Dissertationes Forestales 320

Nordic forest solutions as an opportunity to reform the forestry sector in Russia: A case study in the Republic of Karelia

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Academic dissertation

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ABSTRACT

Forests and forest-related sectors could play a major role in the transition of the global economy from dependence on fossil fuels and non-renewable raw materials to sustainable production and consumption. Forest resources in Russia account for over 20 % of global stocks and can play a significant role in the development of the new forest-based bioeconomy. However, Russian forestry remains very much orientated towards traditional, long-standing foundations that were designed in the middle of the last century. Many of the foundations are out of date and require development. Several attempts have been made to innovate Russian forestry, and recently these have been closely linked to learning and understanding the Nordic experience in forestry, particularly from Finland and Sweden. Interest in Nordic forestry was stimulated by the greater productivity and profitability, achieved under very similar environmental conditions to Russia. Investment in soil preparation, active silvicultural systems, and road construction, as well as the utilisation of wood-based energy, are among the factors that affect the outcomes of forestry in Nordic countries. As such, it is believed that Nordic forest practices could bring several innovative and proven-over-time solutions to the development of forestry in Russia. However, due to the unique institutional and operational frameworks that currently exist in the country, Nordic forest solutions cannot be readily adapted for the local conditions. Transfer and implementation of the solutions require an understanding of the Russian operational environment.

Thus, the general aim of this thesis was to systematically analyse the opportunities and challenges of reforming the forestry sector in Russia through the adoption of possible innovations from Finland and Sweden. The study focused on the Nordic forest solutions in intensive forest management (NIFMS), road construction (NFRS) and forest energy utilisation (NFES). In addition, the general principles of strategic planning and thinking used by the Russian forestry companies were studied. The empirical part of the study was based on an analysis of the situation in the Republic of Karelia, one of the main forest regions in Russia, whose territorial and resourcing indicators are commensurate with Finland and Sweden. The key findings and conclusions are of relevance for other forest regions in Russia.

According to the results, Nordic forest solutions look promising for the Russian forestry sector, although transferring and implementing the solutions in Russia might be limited due to political and legislative factors in the local operational environment. Specifically, the prospects of NFRS are accompanied by an unprepared regulatory climate regarding the prolongation of forest leasing contracts, while NFES is stymied by a lack of sufficient economic and legislative drivers to support the development of biofuels in Russia. A sufficiently dense road network and the utilisation of energy wood are important components of NIFMS, where the latter is cited as the centrepiece of the solutions. Therefore, the solutions need to be addressed in an integrated manner, as a single packaged issue. The planning and application of the solutions should follow the principles of sustainable development, otherwise, the solutions might fail in the long-term. These principles are not yet embedded in the Russian operational environment and this should be carefully considered in future forestry development in the country.

Keywords: Russia, Karelia, Nordic forestry, forest management, strategic planning.

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Sergei Senko

Joensuu, October 2021

LIST OF ORIGINAL ARTICLES

The thesis is based on the following articles, which are referred to in the text by the Roman numerals **I-IV**. Articles **I-IV** are reproduced with the kind permission of publishers.

I. Gerasimov Y., Senko S., Karjalainen T. (2013). Prospects of forest road infrastructure development in northwest Russia with proven Nordic solutions. Scandinavian Journal of Forest Research 28:758-774. https://doi.org/10.1080/02827581.2013.838299

II. Gerasimov Y., Senko S., Karjalainen T. (2013). Nordic forest energy solutions in the Republic of Karelia. Forests 4: 945-967. https://doi.org/10.3390/f4040945

III. Senko S., Kurttila M., Karjalainen T. (2018). Prospects for Nordic intensive forest management solutions in the Republic of Karelia. Silva Fennica 52: 7763. https://doi.org/10.14214/sf.7763

IV. Senko S., Pykäläinen J. (2020). Exploring the views of forest industry companies on the long-term forestry development in Russia: A case study in Republic of Karelia. Forest Policy and Economics 120: 102311. https://doi.org/10.1016/j.forpol.2020.102311

Contribution of the author

Sergei Senko was responsible for running the experimental parts of the studies and for data analysis in all the articles. His contribution to the writing of articles was as follows:

I. 50%

II. 50%

III. 100%

IV. 100%

The co-authors all contributed to the articles through comments that significantly improved the publications. The research ideas for articles **I**, **II**, and **III** were developed by Yuri Gerasimov and Timo Karjalainen, and by Sergei Senko and Jouni Pykäläinen for article **IV**. Mikko Kurttila advised in improving the methodological section in article **III**. Jouni Pykäläinen advised in the design of the experiments and choice of methods in article **IV**.

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LIST OF ABBREVIATIONS

AHP	Analytic hierarchy process
A'WOT	AHP SWOT
CI	Consistency index
CR	Consistency ratio
CV	Cumulative voting
GDP	Gross domestic product
MCDS	Multi-criteria decision support
NFES	Nordic forest energy solutions
NFRS	Nordic forest roads solutions
NIFMS	Nordic intensive forest management solutions
PESTE	Political, Economic, Social, Technological, and Environmental
R&D	Research and development
SWOT	Strengths, weaknesses, opportunities, and threats

1 INTRODUCTION

The global economy is going through a transition, from dependence on fossil fuels and non-renewable raw materials to sustainable production and consumption (United Nations 2015; Bugge et al. 2016). Forests and forest-related sectors can play an important role in this regard. Forests represent an enormously abundant source of biomass that could be used sustainably to produce value-added products and services, provide energy security and efficiency, and contribute to climate change mitigation and biodiversity conservation (Hurmekoski et al. 2019; Lovrić et al. 2019; Näyhä 2019). Opportunities should incorporate innovative and efficient ways of forest management in order to comply with the new forest-based bioeconomy, the value of which can, and should, be shared globally (e.g., Winkel 2017).

Forest resources in Russia account for over 20% of global stocks and can play a significant role in the development of the forest-based bioeconomy (FAO 2014; Lamers et al. 2016; Berlina and Trubin 2019). However, Russian forestry remains strongly orientated on the traditional, long-standing foundations that were designed in the middle of the last century, with the attendant decisions, technology, and knowledge of that time (FAO 2012). The foundations include, among other factors, capital assets, institutions, policies, science and education, which continue to underpin the management and utilisation of forest resources in the country. Indeed, the impetus to innovate Russian forestry is becoming an important objective in achieving sustainability goals in the global economy (Newell and Simeone 2014).

During the last two decades, several attempts have been made to improve the Russian forestry sector, for example, through the introduction of new forest legislation (Federal Law 2006; Karvinen et al. 2011), initiation of industrial investment support programs (see Zinovyeva et al. 2019), and the implementation of specialised research and development projects, including those in a cross-border cooperation context (see European Commission 2010; Almazan et al. 2016; European Commission 2018).

The development process remains ongoing in Russia, and recently it has been closely linked to the acquisition of knowledge and transference of international experience in forestry and silviculture. The most frequently discussed are Nordic forestry practices, particularly from Finland and Sweden (Karjalainen et al. 2007; Karjalainen et al. 2008; Karjalainen et al. 2009; Soroka and Ananiev 2009; WWF 2013; Shmatkov 2012: Itkonen 2014; Grabar 2015; Verveiko 2015; Konovalova 2015; Islakayeva 2017; Northern Research Institute of Forestry 2017). Interest in the Nordic experience has been created by the higher productivity and profitability experienced by forestry in those countries, which was achieved in very similar environmental conditions to many forest regions in Russia.

Increased forest productivity in Finland and Sweden is owed to investments and the practice of active silvicultural systems, which were complemented by modern road construction, and the utilisation of wood-based energy (Äijälä et al. 2014; Rytter et al. 2016). These are planned and carried out within the principles of sustainable forest management, which is widely promoted in Nordic forestry (Kotilainen and Rytteri 2011). Nordic practices may bring several innovative and proven-over-time solutions to the developing forest sector in Russia. The solutions could move the forestry sector there towards more active management and silvicultural systems, which would also take into account the sustainability and profitability of the forest resources.

However, due to the unique institutional and operational frameworks that currently exist in Russia, Nordic practices cannot be readily adapted for the local operational environment. The transfer and implementation of the innovative solutions would require an understanding

of the infrastructural, technological, economic, political, social, and other related factors in the country, which may enable or hinder the adaptation under local conditions. The intricate characteristics of the operational environment may also influence the main actors in the operational environment, conditioning them to make their behaviour compatible with the established norms and practices in forestry. To that end, the views of the actors may also contain important individual, group, and contextual factors associated with the current state of the operational environment in Russia. Understanding these views will help to reveal the principles used by the actors when planning strategic decisions and actions in the Russian forest sector, including the adoption of innovations that could be incorporated in the further development of forestry solutions in the country. The key actors here are the wood harvesting companies, which are the main forest users and are likely to be the main practitioners of Nordic forest solutions in Russia (should the solutions be implemented in the country).

Thus, the general aim of this current study is to systematically analyse the opportunities and challenges posed by the reformation of the forestry sector in Russia, through the adoption of possible innovations from Finland and Sweden under local conditions. Exploring the views of the local Russian wood procurement organisations in this regard is factored into the analysis. The study is focused on Nordic forest solutions in intensive forest management, road construction and wood-based energy utilisation. The empirical part of the study is based on an analysis of the situation in the Republic of Karelia, one of the main forest regions in Russia, whose territorial and resourcing indicators are commensurate with Finland and Sweden. The key findings and conclusions are of relevance for other forest regions in Russia. The specific objectives of the study are as follows:

i. To provide an overall and constructive picture of the operational environment in the study area in regard to the transfer and implementation of Nordic solutions in intensive forest management, road construction, and wood-based energy utilisation.
ii. To highlight the most important factors that might influence the transfer and the implementation of Nordic solutions in the study area.
iii. To support the formulation of possible alternatives for the transfer of selected Nordic solutions to the study area.
iv. To explore the current principles of planning decisions and actions in forestry used by the future executors of selected Nordic solutions in the study area.

The study builds on four interrelated articles. The operational environment in Karelia was analysed from the development of a transport infrastructure perspective in article **I**, while utilisation of energy wood was evaluated in article **II**, and the practices of intensive forest management and silviculture were assessed in article **III**. These articles were designed to provide an overview of the operational environment in Karelia and to elucidate the key factors that must be considered in the further development of the forest sector in Karelia and Russia. Attempts were also made to contribute to the strategic planning processes of transferring solutions to Russia using multi-criteria decision support methodology.

In the final stage (**IV**), the operational environment of Karelia was analysed by exploring the views and concerns of the local wood harvesting companies in regard to long-term forestry development in the region. The role of the forestry companies in developing the sector is essential, and a more detailed understanding of the mode of long-term thinking of the forestry companies may expose the general principles employed when strategic decisions and actions are planned. This information is highly important in evaluating the opportunities

for Nordic forest solutions in Karelia and Russia, as it will be the same forestry companies that will carry out those solutions in practice.

2 MATERIALS AND METHODS

2.1 Study area

Republic of Karelia is one of the main forest regions of Russia, with over 9 million hectares of forest, which is more than 50% of the total land area. The growing stock is about 1 billion m^3, which is on average 100 m^3/ha with a coniferous cover of 80%. Net annual increment of the forest resource is estimated at over 14 million m^3 or 1.5 m^3/ha (Ministry of Nature Management and Ecology of Karelia 2019). Table 1 provides a statistical overview of Karelian forests, including a comparison with forests in Finland and Sweden.

Forests in Karelia, as in the rest of Russia, are state-owned. According to national forest legislation (Federal Law 2006), people have a common right to access the forest, for example, for walking or gathering berries and mushrooms. More commercial use and management of the forests is based on leasing contracts. The forest can be leased by companies for timber harvesting, collection of non-wood forest resources, hunting, farming, scientific research, education, recreational activities, protection, cultivation, and other activities. The most common type of lease in Karelia is a wood harvesting lease, which covers 99% of the leased forest area (Ministry of Nature Management and Ecology of Karelia 2015).

Karelia is an important region for the development of the national forest sector; it is a significant producer and exporter of roundwood, sawn timber, and pulp and paper products (see Table 2). Many large forestry companies operate in Karelia, including those from Nordic countries. Together, the companies provide over 40% of total employment and about 15% of gross domestic product (GDP) in the region (Kareliastat 2016).

In contrast to the importance of forests and the economy that is based on them in Karelia, the growth of the region's forest sector has been below its resource potential. One cause is the dominance of extensive forest management, which can be defined as the monetary investment per unit area of land, or by the number of treatments performed on a forest stand per rotation, or by a consideration of both (Bell et al. 2006). Simply put, a stand that is treated only once during the forest growth, i.e., for a final harvest, is managed extensively. This practice is widespread in current forest management in Karelia. Specifically, wood harvesting operations focus mainly on the clear cuttings, which are carried out in mature and over-mature stands and are usually located adjacent to the existing roads. Thinning or rather selective cutting in growing forests is performed on a small scale. Reforestation is mostly based on natural regeneration. Planting, soil preparation and young stand improvements are less common (Ministry of Nature Management and Ecology of Karelia 2019).

The quality of the existing forest road infrastructure is poor and is not able to provide appropriate accessibility. Road density is approximately 2m/ha (10m/ha in Finland and Sweden), with most of the roads requiring major repairs. The building of new roads is seldom made, and it is still based on the bulldozer approach, which is costly and often inefficient in water control (Chernyakevich and Kirsanov 2008). The local forest companies mainly work within a road network designed back in the Soviet times (Stepanov and Petrov 2014; Shegelman and Vasilyev 2017; Volkov and Kozyreva 2018).

Table 1. Key statistics of Karelian forest resources. *

Statistic	*Unit rate*	Karelia	Finland	Sweden
Total Area	*10^6 ha*	18.1	33.9	44.8
Forest cover	*10^6 ha*	9	23	22.5
Total growing stock	*10^9 m^3*	1.0	2.3	3.0
	m^3/ha	100	100	130
Net annual increment	*10^6 m^3*	14	100	120
	m^3/ha	1.5	4.3	5.3
Annual wood harvesting	*10^6 m^3*	7	65	90

*Based on Swedish Forest Agency (2014), Ministry of Agriculture and Forestry of Finland (2015), and Ministry of Nature Management and Ecology of Karelia (2019).

Table 2. Key output statistics for the Karelian forestry sector. *

Product	*Unit rate*	Karelia	Russia	% to Russia
Roundwood	*10^3 m^3*	7238	238582	3%
Sawnwood	*10^3 m^3*	923	26049	3.5%
Pulp	*10^3 t*	1129	8578	13%
Paper and Cardboard, *incl.*	*10^3 t*	1009	9015	11%
Newsprint	*10^3 t*	654	1540	42%
Paper Bags	*10^3 pieces*	850	1420	60%

*Based on FSSRF 2020.

Occasionally, such a model of forest management is described as 'timber mining' (e.g., Elbakidze et al. 2013; Angelstam et al. 2016; Angelstam et al. 2019), in the sense that once a forest plot has been completely exhausted, it ceases to be an object of further management, and the wood harvesting activities are moved to a new mature forest asset. The approach has influenced the structure and quality of forest resources in Karelia. For example, the commercial forest land of coniferous forests has reduced considerably over the last 30 years, while in contrast, the area of deciduous forests, such as birch and aspen has significantly increased (Soroka and Ananiev 2009; Ananiev and Moshnikov 2016). The area of mature forests near the road network has reduced steadily. The age structure has also changed; forests currently consist of 34% young stands, 26% middle-aged stands, 7% premature stands and 33% mature and over-mature stands. The uneven age structure hinders the planning of a sustainable yield, especially as there are not enough premature stands (Soroka and Ananiev 2009). As a result, the wood processing industry has struggled with the availability of raw material in recent times (Government of the Republic of Karelia 2019). High-conservation value forests have also been impacted, as the reduced yield of commercial forests, due to inefficient forestry practices, has increased the number of wood harvesting operations in the intact forest landscapes (Shvarts et al. 2015; Angelstam et al. 2016; Blumroeder et al. 2019). A forest of this kind is extremely important, both environmentally and socially, since it provides a habitat for a significant number of species, biological diversity, water protection functions, as well as providing special goods and services to the local communities, which are dependent on them for their livihoods (Kleinschroth et al. 2019).

The forest management practices in Karelia are also typical of other forest regions of Russia, such as Leningrad, Archangelsk, Vologda, Novgorod, Pskov, and Komi Republic

(Karjalainen et al. 2009). In Siberia and the Far East of Russia, the situation is similar, although it is aggravated by other challenges, such as forest fires and illegal logging (e.g., Henry and Tysiachniouk 2018; Loupian et al. 2019). The latter is also evident in the European part of Russia but on a relatively smaller scale (e.g. Bondarev 2018; Shmatkov 2020; Izvestia 2021). Against this background, it is evident that there is a need for the development and innovation of the forest sector, and the advanced Nordic forest solutions might provide the answers to improve current forestry practices in Karelia and move towards more active management and silvicultural systems, which would also take into account the profitability and sustainability of the forest resources.

2.2 Nordic forest solutions

Forests in Finland and Sweden are an important renewable natural resource and provide the backbone of the national and regional economies (e.g., Poudel et al. 2012; Kumar et al. 2020). Nordic forestry has a long tradition and has accumulated considerable experience in that time and has always been associated with efficient and sustainable management and utilisation of forest resources. Forests and forestry in Nordic countries are determined by the natural conditions, rich history, a diversified range of research and developments, as well as the knowledge of the people, who live and work in the forest. The Nordic concept of forestry, which has come to be widely known as the Nordic forestry model, is an industrial and technologically advanced forest management system, which at the same time attempts to share social, environmental, and commercial compromises in the management of forests (Beland Lindahl et al. 2015).

In its present form, the Nordic forestry model has been practised for several decades, although its roots go way back to the last century. Implementation of the Nordic forestry model has resulted in significantly increased forest growth. Currently, forests in Finland and Sweden are producing more timber than ever and are intensively and sustainably utilised. In Finland, forest resources amount to approximately 2.3 billion m^3, which is over 100 m^3/ha. The annual growth of forests is over 100 million m^3 or 4.3 m^3/ha, which is almost double the growth of 50 years ago (Metla 2014; Luke 2019). Annual wood harvesting is over 70 million m^3 but can be sustainably increased to 80 million m^3 (Ministry of Agriculture and Forestry 2015). Swedish forests are very similar in composition and volume to those in Finland. The total yield of wood amounts to approximately 3 billion m^3 (over 130 m^3/ha). Annual growth is around 120 million m^3 or 5.3 m^3/ha, which continues to increase year on year and is already double the growth rate of 100 years ago. Annual wood harvesting is around 90 million m^3 (Swedish Forest Agency 2014; SLU 2020).

The main reason for the increased growth has been the investment in practices developed for intensive and sustainable management of existing forest resources. Specifically, the practices are focused on active silvicultural treatments (e.g., Luke 2019), complemented with modern and extensive forest road construction and the utilisation of wood-based energy.

2.2.1 Forest management and silviculture

Intensive forest management has been a dominant practice in Nordic countries. In contemporary terms, the definition of intensive forestry may vary slightly depending on the growing conditions, whether it is a natural or plantation forest, and the geographical usage context (e.g., West and Shula 2009; Puettmann et al. 2015; Demaraisa et al. 2017). In Finland

and Sweden, intensive forest management primarily refers to the intensive silviculture performed in forest stands, where an effort is made to maintain the natural ecosystem characteristics during stand disturbances. When these practices are applied, the forests are successively managed with more active regeneration, tending of seedling stands, and regular thinning (Metsäkustannus 2011; Äijälä et al. 2014). Regeneration has been greatly improved through artificial planting, soil preparation, and fertilisation in the case of nutritional deficiencies. Respacing and cleaning operations are used to prepare the structure and growth conditions of the future forest stand. In some cases, the start of operations has already commenced in five-year old stands. Thinning has been a common practice and is usually carried out two or three times over a forest rotation to maximise the forest crop (Kärhä et al. 2004; Mäkinen and Isomäki 2004).

Such intensive silvicultural practices, the so-called Nordic intensive forest management solutions (NIFMS), have delivered several clear benefits to the forestry sector in Finland and Sweden. Among the main benefits are optimised forest structure and increased timber quality, which leads to a larger output of high-value wood assortments. However, its success would not have been achieved, especially economically, without suitable access to forest resources.

2.2.2 Forest road construction

A sufficiently dense forest road network has played a fundamental role in ensuring accessibility to the forest resources, as well as providing the impetus for the cost-efficiency of the implemented silvicultural treatments. Since the middle of the last century, more than 210,000 and 270,000 km of roads have been constructed in Sweden and Finland, respectively, to assist in the management and exploitation of forest resources. The current road density in these countries is on average 10 m/ha, and the forwarding distance of up to 200 m (Metla 2014; NVDB 2020) is the highest in Europe and has a major impact on the profitability of wood harvesting and procurement operations (e.g., Kaczan 2020).

Particular attention has also been paid to the quality and cost of road construction in these countries (Tapio 2008). A significant improvement in this regard has been made in the road-building techniques. Specifically, hydraulic excavators have replaced the bulldozers that had typically been used in tandem with other complementary machines (a disadvantage due to higher maintenance costs). An excavator is very versatile, is more efficient than a bulldozer, and is equipped with a variety of arms that are able to build up a road foundation and side ditches, as well as install culverts, in a single operation. In doing so, the ground material excavated from the side ditches is transferred to the foundation, thus eliminating the need for additional construction materials (except for surfacing). Typically, other road construction machinery is not then required for the excavation. As a result, the number of earthworks is reduced, while the overall construction performance increases, thereby positively impacting costs at the same time.

Another notable improvement has been in the compaction of the road foundation. Mechanical compaction, which must satisfy several parameters, such as control of the moisture content and density of the soil layer thickness, packing pressure on the soil, the number of treatments etc., has been partly replaced with natural stabilisation in some cases. That is, the road foundations are constructed well in advance and then are left for about a year until the stabilisation occurs naturally. Subsequently, a single-layer thickness of gravel (road surface dressing) is laid on the already dried out and stabilised foundation. As a rule, the gravel comes from local pits. Optimisation of the gravel is not performed. For road

construction on waterlogged or humid soils, artificial non-woven materials, such as geotextiles are used (Greis and Kontinen 2014).

Some of these methods and approaches were adopted and successfully adapted from the approach used in the construction of public roads (e.g., use of geotextiles). The implementation of Nordic forest road solutions (NFRS) in Finland and Sweden has made it possible to reduce construction costs, increase reliability and the service life of the road infrastructure, and improve wood procurement efficiency and accessibility. The latter has also been instrumental in facilitating the development of wood-based energy utilisation.

2.2.3 Wood-based energy utilisation

Energy wood has become the third wood assortment in Finland and Sweden (on par with sawlogs and pulpwood) and its supply and extraction from the forest have been a novel part of the Nordic forest energy solution (NFES) (Malinen et al. 2001; Asikainen et al. 2011). Wood-based energy is widely used in heating and power (or combined) plants throughout these countries (see Alakangas et al. 2018). The raw material is composed of logging residues, stumps, and small-diameter trees from final felling and thinning operations, including those performed in young stands (e.g., Ahtikoski et al. 2008). This has enabled the creation of an entirely new energy wood procurement system (Routa et al. 2013), which (among other factors) helps the local forest users to cover the expenses entailed with the growth of the forest, as well support the socio-economic development of small cities and towns through the establishment of independent energy supply systems controlled by local cooperatives (e.g., Enonenergia 2020; Lehtinen et al. 2020).

The utilisation of woody biomass for energy is also important from a silvicultural point of view, especially as it provides space and resources for the main crop and helps regeneration operations (Äijälä et al. 2014). Moreover, wood is a renewable source of energy, and its utilisation contributes to the mitigation of greenhouse gas emissions and climate change mitigation, i.e., issues that have been an important part of sustainable development policies in the Nordic countries.

2.2.4 Principles of sustainability in planning and decision-making

Commitment to the objectives of sustainable development is a key component of forest politics in Nordic countries (e.g., Beland Lindahl et al. 2017). However, it is noteworthy that in the early stages of development over the past decades, forestry practices in Finland and Sweden were focused mainly on a single dominant objective, i.e., the provision of raw material to the forest industry (e.g., Kotilainen and Rytteri 2011). By the end of the twentieth century, when sustainable development policies were introduced at global, national and local levels (Ministerial Conference on Protection of Forests in Europe, 1995, 1998, 2001), the interpretation of the concept became much broader. More precisely, due to increased global concerns regarding the maintenance of biodiversity, climate and other ecosystem services that affect long term development, the focus on timber production solely has changed to encompass a wider range of economic, social, and ecological objectives (Hassan et al., 2005).

Since then, forest users and managers in Finland and Sweden are required to consider multiple functions in the operating activities and in the strategic planning processes. The emphasis is on the needs of the forest and non-forest products and services, the preservation of forest health and diversity, as well as contribute to the social-cultural environment of local communities. These principles have formed the basis of sustainable forest management

policies in the Nordic countries. Forestry has been focused on not just economic advantage from the use of forest resources (i.e., the sale of wood and wood-based products), but also maintain ecological and social considerations in the management of forests by also taking into account the interests of relevant stakeholders (Kotilainen and Rytteri 2011).

Development of sustainable forest management in Finland and Sweden is supported by several policy tools, for example, legal frameworks and legislation (Appelstrand 2012; Ministry of Agriculture and Forestry of Finland 2015, 2017), forest certification (Schlüter et al. 2009), natural resource plans (e.g., Louhisalmi et al. 2007; Maukonen et al. 2008), Natura 2000 schemes (Sundseth and Creed 2008), and the voluntary protection of biodiversity (see Hiedanpää and Borgström 2014). Nordic forestry, its ideology and practices attempt to be a model of commitment to sustainable development (Beland Lindahl et al. 2015), although the concept still experiences some criticism and controversy (e.g., Beland Lindahl et al. 2017). The experience can be used by others for innovation and development.

2.3 Research design

The transfer of Nordic forest solutions to Karelia, and their subsequent implementation, requires a careful assessment of the local operational environment. Analysis of the operational environment is often influenced by changes within internal and external factors. Moreover, multiple qualitative and quantitative criteria, their interdependencies and possible subjective views might also complicate the task. Making reliable decisions and judgements under these circumstances becomes difficult. To address the key objectives of this current study and contribute to further strategic planning processes, a systematic and analytical approach was utilised here based on the use of modern decision support applications and methods.

Specifically, articles **I**, **II** and **III** followed a technique that combined SWOT (Strengths, Weaknesses, Opportunities, Threats) and the multi-criteria decision support (MCDS) method in an analytic hierarchy process (AHP), hereafter called the A'WOT approach (Kurttila et al. 2000). Article **IV** was carried out with a two-stage survey; an unstructured interview approach for the first stage and cumulative voting (CV) for the second stage. The results of the survey were summarised into a PESTE (Political, Economic, Social, Technological, Environmental) framework.

2.3.1 A`WOT

When SWOT is applied (Leraned et al. 1965; Weihrich 1982), it is possible to provide a solid basis for the scanning of the operational environment. However, the application of the method, as such, provides only a qualitative examination of the environmental factors. The importance and significance of the SWOT factors are not considered (Ghazinoory et al. 2007). Therefore, A`WOT was developed by combining SWOT analysis with AHP (i.e., A`WOT) to improve the quantitative information basis for analytical processes and to support decision-making (Kurttila et al. 2000). The AHP method was originally prepared by Saaty (1980) and is a mathematical calculation framework for the analyses of complex decision problems, where both qualitative and quantitative data might be processed. It is conducted through pairwise comparisons and relies on the pairwise evaluations of elements of the decision hierarchy to derive priorities. In the A`WOT approach, AHP is used to assign relative weighting factors identified in the SWOT procedure. That is, the results of AHP are

numerical values that show the priorities of the factors included in the SWOT analysis. These results can be thereafter utilised for structuring the problem, formulating the strategic alternatives for the transfer of the considered Nordic forest solutions to Karelia, and also for the evaluation process. In addition, as recommended by Saaty (2008), these measurements rely on the judgement of reliable experts to emphasise and substantiate priority scales.

The design of the A`WOT stages is a critical point to obtain reliable results. As such, articles **I**, **II**, and **III** were planned and implemented according to the guidelines issued for conducting A`WOT (Kurttila et al. 2000; Kangas et al. 2015). The research work commenced with pinpointing the operational environment factors that may influence the transfer of NFRS, NFES, and NIFMS to Karelia. This was carried out with a comprehensive review of various literary sources; 80 academic journals, 45 professional magazines, 27 forest statistics, 14 governmental programs, 11 conference proceedings, 10 project reports and working papers, and 6 various manuals. In addition, several key experts were consulted. The findings were allocated to the SWOT frameworks in the form of Strengths, Weaknesses, Opportunities, and Threats. Identification of the most important factors and parameters of the transfer of NFRS, NFES and NIFMS involved the following activities:

- At the start, data from the literature were used to provide a broad content covering all possible technological, economic, environmental, political, and socio-demographical trends and challenges that may affect the transfer and application of the relevant Nordic solutions in Karelia.
- Then, to define the main factors and to thereafter allocate them to the SWOT framework, consultations with several experts, and internal discussions between authors were undertaken. Consequently, some of the trends and challenges were combined and presented as one factor, while others were placed as is.
- After the data was narrowed down, a set of identified environments was divided into internal strengths and weaknesses, and external opportunities and threats.
- Finally, the factors were illustrated in a SWOT quadrangle.

The factors identified and illustrated in SWOT were then prioritised with the AHP procedure for identifying the relevant hierarchy of the most critical factors that could enable or hinder the transfer of NFRS, NFES and NIFMS to Karelia. For this purpose, local experts from the local forest industry and the Research and Development (R&D) organisations were interviewed. The interviews were undertaken individually in early 2013 in Karelia. The forest industry was represented by logging companies, and R&D organisations – a state university and a research institute. The total number of respondents per each study was twelve (**I**), eleven (**II**) and thirteen (**III**) (Table 3).

Table 3. Number of respondents per study and stakeholder group.

Study	Industry	R&D	Total
NFRS (I)	7	5	12
NFES (II)	3	8	11
NIFMS (III)	6	7	13
Total	16	20	36

The industry respondents represented different levels of management, such as general directors, operational and technical managers, and other similar positions, who have long-standing experience in wood harvesting, forest management, and wood processing. In total, 16 industry experts took part in the interviews, representing 10 different domestic forestry companies. The R&D respondents included experts from the Petrozavodsk State University, the Karelian Forestry Research Center, and some individual experts from other R&D organizations. The selection of respondents was based on several discussions with key informants from forestry authorities, research organisations, and industry associations, who have extensive professional networks. In this way, the chosen respondents were proven experts in terms of reputation, expertise and knowledge on the topics that they were supposed to be interviewed. The total number of respondents per group varied and was dependent on their availability and willingess to participate in the interviews.

At each of the interviews, the factors were initially explained, and the respondents were then asked to assign a relative weighting to (a) each of the factors for pair-wise comparison within a given SWOT group (i.e., the local priority) and, after, (b) to the factors with the highest priority from each SWOT group. These four factors were compared pairwise to each other, which then allowed them to be scaled to the level of priority (i.e., to know the overall priority of each SWOT group). Next, the relative priorities of these four factors were used to scale the global priorities for the remaining independent factors in each SWOT group. This was computed by multiplying the priority of the factor within the group by the priority of the group, i.e., by the relative priorities of those four factors corresponding to each group. The global priority scores of all factors across the SWOT groups sum to one and each score indicates the relative importance of each factor in the decision. In articles **I** and **II**, only the local and overall priorities of each SWOT group were described, referring to the similar methodology described in Kurttila et al. (2000). The global priorities for articles **I** and **II** were additionally calculated for this thesis.

The results obtained were selected for further analysis and to determine the mutual influence of the factors that contribute to the strategic planning process and to the selection of a final strategy. In articles **I** and **II**, the external opportunities and threats were analysed with a view to determining their probability and impact on the operational environment.

In A`WOT, AHP was applied to many interviews and respondents. Therefore, the different elicitations were aggregated using basic statistics (mean, median, standard deviation). In articles **I** and **II**, the Perth-formula (Kauko 2002) was also used as follows:

$$\text{Aggregation of the elicitations with the Perth formula} = \frac{\text{the smallest value (a)} + 4 \times \text{the median (b)} + \text{the largest value (c)}}{6}$$

In this way, the bias of the extreme elicitations for value (a) and value (c) in the calculations is mitigated (see also Kryvobokov 2005 for details).

In each pair-wise comparison in articles **I**, **II**, **III**, the most important factor was assigned a weighting (2–9) based on its relative importance. A score of one indicates equal weighting for the two factors. Information delivered from a pair-wise comparison is represented in comparison matrix A:

$$A = \begin{bmatrix} 1 & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \cdots & 1 \end{bmatrix}$$

where a is entries and n is the number of factors

A factor priority score was then calculated for each comparison using the eigenvalue method, and mean values were calculated for each SWOT group (see Malovrh et al. 2012). The priority vector W = (w1, …, wn) is obtained by solving the equation:

$$AW = \lambda maxW$$

where λmax is the largest eigenvalue of matrix A.

Concerning consistency, matrix A is acceptably consistent if:

$$\text{Consistency Ratio (CR)} = \frac{CI}{R} < 0.1$$

$$\text{Consistency Index (CI)} = \frac{\lambda max - n}{(1 - n)}$$

where R is the average random consistency index.

Serious inconsistency exists if CR > 0.1, and AHP may not yield meaningful results. In this case, the experts should reconsider their conclusions. The priority vectors W and consistency ratios CR of the SWOT group comparison matrix A were calculated with the decision support software MPRIORITY 1.0 (Abakarov 2005).

2.2.2 Unstructured interviews, cumulative voting and PESTE analysis

Exploring the views of the wood harvesting companies in regard to forests and forestry development in the long term in Karelia was the final task of the study. The term "views", especially when it is related to the long-term, is often based on hypothetical, abstract and non-systematic assumptions that are not sufficient to meet the needs of the current study objectives. Therefore, article **IV** followed a descriptive and systematic participatory approach to facilitate the determination of the most critical issues in a qualitative and quantitative framework. The study comprised a two-stage survey, conducted in 2016 (from May to October) in the Republic of Karelia. The survey targeted experts from the forestry companies in Karelia that are active in wood harvesting operations and have long-term forest leasing contracts. The survey avoided foreign-funded companies as the study is focused only on exploring the views of traditional Russian companies.

The experts represented only high-level management positions, such as CEOs, directors and other similar positions, who have the authority to establish the development strategy of the company or can significantly influence the strategy. The selection of respondents and interviewees was based on several discussions with key informants from forestry authorities, research organisations, and industry associations, who have wide professional networks. In this way, the chosen experts were mostly well-known, and their status, or the status of the company they represent, allow them to contribute to the development of forestry in the region.

In total, 14 experts took part in the initial interview, representing 12 different domestic forestry companies with a total leased area of over 7 million hectares.

The general aim of the survey was to identify the factors and the priorities that experts believe need to be taken into account to provide, or at least to contribute to, the long-term development of the forestry sector in Karelia. This survey employed an unstructured interview approach (Given 2008) for the first stage of the survey (formulation of the issues) and employed CV (Blair 1973) for the second stage (exposing the options). The range of methods was selected because of the specificity of the target expert group. More precisely, the management culture in Russia is still rather dictatorial and autocratic (legacies from Soviet times) (Kolennikova 2013) and managers are often reluctant to try new ways of doing things. Typically, top-level managers are high-status appointees, are extremely time-limited, and are often passive towards tasks and questions that are not directly relevant to the order of the workday. Therefore, the methods selected for the survey stages were designed to be carried out easily, quickly, and efficiently, with a simple and clear scheme.

An unstructured interview is a qualitative research method for data collection that aims to gather unanticipated, first-hand information that can be used to develop a better understanding of the respondents' view on an issue (Zhang and Wildemuth 2009). The CV approach was used here to provide a quantitative-based analysis of the expert opinions. It is a prioritisation method (similar to the 100-Point method, the Hundred-Dollar test) where each participant (i.e. voter) is given a hundred points, dollars or other imaginary units that can be spent on prioritisation on a list of items (Blair 1973). The points can be distributed by the participant in favour of their preferences.

At the first stage, the survey provided the experts' view of the long-term targets for the development of the forestry sector in Karelia, through the use of individual, unstructured interviews. The interviews included only one open-ended question, framed in such a way that the answer from the expert should constitute a list. At each of the face-to-face meetings, the question was as follows: *What actions should be primarily taken to ensure, or at least to support, the development of forestry in Karelia in the long term?* Each of the experts identified a personal list of actions and provided an argument for every single action. The interviews were recorded on audio (in total 350 minutes of audio records that were then transcribed into 20 pages of text material), and keynotes were also documented on paper for further analysis. The length of the interviews ranged from 10 minutes to an hour. When all interviews were completed, the identified actions were combined into a common list, where each action was provided with a short description. The second round of the survey applied a standard CV, intending to identify priority themes from the dataset.

To increase the visibility of the identified actions (i.e., strategic views on forestry development in Karelia), the expert assessments were summarised into a PESTE framework. The points allocated by the experts to every action were used to provide a quantitative principle in the PESTE analysis. Specifically, all points assigned to an action classified under the same category were summed. This made it possible to scale each of the PESTE categories.

The CV approach is easy to manipulate (Nurmi 1987) so it is possible to vote strategically (see Riņķevičs and Torkar (2013) for details). In order to determine the effects of possible strategic voting, the influence of each participant on the final priority order (so-called social choice) was analyzed (Vainikainen et al. 2008). Specifically, it was examined by determining the correlations between the results of the final rank ordering with and without each participant, in addition to the stated rank ordering of each participant and the final rank ordering with and without this participant. Correlations were measured as described in Vainikainena et al. (2008) with the use of Spearman's coefficient and formula (Siegel, 1956).

Spearman's rank correlation coefficient by Siegel (1956)

$$= \frac{\sum r(x_i)^2 + \sum r(y_i)^2 - \sum (r(x_i) - r(y_i))^2}{2\sqrt{\sum r(x_i)^2 \sum r(y_i)^2}}$$

$$\sum \mathrm{r}(\mathrm{x_i})^2 = \frac{\mathrm{n}^3 - \mathrm{n}}{12} - \sum \frac{\mathrm{t_x^3} - \mathrm{t_x}}{12}$$

$$\sum r(y_i)^2 = \frac{n^3 - n}{12} - \sum \frac{t_y^3 - t_y}{12}$$

where x and y are voters, r(xi) and r(yi) are the ranks they give to criterion i, n equals the number of criteria, tx equals the number of criteria that share a certain rank in the ranking of voter x, and ty equals the number of criteria that share a certain rank in the ranking of voter y.

Another measure used for the analyses of the voting pattern is to calculate the standard deviation of each participant, whereby the extremity of the preferences or tactical manner of voting can also be examined.

3 RESULTS

In articles **I**, **II**, and **III**, the operational environment factors that may enable/hinder the transfer and application of NFRS, NFES and NIFMS in Karelia were reviewed. The factors were presented in the form of Strengths, Weaknesses, Opportunities, and Threats. The number of factors identified during the literature review stage was 26 (**I**), 27 (**II**), and 23 (**III**). Every factor was provided with a short explanation. The respondents assigned a priority to each factor through pair-wise comparisons. These priorities represented numerical values wherein it is possible to define the prioritisation factors that are more important and determine their importance in comparison to other factors in the SWOT quadrangle. Based on a close consideration of the foremost factors, the results can be utilised for structuring the problem, defining new objectives and implementation, and formulating possible alternatives and strategies for transferring NFRS, NFES and NIFMS to Karelia. The additional contribution to the strategic planning process in articles **I**, **II**, and **III** came in the form of determining the mutual influence of the factors that are used in SWOT, and their probability and impact analysis.

In article **IV**, the concerns and views of the expert group from forestry companies were scrutinised. The results were presented in the form of a list of actions that the expert group believed needed to be taken into account to provide, or at least to contribute, to the development of the forestry sector in Karelia in the long term. Through the CV procedure, the experts assigned a priority to each action in the list, thereby providing a complete rank order of importance of the actions. At the final stage of the study, the expert assessments were classified under a range of categories; Political, Economic, Social, Technological, and Environmental. The results illustrated the mode of thinking that develops at the company level and the possible principles used when strategic planning in those companies.

3.1 Key factors affecting implementation of NFRS in Karelia

The Strength factor "*Moderate building cost and high performance*", Weaknesses "*Strong dependence on the availability of local stone-pits*", Opportunity "*Unlimited market potential*", and Threat "*Lack of legal framework under forest land leasing*" were considered the highest priority factors representing the SWOT groups (**I**). The results of their pairwise comparison show that Strengths and Threats are the most important SWOT groups, Weaknesses and Opportunities are the least important. In terms of overall scores, the greatest global priorities are represented by the Threat "*The lack of legal framework under forest land leasing*" (Global weighting (GW) = 0.078), followed by Strengths "*Better manufacturability*" (GW = 0.063), "*Moderate building cost and high performance*" (GW = 0.062), Threats "*Low profitability of forestry business*" (GW = 0.058), "*Limited resources of construction materials*" (GW = 0.058), and Weaknesses "*Dependence from the local construction material*" (GW = 0.057). The remaining factors were considered to have lower global priorities (Table 4).

The most common explanation of the respondents for the prioritized Threat "*The lack of legal framework under forest land leasing*" was the insecurity of private investments in modern forest technology in Russia. The high investment cost might require a longer payback period and this was considered as a significant risk due to the uncertainty of the extension of forest leasing contracts. The presence of two Strengths among the most prioritized factors explains the high interest in NFRS from the respondents, despite this Threat. Other factors in the matrix were of a more general explanation.

Opinions of industry and R&D respondents on some factors diverged. For example, the local weighting of Strengths "*Moderate building cost and high performance*" and "*Lower machinery investments"* were greater for the R&D respondents than the industry respondents, but vice versa for "*Environmental friendliness*" and "*Water control*". Here, respondents from R&D had a more theoretical background, while the preferences of the industry specialists were based on their limited experience of the technology.

The respondents from R&D prioritised Weakness "*Dependence from the local construction material*" by considering this factor in a wider geographical context (outside Karelia), while the industry respondents did not see this as significant for the area where they operate (inside Karelia), and gave greater preference to other factors.

Opportunities "*Fire control*" and "*Multiple use of forest sources*" were the major external opportunities for the respondents from industry, as the factors, in their opinion, are related to the profits or losses of wood harvesting activities. According to the Russian forest legislation, forest fire control is under the responsibilities of forest leaseholders. The respondents from R&D considered these Opportunities to be part of the "*Unlimited market potential*" of the Russian forestry sector.

Threat "*Dominance of extensive forest management*" was considered by R&D as one of the major limiting factors to the implementation of NFRS in Karelia. The industry respondents evaluated this factor as less important in their replies as they see the current forestry practices in Karelia to be less extensive compared to other regions (e.g., Siberia and the Far East of Russia).

More detailed results of the local weighting of the SWOT factors associated with NFRS transfer to Karelia by stakeholder groups, calculated with the Perth formula, are presented in Figs. 1–4.

Table 4. Local weighting (LW)[a] and global weighting (GW) of the SWOT factors associated with NFRS transfer to Karelia (the factors are ranked in decreasing order from highest to lowest weightings for each SWOT group. The factor with the higher weighting is located above the others) (CR is the consistency index per SWOT group)[b].

Strengths (CR=0.076)	***LW***	***GW***	**Weaknesses** (CR=0.064)	***LW***	***GW***
Better manufacturability	0.189	0.063	Dependence from the local construction material	0.313	0.057
Moderate building cost and high performance	0.186	0.062	The lack of investments in R&D	0.281	0.051
Lower machinery investments	0.143	0.048	The lack of specialists training conditions	0.177	0.032
Quality	0.141	0.047	Low awareness of Nordic solution	0.118	0.022
Water control	0.130	0.043	Less effective at moving material distances	0.112	0.020
Environmental friendliness	0.070	0.023			
Great at upgrading existing roads	0.057	0.019			
Proven solutions	0.051	0.017			
Wide use of modern geomaterials	0.033	0.011			
Opportunities (*CR*=0.067)	***LW***	***GW***	**Threats** (*CR*=0.076)	***LW***	***GW***
Unlimited market potential	0.234	0.044	The lack of legal framework under forest land leasing	0.262	0.078
Multiple use of forest sources	0.217	0.041	Low profitability of forestry business	0.196	0.058
Fire control	0.203	0.038	Limited resources of construction materials	0.190	0.056
Authority programs of forest sector development	0.161	0.030	Dominance of extensive forest management	0.123	0.037
Negative attitude reducing to intensive model of forest management	0.114	0.021	Corruption, kickbacks, bureaucracy	0.120	0.036
New technology availability	0.071	0.013	Tech-substitute	0.109	0.032

[a] Group priority was calculated as follows: Strengths 0.333; Weaknesses 0.297; Opportunities 0.187; Threats 0.183.

[b] Consistency ratio (CR) of the comparisons between the four SWOT groups was 0.068.

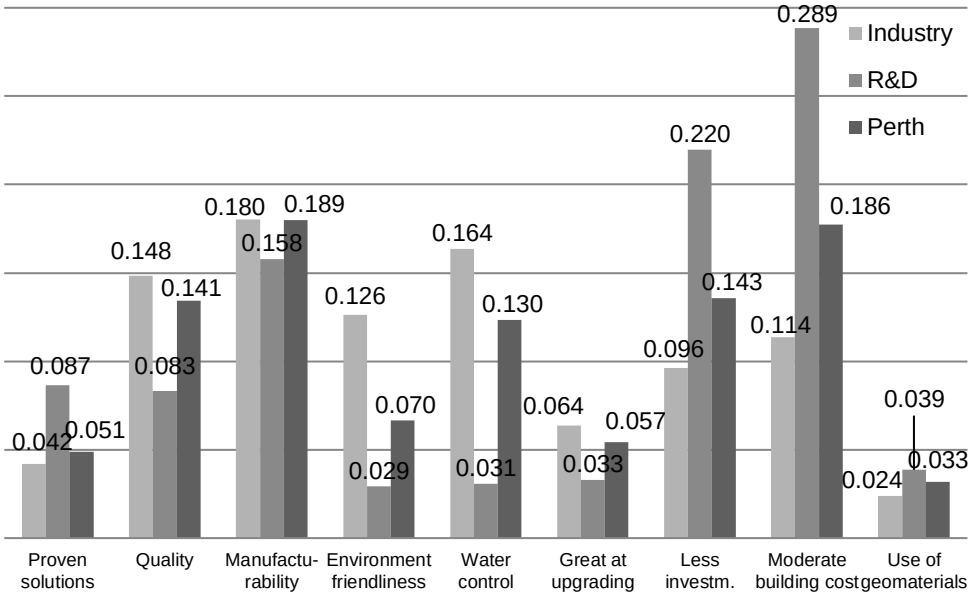

Figure 1. Descriptive statistics for local weightings (LW) for strengths associated with NFRS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

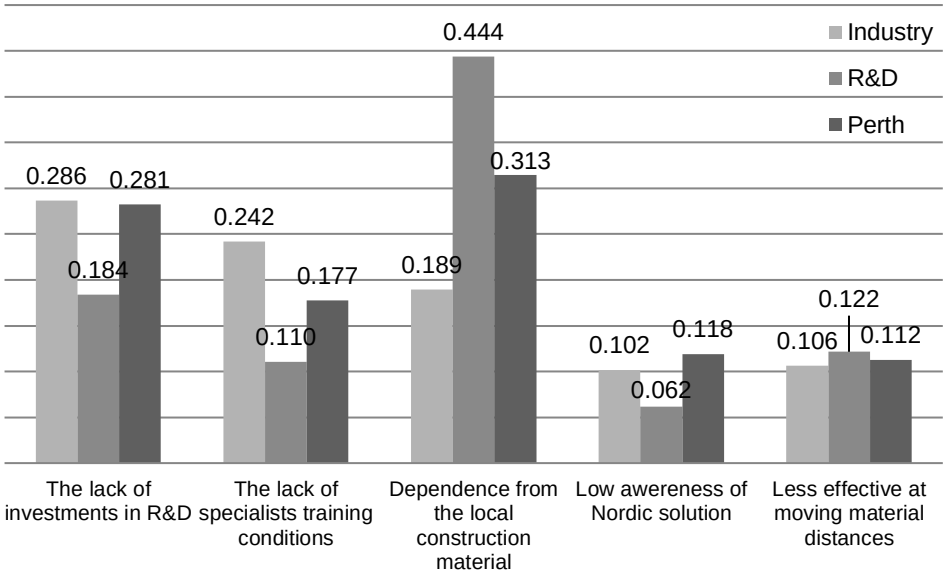

Figure 2. Descriptive statistics for local weightings (LW) for weaknesses associated with NFRS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

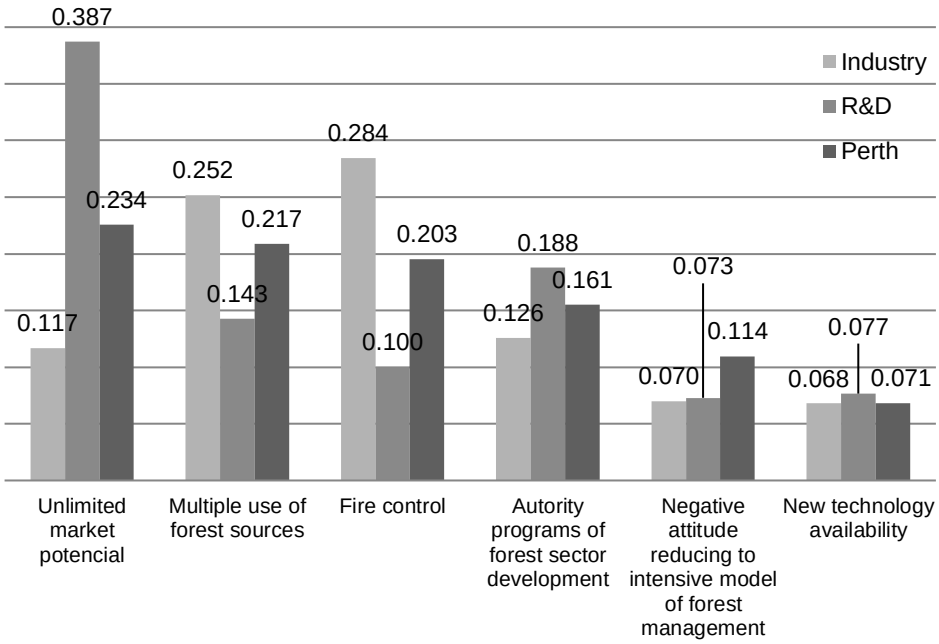

Figure 3. Descriptive statistics for local weightings (LW) for opportunities associated with NFRS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

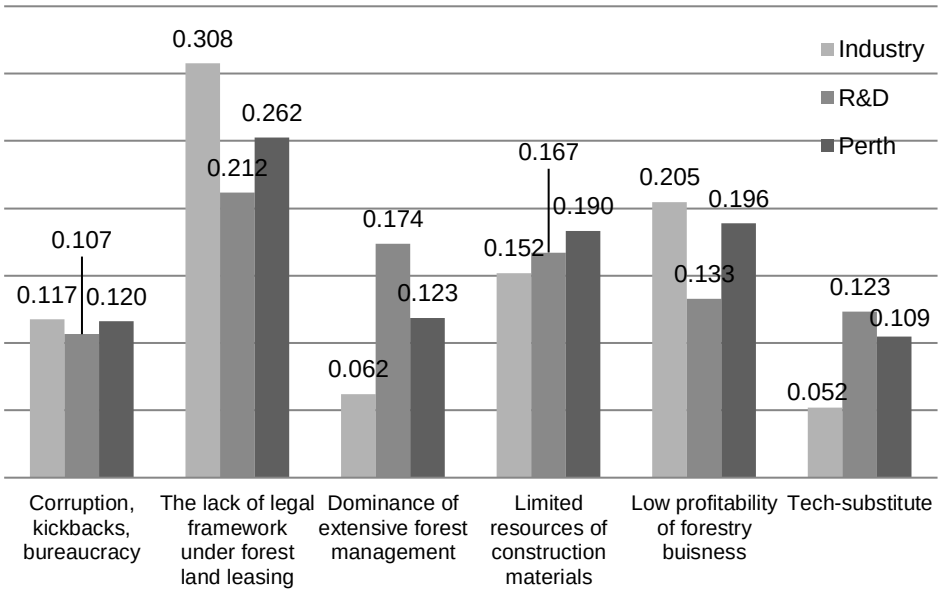

Figure 4. Descriptive statistics for local weightings (LW) for threats associated with NFRS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

3.2 Key factors affecting implementation of NFES in Karelia

The highest priorities representing the SWOT groups (**II**) were "*Contribution to the municipal economy*" (Strengths), "*Lack of development in domestic bioenergy technology*" (Weaknesses), "*Unlimited source and market potentials*" (Opportunities), and "*Lack of government support*" (Threats). The results of the pair-wise comparison show that Threats are the most important SWOT group, Strengths and Opportunities are important, and Weaknesses are the least important. In terms of overall scores, the highest global priorities were represented by the Threat "*Lack of government support*" (GW = 0.100), followed by Strength "*Contribution to the municipal economy*" (GW = 0.086), and Opportunities "*Unlimited source and market potentials*" (GW = 0.074) and "*Transition to intensive forest management*" (GW = 0.067). The remaining factors were considered to have lower global priorities (Table 5).

Threat "*Lack of government support*" was considered by the respondents as the main factor that affects the development of NFES in Karelia, by referring to the Russian Government policy that is more focused on fossil fuels rather than other types of energy. Strength "*Contribution to municipal economy*" was considered as the way to promote NFES in Karelia and Russia. There are numerous remote settlements, which do not have access to the traditional systems of energy supply but are located around areas with active wood harvesting operations. Logging residues, as well as the lower-quality wood, could be utilized to supply the heating systems in such settlements at a reasonable cost. The establishment of relevant infrastructure is then needed. Opportunities "*Unlimited source and market potentials*" and "*Transition to intensive forest management*" were considered by the respondents as additional arguments that can support the above.

There was convergence among the respondents on most of the factors. However, the idea of establishing wood-based energy systems in the remote settlements for the promotion of NFES in Russia was less discussed by the industry respondents and thus this factor was not prioritised in their answers. The respondents from R&D expressed a sceptical view on the external Opportunity "*Authority programs for forest sector development*" due to the low efficiency of such programs in the past. The industry respondents believed that only with the active participation of the Government can the renewable energy sector be developed more rapidly in the country, although the probability that efficient programs could be introduced was considerd low.

More detailed results of the local weighting of the SWOT factors associated with NFES transfer to Karelia by the stakeholder group, calculated with the Perth formula, are presented in Figs. 5–8. In article **II**, the results of local weightings by the stakeholder group were combined because of the small number of industry respondents compared to R&D.

Table 5. Local weighting (LW)[a] and global weighting (GW) of the SWOT factors associated with NFES transfer to Karelia (factors are ranked in decreasing order from highest to lowest weightings for each SWOT group. The factor with the higher weighting is located above the others) (CR is the consistency index per SWOT group)[b].

Strengths (CR=0.060)	***LW***	***GW***	**Weaknesses** (CR=0.069)	***LW***	***GW***
Contribution to municipal economy	0.318	0.086	Lack of development in domestic bioenergy technology	0.329	0.053
Proven solutions	0.159	0.043	High transportation cost	0.168	0.027
Moderate heating cost	0.158	0.043	High demands for skilled specialists	0.139	0.022
Improvement of young forest thinning	0.110	0.030	Low awareness of Nordic solutions	0.126	0.020
Enhanced energy security	0.110	0.030	High demands for density and quality of forest roads	0.103	0.016
Environmental friendliness	0.079	0.021	High quality demands for wood fuel	0.081	0.013
Fire control	0.066	0.018	Site productivity	0.054	0.009
Opportunities (*CR*=0.056)	***LW***	***GW***	**Threats** (*CR*=0.059)	***LW***	***GW***
Unlimited source and market potentials	0.284	0.074	Lack of government support	0.322	0.100
Transition to intensive forest management	0.259	0.067	Insufficient forest road network	0.173	0.054
Authority programs for forest sector development	0.126	0.033	Gasification	0.169	0.052
Increasing fossil fuel prices	0.115	0.030	Financial indiscipline	0.129	0.040
Advantageous location of the existing boilers	0.090	0.023	Dominance of extensive forest management	0.121	0.038
Improvement of forest road network	0.077	0.020	High investment cost	0.086	0.027
Availability of new technology	0.049	0.013			

[a] Group priority was calculated as follows: Strengths 0.270; Weaknesses 0.160; Opportunities 0.260; Threats 0.310.

[b] Consistency ratio (CR) of the comparisons between the four SWOT groups was 0.065.

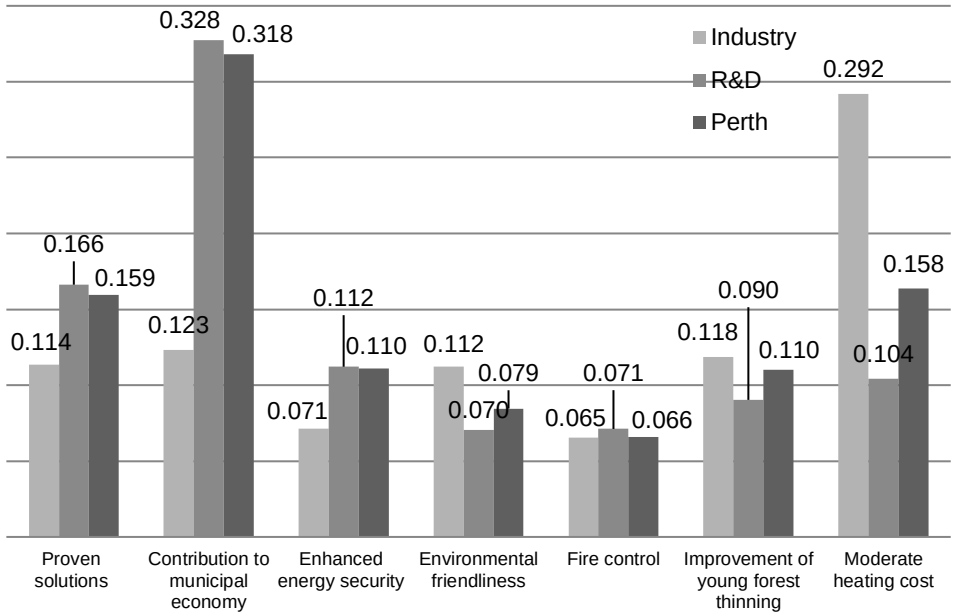

Figure 5. Descriptive statistics for local weightings (LW) for strengths associated with NFES transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

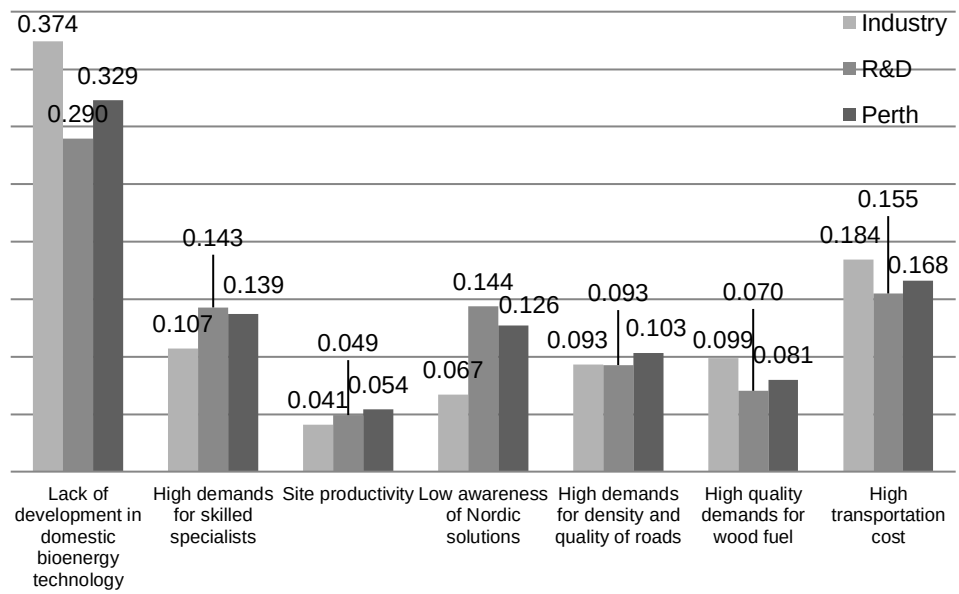

Figure 6. Descriptive statistics for local weightings (LW) for weaknesses associated with NFES transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

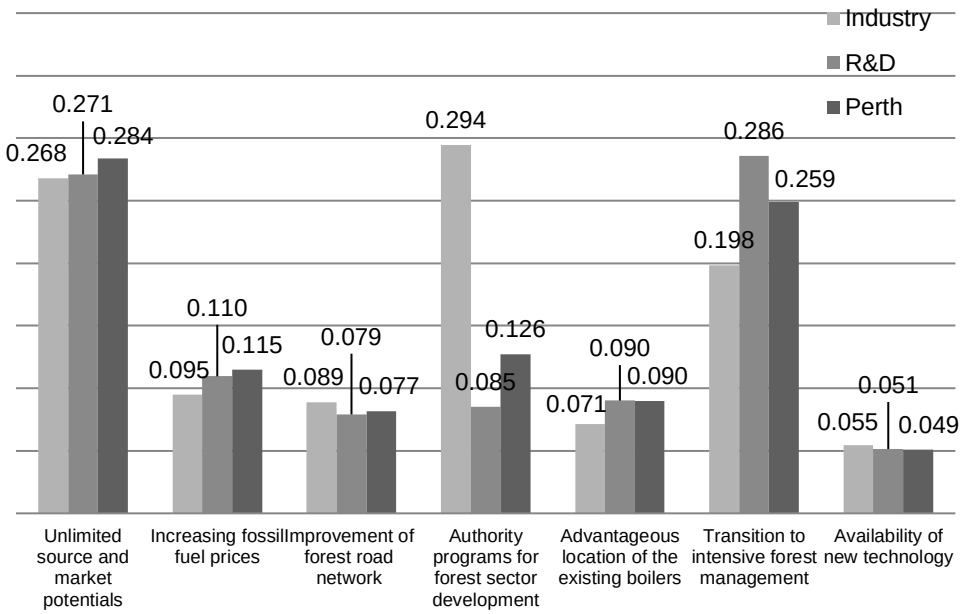

Figure 7. Descriptive statistics for local weightings (LW) for opportunities associated with NFES transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

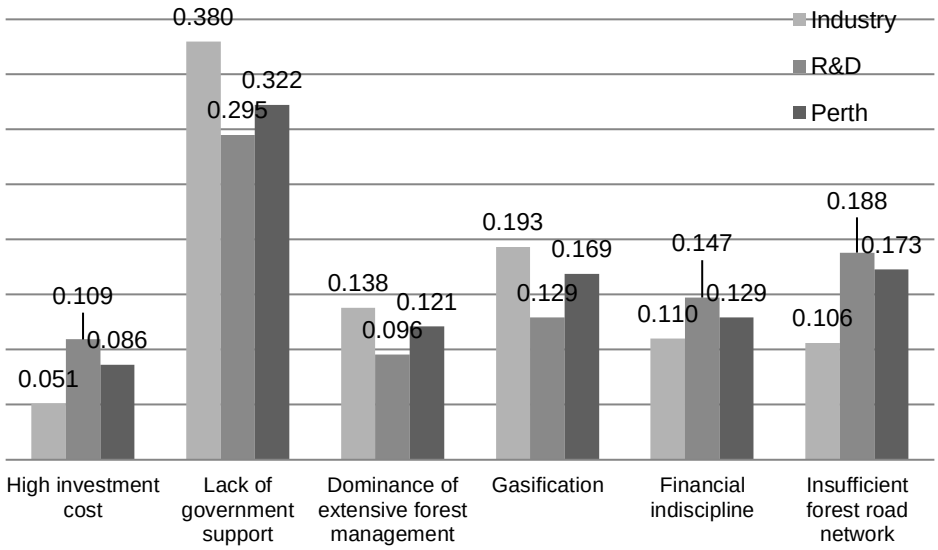

Figure 8. Descriptive statistics for local weightings (LW) for threats associated with NFES transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

3.3 Key factors affecting implementation of NIFMS in Karelia

The highest priority factors representing the SWOT groups (**III**) were "*Improving quality and value of timber*" (Strengths), "*Slow return on investments*" (Weaknesses), "*High potential of forest resource*" (Opportunities) and "*Unprepared regulatory environment*" (Threats). The results show that Strengths are the most important SWOT group, Threats are important, and Weaknesses and Opportunities are the least important. In terms of overall scores, two of the greatest global priorities represented Strengths; "*Improving quality and value of timber*" (GW = 0.116) and "*Support for principles of sustained yield*" (GW = 0.104) (Table 5), followed by the threat "*Unprepared regulatory environment*" (GW = 0.077). The remaining factors were considered to have lower global priorities (Table 6). Positive factors were predominant. The results mean that in terms of future development of NIFMS in Karelia, it is reasonable to initially look at the advantages of the application in the region.

The respondents perceived the potential for NIFMS implementation in Karelia and Russia. Their main argument was that current foresty practices do not contribute to the sustainable development of the local forests and the forestry sector in the region. The successful experience from neighbouring Finland was considered by the respondents as an advantage. Threat "*Unprepared regulatory environment*" was considered by the respondents as the main obstacle to the development of NIFMS in Karelia. The respondents expressed a need for improvements in the corresponding forestry regulations to enable rapid uptake of NIFMS. The respondents were less concerned about the environmental issues that can arise when practising NIFMS. Both groups of respondents gave similar low preferences on Threat "*Forest degradation*".

Overall, the respondents expressed, to a large extent, the same views on most of the factors, but some of the responses did diverge on some points. For example, the high potential of forest resources is a major Opportunity for R&D respondents. However, industry respondents suggested that "*Proven Nordic expertise*", together with "*Authority programs for forest sector development*" and "*Availability of modern technology*" should instead be considered. Another example is that "*Wood-based energy development*" was considered a more solid Opportunity for R&D respondents, while industry specialists were more sceptical on this due to the lack of normal business and the operational environment that supports the utilization of woody biomass (meaning that the establishment of corresponding infrastructure is then needed).

More detailed results of the local weighting of the SWOT factors associated with NIFMS transfer to Karelia by stakeholder group, calculated with the arithmetic mean formula, are presented in Figs. 9–12.

Table 6. Local weighting (LW)[a] and global weighting (GW) of the SWOT factors associated with NIFMS transfer to Karelia (factors are ranked in decreasing order from highest to lowest weightings for each SWOT group. The factor with the higher weighting is located above the others) (CR is the consistency index per SWOT group)[b].

Strengths (CR=0.060)	***LW***	***GW***	**Weaknesses** (CR=0.059)	***LW***	***GW***
Improving productivity and quality of timber	0.292	0.116	Slow return on investments	0.342	0.059
Support for principles of sustained yield	0.262	0.104	High cost for young forest thinning	0.185	0.032
Better forest road network	0.120	0.048	Low market demand for energy wood	0.184	0.032
Contribution to municipal and regional economy	0.119	0.047	High demand for skilled specialists	0.169	0.029
Employment development	0.116	0.046	Lack of investments in R&D	0.120	0.021
Improving forest health and fire control	0.091	0.036			
Opportunities (*CR*=0.064)	***LW***	***GW***	**Threats** (*CR*=0.071)	***LW***	***GW***
High potential of forest resource	0.308	0.055	Unprepared regulatory environment	0.311	0.077
Proven Nordic expertise	0.221	0.040	Insecurity of private investments	0.185	0.046
Authority programs for forest sector development	0.196	0.035	Low forest road density and quality	0.160	0.040
Wood-based energy development	0.145	0.026	Low profitability in forestry	0.101	0.025
Availability of new technology	0.129	0.023	High investment cost	0.088	0.022
			Negative attitude to intensive forestry	0.082	0.021
			Forest degradation	0.072	0.018

[a] Group priority was calculated as follows: Strengths 0.398; Weaknesses 0.174; Opportunities 0.180; Threats 0.249.

[b] Consistency ratio (CR) of the comparisons between the four SWOT groups was 0.043.

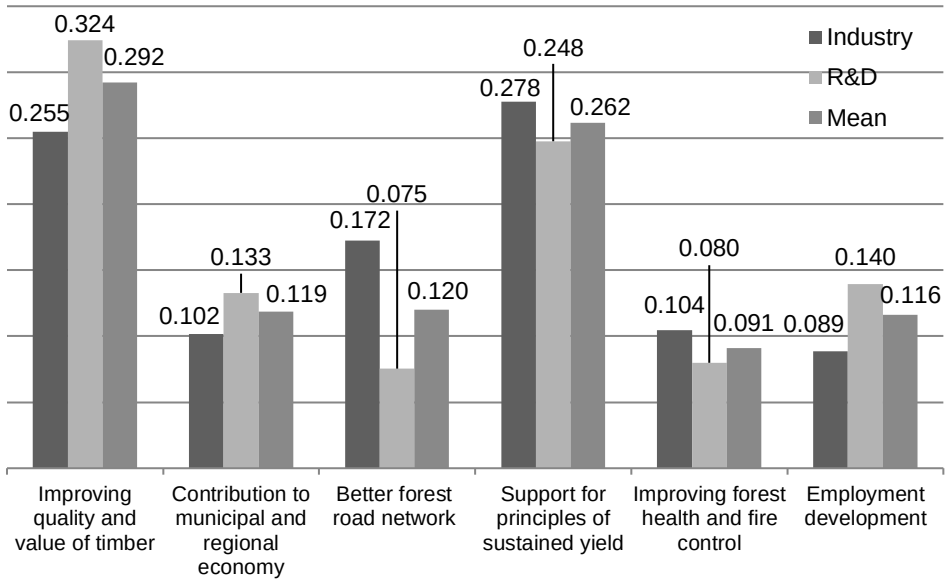

Figure 9. Descriptive statistics for local weightings (LW) for strengths associated with NIFMS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

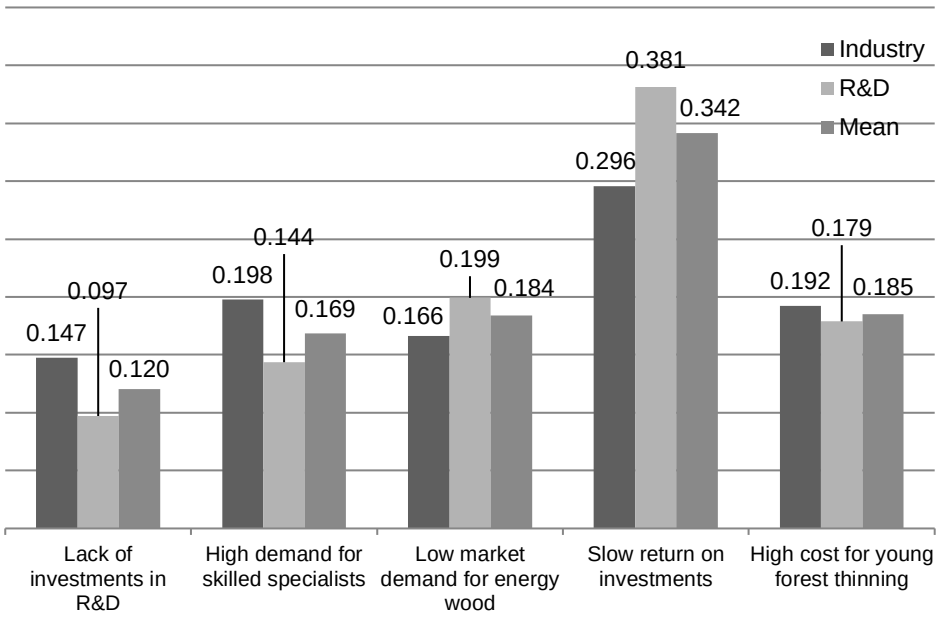

Figure 10. Descriptive statistics for local weightings (LW) for weaknesses associated with NIFMS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

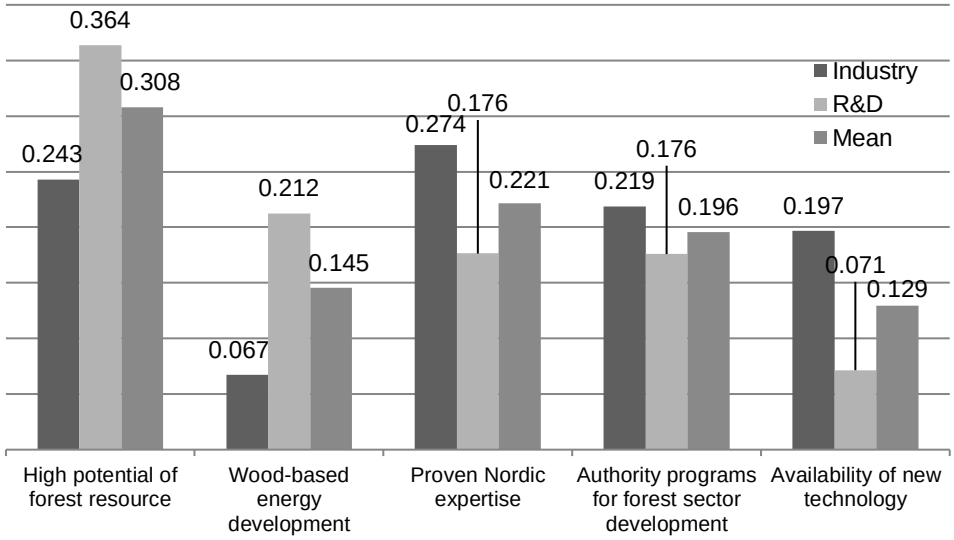

Figure 11. Descriptive statistics for local weightings (LW) for opportunities associated with NIFMS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

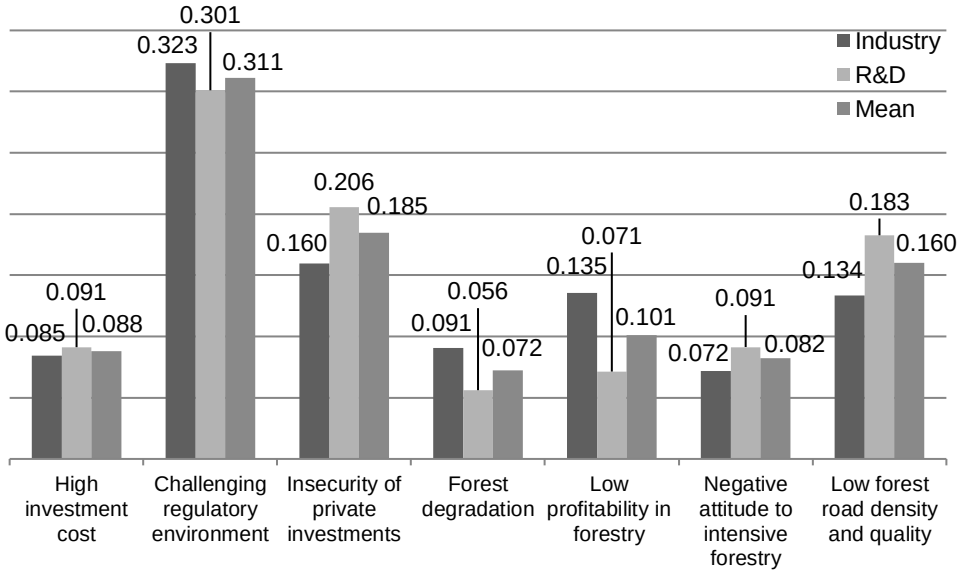

Figure 12. Descriptive statistics for local weightings (LW) for threats associated with NIFMS transfer to Karelia by respondent group obtained with the analytic hierarchy process (AHP) procedure.

3.4 Views of the forest industry companies on long-term development of the forestry sector in Karelia

The overview of the actions identified in article **IV** and the points given to the actions during the CV procedure are combined and shown in Table 7. The most prioritised action "*Change the State's attitude to the forest sector*" was allocated 210 votes, which was the clear leader in the ranking list. "*Develop intensive forest management*" (155 votes), "*Improve forest transport infrastructure*" (136 votes), "*Ensure stable, predictable and effective sales of forest products*" (128 votes), "*Provide a reliable forest resource assessment*" (114 votes), "*Ensure stable and regional forest legislation*" (111 votes), "*Develop broadleaf wood processing capacity*" (94 votes), and "*Develop domestic harvesting machinery*" (85 votes) were also considered to be the most prioritised group of actions. The medium actions group included "*Change or modify the management structure of the State forest*" (65 votes), "*Open nurseries for containerised seedlings*" (60 votes), "*Develop a system of governmental support for forest leaseholders*" (57 votes), "*Reorganise forest district bodies*" (56 votes), and "*Improve training for forest specialists*" (47 votes). The remaining actions "*Develop remote forest settlements*" (31 votes), "*Extension of leased forest area for a more reliable wood supply*" (28 votes) and "*Propagate a tree care culture*" (23 votes) were considered the least important.

Table 7. Overview of the survey.

Actions	Votes
Change the State's attitude to the forest sector	210
Develop intensive forest management	155
Improve forest transport infrastructure	136
Ensure stable/predictable/effective sales terms of forest products	128
Provide a reliable forest resource assessment	114
Ensure stable and regional forest legislation	111
Develop broadleaf wood processing capacity	94
Develop domestic harvesting machinery	85
Change/Modify a management structure of State forest	65
Open nurseries for containerised seedlings	60
Develop a system of government support for forest leaseholders	57
Reorganise forest district bodies	56
Improve training for forest specialists	47
Develop remote forest settlements	31
Extension of leased forest area for a more reliable wood supply	28
Propagate a tree care culture	23

The arguments behind the actions given by the experts during the first stage of the survey were processed, summarized, and can be described as follows:

- *Develop intensive forest management* to heighten economic interest among forest users in regard to thinning of forests. The thinning intensity currently allowable in Karelia does not provide economic or silvicultural effects, as existing forest regulations are not appropriate for an intensification of forest management.

- *Change the management structure of State forests*. The current forest leasing structure (instead of forest ownership) does not provide sufficient stimulus to a leaseholder to develop forestry over the long term, since there are no guarantees that leasing contracts will be extended once expired. For this reason, long-term investments in Russian forestry are highly unsecured and so seldom occur. Against this background, alternative solutions could be, for example, (1) ensure that the current tenant receives priority in the renewal of the lease, (2) extend contract validity for a period of at least one felling rotation (current maximum is 49 years), and (3) transfer the forest into private ownership.
- *Ensure stable and regional forest legislation*, because (1) existing forest regulations are often changed, some of which contradict each other or break the regulations of other natural resources, for example, water or land, (2) the natural and climatic diversity of the region is poorly understood, (3) there are several bureaucratic barriers, e.g. Article 74.1 of the Forest Code of the Russian Federation, (4) forest legislation is perceived to serve the interests of the wood processing industry, rather than wood procurement, and (5) a differentiated approach in the formation of lease rates is not in place, for example, based on the economic/geographical availability of forest resources.
- *Change the State's attitude to the forest sector*. Currently, the forest sector in Russia is not a priority under the national economic policy. To enhance the status of the forest sector in the national economy and support the long-term development of the forest sector, it is necessary to have a robust government policy, for example, in the form of strategy, development programs, or legislation. The State should act as a "locomotive" for the development of the forest sector in the country
- *Ensure stable/predictable/effective sales terms of forest products*. Today, the forest products market in Karelia is unstable. Several issues need to be considered, in particular (1) determine the core wood processing plants (productive forces) at the State level around which the stable business could be organized and eliminate the rest, (2) create a stable "rules of the game" in the wood market, make them secure and predictable, improve wood supply contracts, (3) transparent market price formation, which would take into account the actual cost of wood harvesting, as well as geographical, natural and climatic factors, and (4) support the market, where the raw materials available in Karelia should be focused on domestic consumption as much as possible.
- *Develop remote forest settlements*. Small towns and villages located adjacent to forests, especially in the northern part of the region, are economically depressed, the population is declining and local business development is poor. The major problem in this context is the sourcing of a labour force. Young and employable specialists from the district centres have little interest in moving to remote forest settlements.
- *Provision of a reliable forest resource assessment* for better forest planning, since the current forest inventory data is outdated and contains significant errors and mismatches.
- *Improve forest transport infrastructure*. Existing forest roads in Karelia are poor in quality and quantity. Shipping is highly problematic as internal ports, waterways, and barges are technically obsolete. The existing capacity of the railway line in some areas of Karelia leaves much to be desired. The underdevelopment of the forest transport infrastructure makes long-term development a major challenge.
- *Improve training for forest specialists*. The existing skill level of engineering and technical personnel, supervisors and blue-collar labourers needs to be significantly improved. Graduates currently lack professional qualifications, which often forces companies to recruit staff from related professions and retrain them.

- *Extension of a leased forest area for a more reliable wood supply*. Enterprises with large productive capacities require a better wood supply.
- *Develop a system of government support for forest leaseholders* that could potentially increase private investment in the forest sector. As the sole forest owner, the State does not compensate leaseholders for the costs incurred in silvicultural operations, including road construction and maintenance.
- *Develop broadleaf wood processing capacity*. Tree species composition is inclined to change in Karelia: broad-leaved species have progressively replaced conifers. This trend is expected to continue in the future. To keep the cost of wood harvesting at the same level, it is necessary to have an appropriate productive capacity to be able to process broadleaf wood on a regular and ongoing basis.
- *Open nurseries for containerized seedlings* to ensure efficient forest regeneration, which is an important element in the cost-beneficial forest business. Currently, reforestation in Karelia is mostly based on natural regeneration. Artificial planting is a less common practice; bare-root seedlings are mainly used, although this type of planting material has low survival rates and high demand for in-filling, which incurs additional expenditure.
- *Develop domestic harvesting machinery*. The purchase of forest machines for timber harvesting from abroad has become economically difficult for many Russian companies. Heavy export customs duties and the current high cost of modern machinery means that expenditure exceeds revenue in many cases.
- *Propagate a tree care culture* to retain a forest heritage for subsequent generations. Unfortunately, measures aimed at forest care, such as regeneration, tending and thinning, are often neglected in Karelian forestry management. The focal point of most companies is the marginal benefits within the shortest possible timeframe. At the same time, national policy, which could potentially improve the situation, pushes the problem to the side. While this situation continues, the long-term perspectives for the development of forestry in Karelia will remain uncertain.
- *Reorganize forest district bodies*. The operating principle of the forest district bodies (the so-called "Lesnichestvo"; the elementary organizational units of Russian forest administration) does not provide clear guidance to either forest users, i.e. forest leaseholders, or to the forest sector in general. Forest districts act more in a "punitive" role by establishing a range of bureaucratic barriers to the operations of a company. Instead, the forest districts should endeavour to support leaseholders in their management of forests rather than penalizing faults.

The expert views and the combined votes for each PESTE category are shown in Fig. 13.

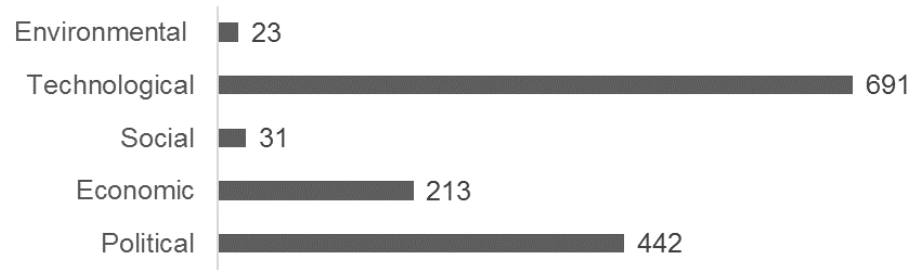

Figure 13. Cumulative voting (CV) results outlined in the PESTE framework.

The Political category (which also includes legal aspects) included "*Change the State's attitude to the forest sector*" (210 votes), "*Ensure stable and regional forest legislation*" (111 votes), "*Change or modify the management structure of the State forest*" (65 votes) and "*Reorganise forest district bodies*" (56 votes). The Economic category included "*Ensure stable, predictable and effective sales terms for forest products*" (128 votes), "*Extension of leased forest area for a more reliable wood supply*" (28 votes) and "*Develop a system of governmental support for forest leaseholders*" (57 votes). The Social category included "*Develop remote forest settlements*" (31 votes). The Technological category included "*Develop intensive forest management*" (155 votes), "*Provide a reliable forest resource assessment*" (114 votes), "*Improve forest transport infrastructure*" (136 votes), "*Develop broadleaf wood processing capacity*" (94 votes), "*Open nurseries for containerised seedlings*" (60 votes), "*Develop domestic harvesting machinery*" (85 votes) and "*Improve training for forest specialists*" (47 votes). The Environmental category included "*Propagate a tree care culture*" (23 votes). Technological was the highest represented category with a total of 691 votes, while Social and Environmental were the least represented categories with 31 and 23 votes, respectively.

4 DISCUSSION

4.1 Opportunities and challenges of reforming the forestry sector in Karelia through the adoption of Nordic forest solutions (I, II, and III)

The results outlined in article **I** show that deficiencies in the legal framework that underpin the system of leasing forests should be given priority consideration when employing NFRS in Russia. Of particular importance is the issue of insecurity of private investments in road construction that arise due to the extension of forest leasing contracts. According to national forest legislation (Forest Code 2006), a current tenant has a nominal pre-emption right of contract prolongation, but in practice, this right is not fully utilised under Russian legislation (Torniainen 2009). All contracts that expire are automatically extended through open auctions, the results of which are not always foreseeable. For example, there might be cases when the lot price of the forest area becomes so high that values exceed the cost of investments that have already been made by the current tenant. Such tenants then have little choice; either agree to the new terms or concede the leasing contracts, causing them to forfeit the resource base. Discussions are currently in progress among the national forest administrations with a view to updating and amending the relevant legal framework (e.g., Petrov 2020). Nonetheless, the regulatory gaps continue to bear risks to private investments (including road construction) and more generally to long-term planning and decision-making in forestry (Hermansson 2012).

From the point of view of technical development and application of NFRS in Russia, careful consideration should also be given to the local road construction materials, such as sub-soils and stones. Their lack of availability and affordability might be critical for many regions in Russia (Zanin 2011). Furthermore, the impact of building roads on the environment should not be underestimated (Boston 2016). For example, it might lead to loss of habitat due to the conversion of the natural land cover into an artificial surface (e.g. Geneletti 2003) or its fragmentation into smaller and more isolated areas that were originally used by animals (e.g. Kivinen et al. 2011). Poorly designed and constructed forest roads can also cause soil

erosion and off-site water pollution (e.g. Boston 2016). Therefore, in addition to cost efficiency, it is critical to consider sustainability issues in forest road construction.

The results described in article **II** clearly show that Russian forest resources have a significant market potential for the utilisation of NFES. However, the basic conditions and infrastructure for fulfilling this significant potential are not properly in place. The main obstacle is the lack of clear government policy regarding the development of alternative energy sources in Russia (Chebotareva et al. 2020). The Russian Government remains orientated towards traditional energy sources, such as oil, coal, and gas (Mitrova and Melnikov 2019). The use of wood remains minor in the overall energy supply, even though globally it has been an important part of climate change adaptation and mitigation policies.

Despite the negative connotation, the results show that the use of energy wood at the municipal level is a constitutive strength for driving further development of NFES in Russia. More precisely, NFES may have a wider application across small towns and villages in remote forest areas of Russia that have no access to the traditional systems of energy supply (IRENA 2017). Generally, such settlements are highly dependent on the subvention and donation from the regional centres and are often characterised by isolation, both in terms of location and socio-economic development. Many face a significant population loss caused by adverse living conditions and lack of jobs (e.g., Shubin 2012; Bednarikova et al. 2016); some even struggle for survival (e.g., Kovalyova 2019). As the Nordic practice shows, building necessary infrastructure, or modernisation of the existing boiler houses and pipeline networks, which would make possible the utilisation of energy wood, may offer the municipalities energy independence, new jobs, and increased revenue to the local economy (e.g., Enonenergia 2020). A consistent cost-benefit analysis to evaluate the feasibility of such a transition in remote forest areas is then required. The feasibility should be focused on boiler house location and capacity, raw material availability and quality, transportation distances, logistics, and labour supply.

The results in article **III** reveal that NIFMS may improve the productivity and quality of forests and support the sustained yield of raw material for the forest industry. NIFMS implies the creation of new jobs and enterprises in small towns and villages. Responsibly and intensively managed forests have a role to play in providing other non-wood forest products and services, which could also contribute to the municipal economies. There are also benefits in terms of forest health and fire control through intensified silvicultural treatments and better access. A sufficiently dense forest road network is required that would increase the utilisation of energy wood, although this will require more initial investment and government support.

The unprepared regulatory environment identified in article **III** is a critical threat to the further development of NIFMS in Karelia. In the strategic planning process, this factor should be minimised or even converted into Opportunities by improving existing forestry regulations. Some advances have already been made in Arkhangelsk, Komi, and Leningrad regions through the introduction of new forest thinning rules and regulations (e.g., The Press Centre of International Paper in Russia, 2017). A new regulatory framework that could address the requirements of intensive forest management has also been introduced in Karelia (Ministry of Natural Resources and Ecology of Russian Federation 2020), although its effectiveness has yet to be analysed.

The effects of intensified biomass production management strategies on biodiversity and further forest reproduction (Toral 2002; Hacker 2005) were underestimated in the Threats group in article **III**. The Nordic experience indicates that when intensive forest management is planned for the long-term, it is important that the environmental and other sustainable development dimensions are carefully taken into account in the planning and decision-

making process. This is particularly true for industry forest users, who are supposed to employ NIFMS (as well as NFRS and NFES) in practice in Karelia and Russia. This issue was the research question in the study described in article **IV**.

4.2 Prospects for the long-term development of the forestry sector in Karelia (IV)

Long-term development of the forestry sector is largely perceived by forestry experts as a technical phenomenon that is associated with the management of business demands and is concerned with sorting out the related challenges that regularly stifle the forestry companies. The most notable concerns are inefficient wood harvesting regulations, poor road infrastructure, non-transparent terms of wood sales, lack of reliable forest data, inefficient processing capacities, and the high costs for forest machinery, which seem to be rather pragmatic in the context of long-term development. The experts did not refer to expectations regarding sustainability-related aims, such as climate change mitigation, energy security, technological progress, biodiversity conservation, social capital growth, and rural value creation (Gawel et al., 2019). These are considered to be less important in the pursuit of more strategic targets or are considered to be at a sufficiently high level of development compared to the identified challenges. We can assume that the concept of sustainability is not yet fully embedded in the development and planning processes at the studied companies.

An exploration of the expert views within the PESTE categories provided further arguments in favour of the findings outlined above. The experts expressed a preference for technological, political, and economic issues concerning long-term forestry development in Karelia. Social and environmental considerations were deemed by the experts to be of minor importance, which weakens the most basic principles accorded by sustainable development policies and strategies (Ministerial Conference on Protection of Forests in Europe, 1995, 1998, 2001). As this mode of thinking might be focused mainly on vested benefits (financial, material or otherwise), it would suggest an image of irresponsible consumerism (Grappi et al., 2013). To that end, possible future impacts cannot be underestimated. This is especially true for wood harvesting companies, whose day-to-day decisions and actions have tangible implications for forest development, and for those who depend on forests for their livelihoods.

However, the rationale behind the views of the experts can be explained, for example, by the concerns of the companies in relation to the State's attitude to the development of the forestry sector within the wider national economy. The Russian state is the sole forest owner and is responsible for driving policy and for setting the course for forestry development in the country. The experts strongly believe that the forestry sector is not a priority for the national economy; State participation in the maintenance of the forestry sector is low; governmental policy is unclear and often unpredictable. These factors generate a lack of trust and increase the uncertainty for entrepreneurial activities as they reduce the flow of information essential for long-term decisions and actions (OECD 2013). In such a business environment, the prime consideration for the companies becomes the promotion of their own business demands and activities, while taking fewer risks and responsibilities in the planning and operating stages. This could explain why decisions that could incorporate sustainability-related issues into the business model are not of immediate interest and importance and are seldom incorporated in the strategic thinking process.

Moreover, a lack of awareness or understanding of sustainable development concepts and issues by the forest users may be another reason for the expert views. Crotty and Hall (2012) have shown this to be a critical issue in Russia, linking it to a lack of general education and

training. Furthermore, Zhevlakova (2013) and Kankovskaya (2016) noted that the teaching of sustainable development in Russia lacks a systematic approach and specialised methods to explore and engage with the principles of sustainability in different practice areas. Moreover, the principles of sustainability are poorly discussed in the Russian mass media (e.g., Dobrovidova and Davydova, 2013), which may also impact awareness. Janoušková et al. (2019) noted that the mass media have an important role in setting the sustainability agenda and in framing a broader understanding of its principles among stakeholders. Indeed, the issue of a broader understanding was discussed by Gulakov et al. (2020) through a case study of social impact assessment in Russia. Their study showed that a lack of understanding of international standards and the low engagement of stakeholders in decision-making are some of the obstacles that prevent a robust social impact assessment of development projects in Russia. These and other similar factors may have affected the views of the experts in our case study too.

The findings outlined in article **IV** suggest that the local forestry sector requires a reappraisal of its value to the national economy, especially from a governmental policy point of view. Strong and clear governmental policies regarding the role of forests in achieving national sustainable development are required but will not be achieved without collaboration between the public and private sectors. The State is expected to be active in developing a new institutional and operational framework that would consider a more open interaction with forest industries and other important stakeholders. It is necessary to increase trust in the business environment that cannot be achieved without appropriate integration of the concerns from the various development entities. Wilson (1997) noted that trust is especially important for economic and sustainable activity, and a lack of trust might explain the low social capital in the current business climate (Petro, 2001; Guillén et al., 2015). Trust can be fostered with active input from the State through the development of a new institutional and operational framework that would set a clear course for long-term forestry development in Russia. Forest companies and other important stakeholders should be able to generate a role for themselves within this framework and then act responsibly and transparently to achieve mutual benefits.

Given the identified challenges, special attention should be given to the Nordic forest solutions in Karelia, and how these solutions could be implemented under the existing business environment. The Nordic experience demonstrates that the principles of sustainable development should underpin the solutions, or else they might be limited in the long-term and likely to fail (Pohjanmies et al., 2017). For example, the excessive emphasis on increased forest growth and utilisation for industry purposes, which occurred over many decades in Finland and Sweden, has led to a loss of biodiversity in local forests (Kouki et al., 2001; Tikkanen et al., 2006; Junninen and Komonen 2011; Felton et al., 2016; Hyvärinen et al. 2019; Huuskonen et al., 2021). Many natural growth stands have been highly productive monocultures; forest-dwelling type species have declined with dozens gone extinct. In some areas, biodiversity may be beyond recovery. Loss of forest biodiversity has been the subject of ferocious debate and research in Finland and Sweden of how it may affect further forest reproduction (e.g., BIOS 2017; Pohjanmies 2018; Peura 2020). Similar challenges can be expected in Karelia unless the relevant stakeholders provide the necessary efforts in the planning stages and implement the principles of sustainable development in practice. Russian forest practitioners have an opportunity to scrutinise these new methods and tools for efficient forest restoration and management beforehand, and appropriate measures and incentives are needed in this regard.

We call for further research that would investigate the environmental and social aspects in contemporary Russian forest management practices, as well as highlight the inherent

operational and institutional barriers and perspectives. Moreover, with the help of this study, several other important dimensions that currently stifle the forestry sector in Karelia have been identified. For example, unreliable forest resource assessment data ensures that the existing forest planning is less efficient. The issue is widely discussed among the stakeholders in Russia (e.g. FAO 2012, 2014; Alekseev 2015, 2019). Some of the modern forest inventory approaches, including those used in the Nordic countries, have already been considered in the country (e.g. Höök 2015). However, most were performed mainly by private stakeholders for a part of their forest area. The lack of modern forest nurseries limits the supply of forest users with qualified planting materials (e.g. Berlina and Trubin 2019; Bolabolov 2020). This might limit the positive effects of intensive forest management in Karelia. It is obvious that more forest nurseries are needed in the coming years to increase the productivity and profitability of local forestry. Finnish and Swedish forest nurseries have extensive experience in producing modern seedlings used in their active forest regeneration. This experience can be analysed and exchanged with the stakeholders from Karelia and Russia. Some projects have already been initiated in this regard (e.g. AFN 2019).

4.3 Limitations of the study

Several limitations related to the methodology employed in this current study were identified during the process of data collection and processing. For example, in articles **I** and **II**, the original A'WOT was applied (see Kurttila et al. 2000), where only local and overall priorities of each SWOT factor and group, respectively, were calculated. The main disadvantage of the approach was identified as the inability to indicate the relative importance of each factor across the SWOT groups (Kajanus et. al 2012). For an improved strategy-making process, it is important to see the global priority scores of all factors in the quadrangle. This would place the factors on a common scale of measurements and ensure that they are interconnected. In the original approach, this might be possible if the number of factors inside each group is equal. Otherwise, the weighting of factors in the SWOT group with a fewer number of factors will be overestimated. In article **I**, nine Strengths, five Weaknesses, and six Opportunity and Threats were analysed, while in article **II**, seven Strengths, Weaknesses and Opportunity were analysed against six Threats. The global priorities for articles **I** and **II** were additionally calculated for the thesis summary.

Clearly differentiating environmental factors among the SWOT groups in articles **I**, **II**, and **III** was a challenge, which may bring some concerns into the interpretation of the results. For example, the considerable potential of forest resources and the timber market was categorised as an Opportunity, while the same factor could also be designated as a Strength or even as a Threat, because it may lead to inaction and depression in the business. Authority programs for forest sector development are an Opportunity, but the issue of implementation and continuation of these programs and their comprehensiveness could also be considered as an external Threat or an internal Weakness. The programs may bring uncertainties in decision-making for stakeholders whenever this support is questionable. Proven Nordic expertise can be both an internal Strength (**I** and **II**) and external Opportunity (**III**). Such difficulty in interpretation occurs when the issue is viewed from different perspectives, and the valuation is, therefore, likely to be highly subjective.

Several factors in the SWOT quadrangle may be perceived as intentionally divided because they may have a similar meaning and could be combined. In article **I**, the Strengths "*Moderate building cost and high performance*", "*Better manufacturability*", "*Quality*", and

"*Water control*" have a coherence between quality and performance, so could be combined. In article **III**, the factors "*Contribution to the municipal and regional economies*" and "*Employment development*" are very much interdependent and could also be combined (as carried out in article **II**). The reason to separate the factors in article **III** was to emphasise the social component in the economical perception of the factor.

Some external factors in articles **I**, **II**, and **III** may be overlooked in the analysis because they appeared after the studies were completed or their significance has only been raised recently. A prominent example is the new intensive forest management regulations that were introduced in some regions of Russia (e.g., Arkhangelsk, Komi, and Leningrad regions) in the last few years (e.g., The Press Centre of International Paper in Russia, 2017). This factor could be considered as an external Opportunity in article **III**. At the beginning of 2020, new regulations have also been introduced in Karelia (Ministry of Natural Resources and Ecology of Russian Federation, 2020).

Article **IV** was limited in sampling the stakeholder groups. However, beyond the industry companies that the study focused on, other stakeholders, such as local communities, indigenous people, R&D and environmental organisations, as well as representatives of the State forestry administrations, must also be considered when analysing the prospects of long-term development of the forestry sector. The comment is also relevant to articles **I**, **II**, and **III** where only the views of industry companies and R&D organisations were analysed. Respondents from the forestry administrations were not considered for this study due to the difficulties of obtaining access, e.g., official and lengthy procedures to organize interviews, establishing the rights to use and publish their opinions, especially by a foreign organization, and other reasons related to the norms of sharing information by the state representatives.

Like many other studies that apply cumulative voting schemes (e.g., Hiltunen et al., 2008; Vainikainen et al., 2008; Riņķevičs and Torkar 2013), article **IV** was sensitive to tactical voting. Two individuals that participated in the survey gave their votes to one particular action "*Change the State's attitude to the forest sector*". While a significant single effect on the final voting results was not found, votes of these individuals may have overemphasised the action or underemphasised actions that other participants regarded as important. This general problem associated with the CV procedure could be avoided by using different voting schemes, such as the Borda count or approval voting (Brams and Fishburn 1978), which have also been tested in forest-related studies (e.g., Vainikainena et al., 2008, Hiltunen et al. 2008).

Difficulties in assigning the emphasised actions into the PESTE framework were also encountered in article **IV**, similar to the challenge faced with SWOT in articles **I**, **II**, and **III**. For example, "*Improve training for forest specialists*" was allocated to the Technological category, but it could also have been assigned to the Social category as it is essentially an education-related factor. "*Propagate a tree care culture*" was allocated to the Environmental category but could also be considered as a political initiative, while "*Ensure stable/predictable/effective sales terms for forest products*" and "*Develop a system of governmental support for forest leaseholders*" could be allocated to both the Economic and Political categories. Clearly, the valuation is likely to be subjective. The same problem was also encountered in articles **I**, **II**, and **III**.

4.4 Contribution of the study

The major contribution of this thesis relates to the structural approach of how the complex and multifaceted problem of regional significance has been reviewed and analysed (Fig. 14).

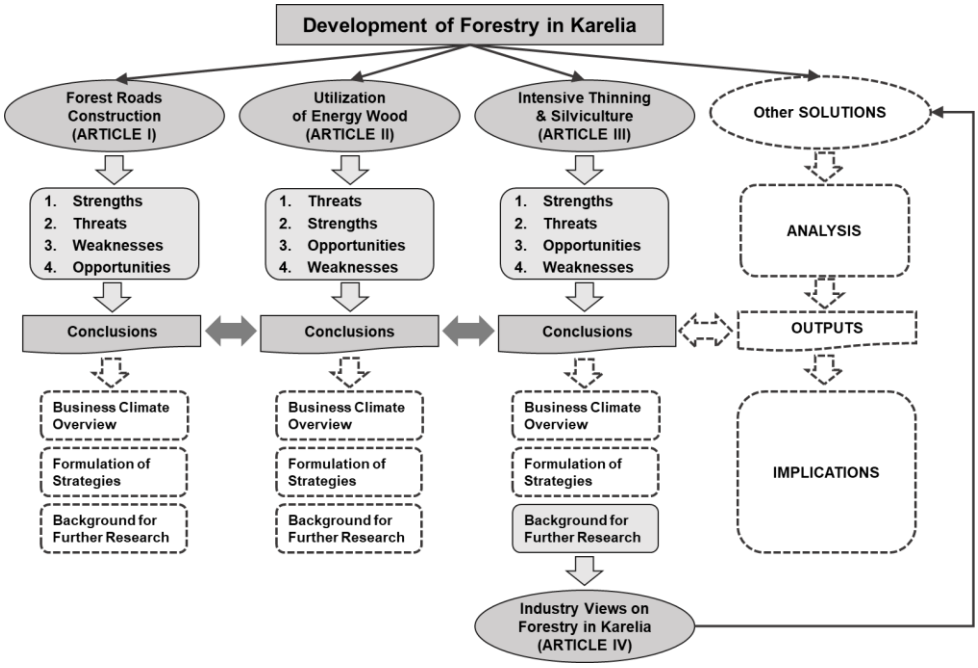

Figure 14. Contribution to the structural analysis of the problem; implications for research and stakeholders.

The study considered the prospects of reforming the forestry sector in the Republic of Karelia through the transfer and application of Nordic forest solutions in a systematic, gradual way, revealing the key aspects of technological, economic, ecological, political, and social development of the whole region. To ensure a structural approach, the problem was initially divided into three dimensions, i.e., forest road construction, utilisation of energy wood, and the intensification of thinning and silviculture. Each dimension was analysed within a separate study, one that yielded a versatile picture of the related operational environment and identified the main prospects and challenges in the region. At this stage, the study has described the key factors that may enable or hinder the transfer of Nordic forest solutions to Karelia. The identified factors and their positions in the matrices can be used in formulating strategies and policies for future renewal of forestry in Karelia. The findings may also provide a robust framework for estimating the risks and benefits of forestry business in the region. The results are relevant for other regions of Russia since the forest management practices in Karelia are similar to many other important forest regions of Russia, such as Leningrad, Archangelsk, Komi, Vologda, Novgorod, and Pskov.

Aside from the qualitative and quantitative analysis of the factors, the study was also able to emphasise several important interrelations and sequences between the identified factors and their numerical values in the SWOT matrices, which can be the subject for further research. One such example was the assumptions made in article **III** regarding the role of sustainability aspects in the Nordic forest solutions and how it may impact the implementation of the solutions in the long-term. The issue was further scrutinised in article **IV**. This study has collected unique empirical data that has demonstrated the mode of

strategic thinking and planning that can be found at the company board level in wood harvesting companies in Karelia. As the main forest users and the most probable practitioners of Nordic forest solutions in Karelia, the forestry companies have special importance in forestry development in the region. In article **IV**, empirically studied interactions of their strategic views with the actual forest policy trends and developments in Russia and globally were presented. Previously, such types of issues have been discussed in the literature, often only in a descriptive way (e.g., FAO 2012; Trishkin et al., 2014; Angelstam et al., 2016). Also, article **IV** highlighted several other important dimensions that currently stifle the forestry sector in Karelia, such as unreliable forest resource assessment data and the lack of modern forest nurseries. These dimensions can be used to analyse the new forest solutions from the Nordic countries, or from elsewhere, to better foster their implementation in Karelia and Russia.

The key observations of this study seek to contribute both to the informational needs of policy planning and development, as well as provide an opportunity for further conceptual and methodological studies. The scope of such studies could cover, for example, the issues of intensive forestry, particularly its further implications in Russia, prospects for continuous cover forestry, forest ownership, the strategic thinking of different forestry stakeholders, and its conformity with the principles of sustainable forest management. The latter is especially important since it would involve more forestry actors in research, wherein various methodological approaches can be tested and applied in Russia. For example, the Delphi method (Linstone and Turoff 1975) has not been widely used in Russian forestry-related studies and might be useful for exploring opportunities for new programs and strategies, and for the identification of important factors for the development of the forestry sector in Russia, both at federal and organisation levels. Corporate foresight can also be accomplished (Rohrbeck 2011; Gershman et al., 2016) and could aid in the interpretation of the factors that may induce a change in the working environment, determine their possible implications, and trigger appropriate responses from stakeholders (Rohrbeck et al. 2015). With corporate foresight, stakeholders may study (and understand) the forces that drive changes in the decision- and strategy-making processes (Battistella 2014). Improvement of A'WOT, especially in regard to the elimination of difficulties with the consistency ratio when evaluating numerous comparison factors, would make this method more time-efficient in data collection. Overall, further investigation of these and other modern decision-support systems would assist in determining the benefits from forest management for the different groups of stakeholders and would also increase the visibility of social and environmental dimensions through participatory planning approaches.

5 CONCLUSIONS

The practice of extensive forest management over many decades is one of the key factors for the weak economic development and ineffective functioning of the forestry sector in Karelia and other forest regions in Russia. Transfer of the novel and proven-over-time Nordic forest solutions from Finland and Sweden in road construction, utilisation of wood-based energy, and intensive forest management, could be an opportunity to improve the current forestry model in the study area and move towards more active management and silvicultural systems. Nordic forest solutions have great potential in Karelian and Russian forests, and for good reason; Finland and Sweden have increased forest productivity and profitability thanks in

large part to the developed solutions, and the success has been achieved in very similar environmental conditions to Karelia and Russia. However, the local operational environment in Karelia differs significantly from Nordic countries. Given the wide range of factors involved, some must be taken onboard by decision-makers to tailor the solutions under the existing operational environment and to develop them further in Russia.

The interdependence of the solutions is an essential factor in terms of understanding further perspectives of Nordic forest solutions in the study area. The solutions are complementary; by implementing one solution, this will intentionally entail the inclusion of targets and indicators of the other solutions. Therefore, the solutions need to be addressed in an integrated manner, as a single packaged issue, with cognisance of their sustainability and possible applicability under the existing operational environment in Russia. The centrepiece of the solutions is intensive forest management. To make it efficient and profitable both for silviculture and business, intensive forestry needs to be complemented with a sufficiently dense forest road infrastructure and by added-value utilisation of wood-based residues derived from thinning and logging operations. The prospects of the former are hindered by an unprepared regulatory environment in regard to the prolongation of the forest leasing contracts, while the latter is stymied by a lack of sufficient economic and legislative drivers to support biofuel development in Russia. These factors limit the long-term private investment in forestry and narrow the applicability of Nordic forest solutions in the country.

Commitment to the objectives of sustainable development is a key component of Nordic intensive forest management. The experience in Finland and Sweden indicates that when intensive forestry is practiced, it is important to follow the principles of sustainable development and to consider how best to employ them in practice. Otherwise, the effects of unsustainable management patterns may lead to negative ecological consequences, such as loss of biodiversity and degradation of ecosystem services. This study shows that adaptation of long-term visions and thinking to the sustainable standards widely discussed in the Nordic countries and globally might be a challenge in Russia. The concept of sustainable forest management is not yet embedded in the development and planning processes in the local forest industry companies. Current business strategies are focused mainly on practical issues, such as the existence of inefficient forestry regulations, lack of roads and wood processing capacities, non-transparent terms of timber sales, and the high costs of forest machinery. There is limited room for the decisions that could incorporate sustainability-related issues as they are not of immediate interest and importance and are seldom accounted for in the strategic thinking processes.

While there might be a variety of explanations for this issue, the lack of strong and clear State forest policy regarding long-term forestry development clouds the visions and thinking of the forestry companies. The current forest governance system lacks credibility among the business communities. Uncertainties for entrepreneurial activities reduce the flow of information essential for making long-term decisions and actions. The forestry companies take fewer risks and responsibilities in the pursuit of their more strategic targets. This explains the low social capital in the business climate in Russia. To change the situation for the better, the State is expected to reappraise existing forestry sector strategies and will be responsible for the development of a new institutional and operational framework, which is needed to set a clear course for forestry development in Russia in the long-term. The forestry companies and other important stakeholders should be able to find their role in this course and to then act responsibly and transparently in the interests of regional and national economies by following the established long-term targets.

Therefore, the prospects of adopting Nordic forest solutions in Karelia and Russia lie, first of all, in the political and legislative provisions of the local operational environment. The future development of the forestry sector should be based on mitigating the identified challenges through governmental efforts, while increasing the participation and the involvement of different stakeholders in the planning and decision-making. Adapting business strategies to sustainable development concepts is important, so relevant promotion is needed. Strong and clear governmental policies, combined with competent and well-trained executors, is critical to achieve efficient long-term forestry development in Russia, where the exchange of advanced forestry experience and expertise from the Nordic countries and globally could be regularised. It should be also noted that some of the wood procurement organisations that have operated in Karelia and Russia for a long time have already brought many of the original aspects of Nordic forestry to the local operational environment. This would suggest that possibilities for a favourable transition and application of the Nordic forest solutions exist to some extent, which will help fulfil future potential.

This study supports forestry development in Karelia but is also relevant for other regions of Russia. The key findings may serve as a robust basis to support better management decisions regarding forests and forestry in the long-term. Wood procurement organisations could utilise our findings as the first step in the identification of factors in their development, and policymakers and researchers to ensure better diffusion of the concepts of intensive and sustainable forest management in Russia. The findings can also be used in the planning and promotion of new sustainable forestry sector strategies both in Karelia and Russia. Russia is especially important since the country contains the largest global wood resources, which could be used in support of a new forest-based bioeconomy and related business models (e.g., D'Amato et al. 2020; Falcone et al. 2020; Wallius et al. 2020). Ultimately, I hope that this study will help stakeholders to improve strategic planning and will encourage the sustainable development of the forestry sector both in Russia and globally.

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