materials
2. Access to a competent and a skilled workforce

In the light of climate change, Agenda 2030 and the transition to a climate-smart society, the insight that the forest may eventually become a scarce commodity has increased among involved actors. Even though there is twice as much forest in Sweden now as 100 years ago, the forest is expected to meet several interests. In addition, the amount of forest that needs to be protected is under discussion and the restrictions put on forest owners by EU regulation is met with concern. But it is not only nature conservation and the EU that can reduce

the amount of available forest, at the time of writing we also see how bark beetles and fires pose major threats to forestry and destroy enormous values in the forests. While forest management appears a strong field in the Nordic SWOT, this is also the area where most threats and weaknesses have been identified.

The other challenge threatening the growth of the Swedish forest industry is the supply of competence. This point of concern is present along the entire value chain, from forestry, via transport to the industry out to the individual citizen. Urbanization is part of the problem, however, the need for new skills with regard to, for example, digitization is another. This challenge is represented in several different parts of the SWOT and is clearly identified as a common challenge among the Nordic countries. Here, measures can be easier to handle and the opportunities to make a difference in the short term could potentially be big.

As many forest properties in *Norway* are small, forest owners lack the needed knowledge about forestry to make decisions on forest management. Thus, guidance for decisions is a basic need for many forest owners. Forest owners also need information on the financial grants and funds, as well as an easy way to apply for these.

Forest contractors need skilled workers, both machine operators and workers for planting and silviculture. The lack of skilled workforce might be linked to the relatively low wages and poor working conditions in forestry compared to other occupations requiring a similar education, e.g. a machine operator in other industries, which causes forest workers to leave forestry in favour of other industries. There is also a need for more timber truck drivers.

The wood-based industry needs a stable, year-round access to timber to prevent unnecessary stops in the production. The ongoing climate change makes the weather, and thus the conditions for running forest machines and timber trucks, more unpredictable with more rainfall and lack of frozen ground in the winters. Like the forest contractors, the industry also needs a skilled and stable workforce.

Both forest contractors and wood-based industry need better infrastructure, forest roads for transport of machinery, workers and timber, and railways for more efficient transport of timber over longer distances.

The Norwegian fiber industry has been significantly reduced in recent decades and the entire value chain has become highly dependent on large exports. In order to maintain a robust value chain over time, it is desirable to establish a new fiber-consuming industry in Norway that can complement the strong sawmill industry. This can also be seen in connection with the fact that an already sustainable and renewable value chain must become more circular.

2.3 Development targets for sustainable wood mobilisation

The development needs identified in the ROSEWOOD4.0 project match the regional and national strategies in all Northern Hub countries. The European Union Forest Strategy promotes the role of forests in attaining economic, ecological and social sustainability. The European Union Biodiversity Strategy underlines the importance of actions of conserving biodiversity and natural ecosystems. Increasing demand for biomass creates new challenges for these issues. It is crucial to find a balance between the use of forests and the protection of biodiversity in all regions.

In *Finland*, the European Union Forest strategy is linked with other national strategies and programmes, such as the National Forest strategy, the National Bioeconomy Strategy, the National Biodiversity Programme, the National Energy and the Climate Strategy, LULUCF, and the Regional Forestry Programmes. At the local level in Finland, the Regional Forest Program 2021–2025 is a joint program of the entire forest sector and the province. The strategic guidelines of the Lapland regional forest program present well the development targets in Lapland. The main needs identified with the ROSEWOOD4.0 SWOT analysis are similar with these goals.

Generally, there is a need for a stronger cooperation between Nordic countries, as it has a positive influence on European Commission policy making.

In ***Sweden,*** the national bioeconomy strategies are linked with the European Union Forest and bioeconomy strategy. The Swedish Parliament has stated that "The value of forests and forest land for biological production must be protected at the same time as biological diversity is preserved and cultural environmental values and social values are protected."
The single most important prerequisite for the effectiveness of the strategy is the common desire to take advantage of the important natural resource that the forest constitutes. For new sustainable businesses in the circular bioeconomy, for more jobs in the forest industries, for more efficient production methods and more forest raw materials as well as an attractive countryside, for the benefit of both entrepreneurs and citizens.
With the forest strategy we want to take advantage of strengths and traditions, have an eye on both threats and opportunities as well as formulate our quest to think and do new.

The transition to a more bio-based economy is already underway and will be significant for the development of the Region. Success presupposes higher competence levels, a greater access to forest raw materials and an attractive forest area. Strategic collaboration and dialogue between new and existing actors and stakeholders drive the development towards increased entrepreneurship with the forest as a base.

Objectives of the Swedish Bioeconomy strategy:

- Leading in circular bioeconomy
  - Innovations, development and new business in industry and new companies
  - Collaboration between forest owners, industry and academia
- More forest raw material
  - Increased productivity in forestry
  - Increased growth of forest raw materials by 10-15% by 2030
- Industrial strategy
  - The industrial strategy must optimize the industry's opportunities to develop solutions to today's and tomorrow's societal challenges through new technology and innovation. This requires, among other things, strong investments in research and development as well as an innovation-friendly regulatory framework.
- Attractive forest area
  - Viable forest companies with innovative business development
  - Health and recreation for residents and visitors

In accordance with the Paris Agreement and Norwegian Climate Act, ***Norway*** seeks to become a low-emission society by 2050. To achieve this, increased focus and investment in the bioeconomy – including forestry – is crucial. The forestry must be sustainable, considering both environment and climate. As much of the wood processing industry in Norway has been closed down in the last 10-20 years, much of the timber that is suitable for this industry is exported. Thus, it is necessary to develop a new forest industry in Norway, most likely based on new products ().[17] A better structure of the forest properties, where small properties are merged into larger units can provide more rational operating units, increase the profitability of forestry, and thus lead to more activity in the forests.

[17] Regjeringen, 2016 https://www.regjeringen.no/no/dokumenter/meld.-st.-6-20162017/id2515774/.

Improved infrastructure is a focus area both nationally and regionally in the Inland Region. The County Governor of the Inland Region also focuses on forestry inventories, as updated information about the forests increases both harvesting and silviculture.

Some municipalities also take measures to increase the use of timber and wood. An example is the municipality of Elverum, which in 2008 made a guide on the use of timber in buildings and city planning. This guide is currently being revised and will be completed in the spring of 2021.

2.4 Presentation of the interregional Roadmap

The goal of the ROSEWOOD4.0 project is to establish an exchange of knowledge based on best practices and innovations (BPI) from other regions in Europe. Based on the findings, suitable BPI shall be transferred to other regions to turn weaknesses into opportunities or strengths. When screening the list of BPI from all over Europe, the strong position of the Northern Hub was confirmed by the large number of BPI that are already in place in the Hub regions in similar ways.

During the validation process, 18 BPI from the Northern Hub and 18 BPI from other Hubs were selected to be the most promising. The selected BPI with matching main needs identified in the Northern Hub are presented in Table 11. The BPI are not in prioritized order in the lists.

Main WEAKNESSES	**Finland**	**Sweden**	**Norway**	**CWE** (Germany, Belgium, France, Switzerland, Austria)	**SWE** (Spain, Italy, Portugal)	**CEE** (Poland, Romania, Slovakia, Ukraine)	**SEE** (Croatia, Greece, Slovenia)
High amount of small forest owners and decreased interest/ competence in forestry for owners.	Virtual forest, Metsään.fi, Forest Finland, Finnish Forest Association		Women in Forestry, FeltGis, Forestry Extension Institute	Forest women network, Forest Land Consolidation, KomSilva			
Lack of qualified and local forestry labor, especially for harvesting operations, planting and silviculture.	Simulators in forest machine education	Simulation-base design for driverless machines, HiVision	Use of drones in vocational education, Forestry Extension Institute	DroneMapper, SilviSmart, Evergreen-Innovation Camp, Drones for seedling transport, EldatSmart, SmartGiga Wood, Avatar, Forwarder			
Poor condition of forest road network	Ash in forest road maintenance		The Forestry Extension Institute	Road condition monitoring			
Shortages in tending of young forests	Kemera		Forestry Fund	Marteloscopes			
Lack of knowledge on recycling and circular business models						ReGap	

MAIN THREATS	Finland	Sweden	Norway	CWE	SWE	CEE	SEE
Urbanizing and lack of attractivity for jobs in the value chain and for jobs in rural areas.	Virtual forest, Metsään.fi		Women in Forestry, Forestry Extension Institute	Virtual Forest, Forest Women Network			
Climate change (eg. forest damages, pests)		ArboAir, Bark Beetle risk		FestMeter	C.A.F.E, CrossFore		
Lack of funding for R&D and efforts to find new opportunities				Evergreen-Innovation Camp			
Social acceptance of forestry	Finnish Forest Association, Forest Finland		The Forestry Extension Institute				
More national/EU restrictions on harvesting and other use of forests.	Virtual forest	Nordluft					
Aging of forest owners	Virtual forest			Virtual Forest			

Table 11: Validated Best Practices and Innovations matched with Main Needs (Weaknesses and Threats)

During all workshops there were excellent discussions for tackling the weaknesses and threats of the Northern Hub. One of the key problems is *the high amount of small forest owners and decreased interest/ competence in forestry for owners.* Foresters have tried to solve this challenge through events and networking, which often proves unsuccessful. There were many BPI from the other regions which could be identified to solve this issue. One of the best solutions for a high amount of small forest owners is a forest consolidation network, which can already be found in Finland and Sweden. However, the BPI from Germany **Forest land consolidation of community forests in NRW** was found to be interesting. More information about this practice should be obtained and it should be examined whether the practice can offer any new solutions for developing the forest consolidation activity in the Northern regions.

The most promising solutions for the weakness *decreased interest/ competence in forestry for owners* were the **Forestry Extension Institute from Norway, Finnish Forest Association and Forest Finland from Finland, and KomSilva** from Germany. Education is the best tool for raising the competence, and the Forestry Extension Institute and Finnish Forest Association are great examples how all stakeholders can work together for addressing this weakness. KomSilva offers a modern platform for raising awareness on forestry, especially for forest owners. Forest Finland is a versatile project launched in 2020 for dissemination of forest and forestry information, using different digital media (e.g. TV and radio) and roadshows. All the four above-mentioned BPI will be highly important in tackling the challenges concerning the threat *Social acceptance of forestry in future*, common to all the three hub partners.

BPI for *managing the data flow* are found both inside – **FeltGIS** – and outside the hub –**SilviSmart**. As far as we know, FeltGIS is the only one of these that uses the StanForD standard for data flow, which is the standard used by the producers of forestry machines. Thus, this technology will be much easier to implement than the others.

The platform *Virtual Forest* is available in Finland and Germany. The Finnish version is a 3D forest visualization combining actual forest data, GIS and game technology. German Virtual Forest was selected to find out whether it includes new features to learn from. **Metsään.fi** is another innovative platform from Finland, which has been found to encourage forest owners to carry out silvicultural works and it shows the cutting possibilities of each forest estate. The online application shows the silvicultural possibilities of each forest estate and their compartments.

There were two other examples of similar practices which are offered by different countries: **Women in Forestry** from Norway and **Forest Women Network** from Austria. These practices were selected because in Finland there is no Forest Network for Women and general activity between these already existing networks

should be strengthened. It is widely recognized that the forest sector must be changed to be equal and a more attractive workplace for women.

The usage of drones has become popular almost in every field, including forestry. Even though there is a high degree of technology around drones already in the Northern Hub, a couple of best practices on this topic were selected. From Sweden, **Arboair** was chosen, a tool for detecting bark beetles by drones. From the other hubs, **Dronemapper, Festmeter and Application Drones for seedling transport** were selected. Dronemapper from Germany is a high-resolution drone imagery for timely information about impacts and forest dynamics.

Festmeter from Austria also offers detection of bark beetle infestation by drones. Application Drones for seedling transport from Austria are designed for the usage in mountainous areas, but similar circumstances can be found in Norway. Also, in Finland there are often planting sites located behind swamp areas, where the seedling transportation is very difficult to accomplish. Drones are also used in forest education; the BPI **Use of drones in vocational education** was selected from Norway. In Sweden, **NordLuft** has developed a proprietary highly advanced drone swarm control system for the use in its agricultural spreading systems.

A serious threat today is climate change which can affect many problems in forestry. Pest damages will be a growing problem in the future, even in the Northern countries. Drones offer many solutions which should be examined carefully. The Swedish BPI **Bark beetle risk maps for forest owners** offers a potential solution. In addition, the BPI **C.A.F.E** from Spain and **DetectIt** from Croatia were identified as promising solutions for tackling the challenges of climate change. C.A.F.E is a tool which enables the decision-making process of forest managers when dealing with multiple criteria forest planning. DecectIt is a forest fire detection device which detects fire by using different sensors.

The *lack of qualified and local forestry labor, especially for harvesting operations, planting and silviculture* is one the main needs, which was matched with many best practices. The Covid19 pandemic has shown the importance of using more local workforce, although the costs are sometimes higher. Examples of selected BPI include the **Simulation-based design for off-road driving/ driverless machines** from Sweden, and the European Union project **AVATAR** which has developed a digital coaching, assistance, and feedback system for improving productivity and job satisfaction for forest machine operators. However, none of the selected best practices offers a solution to the actual problem, i.e. finding more qualified labor. Selected BPI apply to education or they are practices for using technology to make the work more efficient, namely **HiVision** from Sweden, **Simulators in forest machine education** from Finland, **Smart GigaWood** from Austria, and **EldatSmart** from Germany.

One of the main weaknesses for forestry infrastructure in the Northern Hub is the poor condition of the forest roads. The current condition of forest roads should be available for wood and transportation companies in order to gain resource efficiency in wood mobilization. The only truly promising best practice for this weakness is the **Road Condition monitoring** from Switzerland. Finland and Sweden both have a best practice about using the Ash as construction material on roads/surfaces at industries. The utilization of ash as material for road construction and maintenance has produced excellent results in terms of both the technical suitability and the environmental impact. In Sweden, ash products are already used as surfaces at construction sites/industries. In Finland, the use of ash in the construction of the road has been limited, as it is currently subject to environmental permits. There is a need for exchanging BPI already between these countries.

Shortages in tending of young forests is a weakness in the Northern Hub. Forest subsidies/funds like **Kemera** in Finland and **Forestry Fund** in Norway, offer tools for tackling this problem, however there is still a need to find more solutions. The only suitable practice from other hubs was a **Marteloscopes tool** from Switzerland. The demonstration sites serve for virtual tree selection exercises as well as show cases for field visits. The main goal is to train and improve decision-making capacities related to the integration of biodiversity aspects into forest management.

A challenging weakness to find new solutions for is the lack of knowledge on recycling and circular business models. This is a topic where the Northern Hub has a very high technology in some regions, but there is still a lot of new business possibilities to be found in the future. The most promising best practice was ReGap from Poland, which offers wood waste disintegration technology, new sorting techniques for waste wood, and technological guidelines ensuring the rational management of used wood.

The *lack of funding for R&D and efforts to find new opportunities* is one of the threats in the Northern Hub. Evergreen Innovation Camp – a Hackathon from Austria – was selected as the only possible solution for this need. These innovation camps have been used in other business areas, but not so much in forestry.

During the roadmap process there were also many gaps identified. These gaps include those weaknesses and threats for which no suitable solutions were found from other regions.

Only a few BPI were found for *poor condition of the forest roads and shortages in tending young forest*. They are both big challenges in all Northern hub countries, and each country has already many existing practices to solve them. However, there is a need for new solutions. Other gaps identified are the *lack of knowledge on recycling and circular business models, the lack of funding for R&D and efforts to find new opportunities and more national/EU restrictions on harvesting and other use of forests*.

If one of the threats has a higher priority compared to the others, it is the *social acceptance of forestry*. This challenge is recognized in all Northern Hub countries and there is a crucial need to find completely new ways of communicating about forestry.

It is clear that the selected practices include those that can really be implemented in the Northern region. However, this requires a long-term work process with stakeholders, but the Northern hub partners believe that the ROSEWOOD4.0 project will take these actions forward.

2.5 Implementation of the roadmap

The ROSEWOOD4.0 roadmap can be seen as an addition to national and regional forest strategies in the Northern Hub countries. It highlights the development needs of member states based on the threats and weaknesses identified in the SWOT analysis. Solutions for them have been sought from within the Nordic countries and widely from Europe, based on the BPI offered by the participating countries. Their realization and utilization largely depend on how well they serve the needs of each organization or company. It is also worth noting that even if they are not implemented as such, they can be valuable for learnings that can be applied to these circumstances.

In Finland, the Finnish Forest Centre constitutes the regional Forest Programs by running a process of conducting several workshops with all the relevant interest groups. The Forest Program includes the present state of forestry and land use in Lapland and other counties as well as the identified challenges and recommendations to overcome them. The recommendations and responsibilities are directed at specific stakeholders in the forest field: research, forest industry, education, communities, municipalities, county, forest consolidations, state forest enterprises, private forest owners and NGOs. Provincial forestry councils are in charge of preparing the regional forestry programs in co-operation. The best channel to put the ROSEWOOD4.0 roadmap into action in Finland is through cooperation with these regional councils.

In *Sweden*, Paper Province will cooperate with the County of Värmland, Skogsstyrelsen and The Midde North Region to put the ROSEWOOD4.0 roadmap in action for fulfilling the Bioeconomy strategy for the region and for realizing the goals for the clusters.

We will also use our own cluster there we have research, forest industry, education, communities, municipalities, forest consolidations, state forest enterprise, private forest owners to organize meetings and events. Involvement of businesses will also be needed for some of the selected BPs. We are working with a

action plan for the implementation process and will have it ready till summer holiday. We have already had experience of surprising new knowledge when we start working with and start to learn more about specific BPs.

In order to put the ROSEWOOD4.0 roadmap into action in ***Norway*** it seems to be relevant to cooperate both with the County of Innlandet (Innlandet fylkeskommune) and the County Governor of Innlandet (Statsforvalteren I Innlandet) which together are responsible for the regional bioeconomy strategy, and with the clusters Wood Works and Norwegian Wood Cluster which involve businesses and other stakeholders. We will work hard for having the implementing activities as integrated part for fulfilling the Bioeconomy strategy for Innlandet and for realizing the goals for the clusters. We will organize meetings with these important partners and other stakeholders (e.g. Forest extiontion institute (Skogkurs) and secondary school (Solør VGS)) that can support the implementation process. Involvement of businesses will also be needed for some of the selected BPIs. We plan to have an action plan for the implementation process ready until summer holidays. We have already had experience of surprising new knowledge when we started working with and start to learn more about specific best practices. This may make changes in our plans. We will update the roadmap if important changes occur. Finally, we will highlight the unique possibility we have to make the implementing activities transnational since Värmland with Paper Province is our neighbor and there is a well-established cooperation between the regions. This could be done by cooperating with already established transnational projects like the Interreg Sweden Norway "The Bioeconomy Region in Scandinavia" and the "ecoINSIDE2" and by establishing new, joint actions and projects.

A high amount of forest owners and decreased interest / competence in forestry for owners is a common weakness and social acceptance of forestry a common threat to all the three countries in the Northern Hub. For both needs the dissemination and training organisations like the Forestry Extension Institute in Norway and the Finnish Forest Association in Finland could bring digital solutions. The Forest Finland information campaign launched in 2020 is a good example of already existing solutions spreading versatile information on forests and forestry in Finland. However, there is a clear need for joint projects and campaigns among the organisations in the Northern Hub and possibly also other hubs in the future. The ROSEWOOD4.0 network provides an excellent basis for further actions in the collaboration.

One of the main needs regarding the forestry infrastructure in the Northern hub is the poor condition of forest roads. The current condition of forest roads should be available for wood and transportation companies in order to increase the resource efficiency in wood mobilisation. In Northern Finland, the newest forest industry investment by Metsä Group will require better maintenance of roads and other infrastructure in the future. From the best practices of other Hub regions, the Road condition monitoring system could offer an opportunity for a new development project in the Northern Hub. A system of this kind could prove a suitable tool for tests for example with the Finnish Forest Centre, which coordinates many similar projects. In addition to maintaining the infrastructure of forest roads, there is a need for developing the expertise of forest road construction and maintenance. Here, Skogkurs (Forest extension institute) is a natural partner for cooperation in Norway together with other regional expertise. However, there are already companiesin the Northern countries like Roadscanners Oy and Road Consulting Oy, which have specialized in developing tools and services for traffic infrastructure condition monitoring and management. Cooperation with these companies is in needed to be able to find possible solutions concerning forest roads management in all hub countries.

Another identified main weakness in the Northern Hub is the lack of a qualified labor force, especially in harvesting and silviculture, even though forestry education is relatively intensive in nordic countries. An interesting solution from Austria is an Application Drones for seedling transport. This should be presented to local forest service entrepreneurs in order to find out whether it is of interest to them. Drones are also used in forest education in many countries, but the best practice Use of drone in vocational education should be presented in Finland to local vocational education Centre REDU.

The best practice **C.A.F.E** (Carbon, Aqua, Fire & Eco-resilience) is a Decision Support System for a multiple-criteria forest management from Spain. This tool determines the optimum silvicultural activities to manage multiple products, goods and services such as biomass production, CO_2 sequestration, fire risk, water provisioning, climatic resilience or biodiversity, which are simultaneously quantified in time and space for a selected solution. Especially Finland is very interested to present this best practice to local stakeholders, but also Sweden and Norway would like to learn more about this tool. This best practice will also be introduced to Swedish and Norwegian partners from the former Interreg Sweden Norway project called INGO. We think this best practice could be a part of the revitalization process for this consortium that is now on hold.

Climate change will also increase insect damages in the Northern forest. As a solution there were many best practices available. The most promising ones were **Festmeter** from Austria and **Arboair** from Sweden. Festmeter offers a vitality analyses made by drones regarding bark beetle detection in conifer forests. Arboair has also created camera and drone-based solutions to quickly and efficiently identify pest affected areas. Finland would like to learn more especially about the Arboair application and present this tool to its most relevant stakeholders. In Finland, the company BitComp has an AI based forest change detection service, which uses this information for example by assisting the officials to supervise illegal cuttings, and to estimate the extent of fire or storm damages that have occurred in different areas. Cooperation with this kind of company would be a first step to find out, if these best practices offer anything new for the region.

The forest industry in the Northern Hub area is concerned about the sufficiency of forest machine operators. A part of the problem is that the graduated forest machine drivers are not motivated to stay in the forestry field. The Best practice ***AVATAR*** has developed a digital coaching, assistance, and feedback system for improving productivity and job satisfaction of forest machine operators. All Northern hub countries are interested to learn more about this tool and to present it to local forest education centers. Skogkurs in Norway is already involved in this best practice and it will be natural to cooperate closely with them in the work for a broader implementation.

Sweden is also interested in further best practices from the Northern hub like DigiWood, and Women in Forestry.

Correspondingly, **Norway** is interested in the following Northern Hub best practices: **Industry 4.0/DigiWood**. This technology is already fully implemented in one of the Swedish Sawmills for Moelven Industries and we know that Norwegian sawmills in the same company want to learn more about the opportunities found in this best practice. The Norwegian Wood Cluster has a great focus on the reuse of wood and increased knowledge about the **ReGap** will fit well in their work where Forestia is one of the mayor players. Norwegian and Swedish partners in Rosewood4.0 have already started to discuss if the implementation of the best practice **Evergreen Hackathon** could be a joint action for the Norwegian Wood Cluster and Paper Province. Both will have some experience with the Hackathon methodology from their work in the Interreg BSR Connected by the Biobord project.

2.6 Conclusions and Outlook

The ROSEWOOD4.0 network is enabling the exchange of best practices and innovations between regions in Europe. The Northern Hub has already received many new ideas for overcoming the challenges of wood mobilisation, especially related to climate change, lack of qualified labor and fragmentation of forest owners. This interregional roadmap presents recommendations for tackling the weaknesses of the Northern Hub with knowledge and practical experience from other regions in the form of best practices and innovations, which have proven successful in other regions.

Nevertheless, it is not possible to fullyaddress all the present challenges, but we must continue to look for new solutions within the forestry field and beyond. Forestry is an important industry for the members of the

Northern Hub, and support must also be sought from political decision-makers in order to maintain the competitiveness of the field.

In this project, we can also contribute to our interest through information, which can be done within the limits that the current pandemic situation allows. On the other hand, the change in the operating environment through EU, national and regional instruments indicates the direction of development steps and contributes to the operation and development of forestry. Their concrete tools are various forms of support and taxation, which can effectively influence the activity of forest owners and their willingness to sell wood.

Correspondingly, the activity of large forest companies and competition in timber purchasing can activate forest owners as a result of better wood price development. At present, the forest industry is undergoing structural change, with the production of paper industry products declining and the production of pulp continuing at least as before. In anticipation of the breakthrough of new pulp-based products and the acceleration of wood construction, there will be a simultaneous debate on the adequacy of wood raw material and the conservation of forests among the participating countries committed to carbon neutrality.

The communication for the improvement needs of challenges in forestry should come from the whole forest sector. Therefore, the ROSEWOOD4.0 network can bring together various stakeholders from all Northern hub countries. Generally, when initiating new projects, the project consortium should include all relevant stakeholders. In the Northern Hub, the co-operation within the forest sector is active and functioning due to multiple joint projects, so there is a good opportunity to implement the roadmap in the regions.

ROSE WOOD 4.0 Sustainable Wood for Europe

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 862681

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