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Prospects for Nordic intensive forest management solutions in the Republic of Karelia

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Highlights

- SWOT (strengths, weaknesses, opportunities and threats) and multi-criteria decision support analysis were combined to examine the potential for Nordic intensive forest management solutions (NIFMS) in Karelia, Russia.
- NIFMS looks promising for Karelian forestry.
- Improving quality-and-value of timber and sustained yield are the highly prioritized strengths.
- Unprepared forestry regulations are the main threat that needs to be taken into account.

Abstract

In this study, the prospects for future forest management in Republic of Karelia, Russia were analyzed. Forestry has an important role in the economy of Karelia. However, productivity and profitability in the forestry sector are extremely low, forest stand structure and quality are weak, the commercial forest land of coniferous species has declined and the wood processing industry struggles with a deficit of raw materials. The situation is typical to many forest regions in Russia with extensive forest management cited as one reason for the current situation. In contrast, the Nordic countries have significant experience in intensive and sustainable forest management and the results have been to a large extent positive. The transfer of Nordic intensive forest management solutions (NIFMS) could improve forestry in Karelia. SWOT analysis, combined with the multi-criteria decision support (MCDS) method was used to identify local operational environments and to assign priorities. Major threats included unprepared regulations, poor road infrastructure, insecure investments, low forestry productivity, forest degradation, high investment costs and a negative attitude to intensive forestry. The main opportunities are high forest resource potential in Karelia, favorable authority development programs, proven Nordic expertise, wood-based energy development and availability of new technology. Results also showed that the main weaknesses that might influence the NIFMS in Karelia are slow return on investments, low market demand for energy wood, high costs associated with young forest thinnings, high demand for skilled specialists and a lack of investment in research and development.

Keywords thinning; forest management; Russia; SWOT; forestry
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1 Introduction

1.1 Background

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 land area. The total growing stock is about 1 billion m^3, which is on average 100 m^3 ha^{-1} 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^{-1}. The annual allowable cut (AAC) is around 10 million m^3, of which 60% is utilized (Ministry of Nature Management and Ecology of Karelia 2015). Forests play important role in the economy of Karelia, since they provide raw materials for the forest industry, which accounts for about 15% of the region's gross domestic product (GDP) (Kareliastat 2016).

Since the development of industrial-scale forest use in Karelia during the Soviet era, extensive forest management has been the dominant practice in forestry. This means that wood harvesting operations (clear-cutting) are mostly carried out in mature and over-mature stands that are located adjacent to existing roads. Thinning or rather selective cutting in growing forests is performed on a small scale. For instance, in 2015 only 21 000 hectares were thinned (Ministry of Nature Management and Ecology of Karelia 2015), which equates to just 31% of the amount legislated in the Forest Plan of Republic of Karelia (Ministry of Forestry Complex of Karelia 2008). Reforestation is mostly based on natural regeneration. Planting and young stand improvements are less common practices. The quality of the existing forest road infrastructure is extremely low; the road-density is around 2 m ha^{-1}, and 50% require major repairs (Gerasimov et al. 2013a).

The practice of extensive forest management and the absence of cost accounting (legacies from the Soviet times) have led to low forest productivity and profitability in Karelia (Tyukina 2010). For example, the area of forest stands near the road network that are accessible for harvest has reduced annually. Irregular operation and low investment in silviculture, especially thinning, have influenced the structure and quality of the forest resource. In particular, the commercial forest land of coniferous forests over the last 30 years has reduced considerably, while in contrast the area of deciduous forests, such as birch and aspen has significantly increased (see Soroka and Ananiev 2009 for details). In addition, the age structure have changed; currently 34% of the forests consist of young stands, 26% middle-aged stands, 7% premature stands and 33% mature and over-mature stands. The uneven age structure hinders the planning of 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.

The forest management practices in Karelia are similar to other forest regions of Russia, such as Leningrad, Archangelsk, Vologda, Novgorod, Pskov and Komi Republic (Karjalainen et al. 2009). Against this background, it is increasingly evident that there is a need for new developments and innovative solutions for forestry practices. That is why the concept of intensive forest management has been subject of a growing debate among local experts from science (Karjalainen et al. 2007, 2008, 2009; Soroka and Ananiev 2009; Sinkevich 2013; Northern Research Institute of Forestry 2017), business community (Grabar 2015; Verveiko 2015; Konovalova 2015) and environmental organizations (World Wildlife Fund 2013) in Karelia and also in Russia as whole for the last fifteen years.

In contemporary practice, the meaning of intensive forest management may slightly vary depending on particular growing conditions, whether natural or plantation forest, and the geographical usage context (West and Shula 2009; Puettmann et al. 2015; Demaraisa et al. 2017). In Karelia, the intensive forest management refers to the forestry practices developed for intensive management and silviculture of forest resources that are used in the Nordic countries, in particular in Finland and

Sweden. Interest in the experience from Finland and Sweden was caused by a higher productivity and profitability of forestry in these countries achieved in very similar environmental conditions. For example, the forest resource in Finland, mainly natural origin pine and spruce, amounts to approximately 2.3 billion m^3, which is over 100 m^3 ha^{-1}. The annual growth of forests is over 100 million m^3 or 4.3 m^3 ha^{-1}, which is almost double the growth of 50 years ago (Metla 2014) and almost threefold compared to Republic of Karelia. Annual wood harvesting is 65 million m^3, but can be increased sustainably to 80 million m^3 (Ministry of Agriculture and Forestry 2015). In Sweden, the forest resources are very similar in composition and volume of those in Finland. The total volume of wood amounts to approximately 3 billion m^3 (over 130 m^3 ha^{-1}). The annual growth stands at around 120 million m^3 or 5.3 m^3 ha^{-1}, which is already double the growth of 100 years ago, and continues to increase. Annual wood harvesting is around 90 million m^3 (Swedish Forest Agency 2014).

The main reason for the increased growth has been investment and the utilization of practices developed for intensive management and silviculture of forest resources (Äijälä et al. 2014). When these practices are applied, the forests are successively managed with more active regeneration, tending of seedling stands and regular thinning. Regeneration has been greatly improved through artificial planting, soil preparation and fertilization. Respacing and cleaning operations are used to prepare the structure and growth conditions of the future forest stand. Thinning has been a common practice and is usually carried out two or three times over a forest rotation to maximize the forest crop (Kärhä et al. 2004; Mäkinen and Isomäki 2004). A sufficiently dense forest road network is important for accessibility that has a major economic impact on wood harvesting and logistics but also on the utilization of wood-based energy (Routa et al. 2013). The raw material for energy wood is composed of logging residues, stumps, and small-diameter trees from final felling and thinning operations. The utilization of woody biomass of this kind provides space and resources for the main crop and helps regeneration operations (Äijälä et al. 2014).

In terms of the current forest management in Karelia, the Nordic experience represents a number of innovative and proven over time solutions. Transfer of the Nordic intensive forest management solutions (NIFMS) could be an opportunity to improve the current practice in Karelia and move towards more active management and silvicultural systems, which would also take into account the profitability and sustainability of the forest resource.

1.2 Research problem and design

Despite the promise of possible benefits, the implementation of NIFMS transfer requires a careful pre-assessment of the operational environment, which may enable or hinder the transfer, e.g. support in the form of practical development projects. In order to assess this problem comprehensively and to tailor NIFMS to local conditions, systematic and analytical approaches could be used for analyzing the local operational environment. Such approaches could be based on the use of modern decision support applications and methods. Examples of applied techniques are SMART (simple multi-attribute rating technique) (von Winterfeldt and Edwards 1986), SMAA (stochastic multi-criteria acceptability analysis) (Hokkanen et al. 1999), Even Swaps (Hammond et al. 1998), as well as IDA (interactive decision analyses) (Pykäläinen et al. 1999), and IUA (interactive utility analysis) (Pykäläinen et al. 2007). For a detailed overview of these and other methods and their applications, see Kajanus et al. (2012) and Kangas et al. (2015).

This study utilizes a technique that combines SWOT (strengths, weaknesses, opportunities and threats) and the MCDS (multi-criteria decision support) method in an analytic hierarchy process (AHP), hereafter called the A'WOT approach (Kurttila et al. 2000). The SWOT is an analytical tool that is widely used for the analyzes of internal and external environments in strategy development

and related decision support. SWOT is based on the analysis of internal strengths (S) and weaknesses (W), and external opportunities (O) and threats (T) and the development of strategies that fit with the results of these analyses. Extracted strategies based directly on the results of SWOT analysis consist of four categories of factor combinations (Ghazinoory et al. 2007): S and O, S and T, W and T, and W and O.

SWOT analysis was developed in the 1960s by Leraned et al. (1965). The SWOT matrix, as a tool for analyzes of complex problems and situations, was introduced in the 1980s by Weihrich (1982). Since then, SWOT has been used in strategic planning studies in many fields, including forestry (Gerasimov and Karjalainen 2008). Despite its wide applications, the SWOT method also has a number of limitations (Hill and Westbrook 1997). According to Ghazinoory et al. (2007) some of them include (a) a qualitative examination of the environmental factors is usually only considered, (b) it does not prioritize the various factors and strategies and (c) it does not consider the vagueness of the factors when it is difficult to place them clearly within a certain SWOT group.

Kurttila et al. (2000) integrated the eigenvalue calculation framework of the AHP with SWOT analysis to eliminate those deficiencies that were only related to qualitative examinations. The AHP method was originally prepared by Saaty (1980) and is based on a theory of measurement through pairwise comparisons and relies on the pairwise evaluations of elements of the decision hierarchy to derive priorities (Saaty 2008). In general, AHP analyzes complex decision problems with multiple criteria (Kurttila et al. 2000), where both qualitative and quantitative data might be processed. That is, the combination of AHP with SWOT (i.e. A`WOT) is used to improve the quantitative information basis for analytical processes and support for decision-making. A`WOT analytically prioritizes the factors identified in SWOT and makes them commensurable (Kurttila et al. 2000). The method has been applied in a number of planning-related and decision analysis studies (see Kajanus et al. 2012 for details), which include also applications in forestry (Leskinen et al. 2006). To our the best of our knowledge, such a systematic approach has not been widely used in the Russia-related studies.

1.3 Aim and objectives

The development of forest management in Republic of Karelia was analyzed using possible innovations from Nordic countries, in particular Finland and Sweden, with the A'WOT approach. The A'WOT was chosen as a research method due to the complexity of the problem, the strong influence of the "human factor", and the lack of reliable experimental or regulatory instruments. The specific objectives of this study were to: (1) systematically assess the potential of NIFMS in the operational environment of the region and (2) highlight the most important factors that might influence the transfer and the implementation of those solutions in Karelia. The identified internal and external strategic factors could be thereafter used by persons formulating possible alternatives and strategies for the development of NIFMS in Karelia and Russia. The results seek to contribute both to the informational needs of forest management development processes and bring an opportunity for further conceptual and methodological studies. To identify critical issues that could enable or hinder the transfer of NIFMS to Karelia, local stakeholders from the forest industry and from research and development (R&D) organizations were interviewed. Republic of Karelia was chosen as a study area as forestry is an important sector in this region and requires development. The results of the analysis are also of relevance for other regions in Russia.

2 Materials and methods

2.1 Materials, interviews and respondents

Materials needed for the A`WOT analysis introduces a combination of the forest metrics found in forest statistics, academic journals, professional magazines/books, project reports, conference proceedings, various recommendations/instructions and governmental programs/documents/reports that are shown in Supplementary file S1, available at https://doi.org/10.14214/sf.7763, and the results of interviews with experts from the forest industry and R&D organizations. The interviews were undertaken individually in early 2013 in Karelia. The forest industry was represented by four logging companies, R&D organizations – a state university and a research institute. The selection of interviewees was based on several discussions with key informants from research and government institutions and industry associations. The experts are well known, acclaimed and are well aware of the challenges in the field. The total number of respondents was thirteen.

2.2 Application of the A`WOT

According to Kangas et al. (2015), the A'WOT approach consists of the following steps:

(1) The SWOT analysis is carried out. The relevant factors of the external and internal environments are identified and included in the analysis.
(2) Pairwise comparisons between the SWOT factors are carried out separately within each SWOT group and the comparison determines which of the two factors is more important and by how much. With these comparisons as the input, the mutual priorities of the factors are computed.
(3) The mutual importance of the SWOT groups is determined by the application of pairwise comparisons. There are several possibilities as to how to do this. For instance, it is possible to compare the groups as such, or the most important factors in each group.
(4) Alternative strategies are evaluated with respect to each SWOT factor by using pairwise comparisons and the eigenvalue technique.
(5) Global priorities are calculated for the alternative strategies.

In this study, only steps (1), (2) and (3) were carried out that is referred to the phase of an early stage of a strategic planning process (Kangas et al. 2015). As such, A'WOT was used to qualitatively and quantitatively examine the operational environment factors that may influence the transfer of NIFMS to Karelia.

In the first step, the SWOT analysis for the transfer of NIFMS to Karelia were carried out with a comprehensive review of various literary sources mentioned earlier. In addition, a number of key experts were consulted to identify possible additions, wording or corrections. The findings were allocated to the SWOT framework in the form of strengths, weaknesses, opportunities and threats. Identification of the most important factors and parameters of the NIFMS transfer involved the several activities as follows. At the beginning, the data from the literature was used to provide a comprehensive overview of the matter to ensure that the content covered all possible technological, economic, environmental, political, and socio-demographical trends and challenges that may affect the transfer and application of the NIFMS in Karelia. These factors were easily detected since they have been widely discussed in the literature and among local experts in recent times. Then, in order to define the main factors and to thereafter allocate them to the SWOT framework, the consultations with a number of experts, and internal discussions between authors were undertaken. As a consequence, it was decided to combine some of the issues, while others were placed

as independent factors. After the data was narrowed down, a set of identified environments were divided into internal strengths and weaknesses and external opportunities and threats, and then were illustrated in a SWOT quadrangle.

Strength (*S*) is a characteristic of the transfer and implementation of NIFMS in Karelia that gives it an advantage over existing practice. Weakness (*W*) is the limitation in the transfer and implementation of NIFMS in Karelia that will impede the realization of its objectives. Opportunity (*O*) is the element(s) in the operational environment that could be used to contribute to the transfer and implementation of NIFMS in Karelia. Threat (*T*) is the element(s) in the operational environment that may easily block the transfer and implementation of NIFMS in Karelia. *S* and *W* are internal factors that are able to benefit or hinder the transfer directly, and *O* and *T* are external factors that are not under direct control of the transfer, but are able to strongly influence it from the outside to one extent or another.

In the second step, the AHP was used to prioritize factors identified in SWOT in order to identify the most critical issues that contribute or prevent the transfer and implementation of NIFMS to Karelia. As recommended by Saaty (2008), these measurements rely on the judgement of reliable experts to emphasize priority scales. For this reason, we interviewed stakeholder groups from the forest industry (four logging companies) and from R&D organizations (a state university and a research institute).

At each of the meetings, the experts were provided with a questionnaire based on identified SWOT factors. Each factor was provided with a short description in order for the expert to easily understand the sense. The descriptions were based on the literature review carried out during the SWOT procedure. After the experts got familiar with the factors, they were asked to assign relative weighting to each of the factors for pair-wise comparison within a given SWOT group. It should be noted, that we followed the rule where the number of factors for a SWOT group should not exceed ten because the number of pair-wise comparisons needed increases rapidly (Saaty 1980). In each pair-wise comparison, the most important factor was assigned a weight (2–9) based on its relative importance. A score of one indicates equal weight for the two factors. Information delivered from a pair-wise comparison is represented in comparison matrix A:

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

, where a is entries and n is the number of factors.

A factor priority score was then calculated for each comparison using an eigenvalue method, and mean values were calculated for each SWOT group (see Malovrh et al. 2012 for details). The priority vector W = (w1, …, wn) is obtained by solving the equation AW = λmaxW, where λmax is the largest eigenvalue of matrix A. With regard to consistency, matrix A is acceptably consistent if:

$$\mathrm{CR} = \mathrm{CI/R} < 0.1 \tag{2}$$

, where CR is a consistency ratio, CI = (λmax−n)/(1−n) is the consistency index and R is the average random consistency index. Serious inconsistency exists if CR > 0.1, and the 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 and Sush-

kov 2005). The program was chosen, rather than similar software applications (the HIPRE by Hämäläinen and Kettunen (1994)) as it uses a Russian interface, which was more convenient when working with the Russian experts.

In the third step, the pair-wise comparisons were made between the four SWOT groups. The factor with the highest priority from each SWOT group was taken for further comparison. These four factors were compared pairwise to each other, which then allowed them to be scaled in level of priority. Next, the relative priorities of these four factors were used to scale the global priorities for the remaining independent factors in each SWOT group (Kajanus et. al 2012). 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.

The method was applied to thirteen interviews. Therefore, different elicitations were aggregated using basic statistics: mean, median and standard deviation.

Thus, the results of the comparisons are numerical values that show the priorities of the factors included in the SWOT analysis. These results can be thereafter utilized for structuring of the problem, formulating the strategy alternatives for the NIFMS transfer to Karelia, and also for the evaluation process. New objectives and implementations can be defined with a close consideration of the foremost factors (Kurttila et al. 2000).

2.3 Additional data analysis and interpretation

To contribute further to the strategic planning process in this study, structuring the results and determining the mutual influence of the factors that are used in SWOT analysis seems to be useful since it may affect the selection of the final strategy (Yuksel and Dagdeviren 2007; Gerasimov and Karjalainen 2008). The strategic *O* and *T* factors were therefore taken for further analysis in a final step. *O* and *T* are important factors when it comes to development of the strategy for NIFMS transfer and implementation in Karelia. As was mentioned in a number of previous studies (Gerasimov et al. 2013a, 2013b), a sophisticated assessment of *O* and *T*, taking into account the *S* and *W* factors, permits the drawing of strategic conclusions from this analysis, which allows a better structuring of the problems and challenges, and helps to find solutions within the existing and prospective resources. This step helps to formulate basic strategic directions.

Specifically, the numerical values for the identified *O* and *T* were firstly used to divide them into three priority groups depending on their importance (by analogy to Gerasimov et al. 2013a, 2013b). Then, taking into account the *S* and *W* factors, the mutual influence of the strategic *O* and *T* factors was considered. Each of the groups included the following criteria: strategic *O* and *T* factors that require the concentration of all necessary resources for their successful implementation were assigned the highest priority; these are crucial factors in the further development of NIFMS in Karelia and must be under constant supervision; *O* factors that require resources, and *T* factors that require a level of control are assigned medium priority; the remaining *O* and *T* factors are assigned the lowest priority. Determination of the mutual influence of the factors was carried out through further discussions and analyses with a few of the key respondents, and by internal audits.

3 Results

3.1 SWOT results

The list of key operational environment factors that enable/hinder the implementation of NIFMS transfer to Karelia and that were selected for the interviews and further analyzes is shown in Table 1. Based on the literature review, an internal audit and a survey of the experts, the SWOT factors were described and shown in Suppl. file S2, available at https://doi.org/10.14214/sf.7763.

3.2 AHP Results

The local and global weightings for the individual SWOT factors are shown in Table 1. More detailed statistics on the priorities by stakeholder group are presented in Figs. 1–5. According to the quantitative results of the AHP analysis, four factors of the highest priority were selected representing the SWOT groups. The *S* factors were represented by the factor "Improving quality and value of timber", *W* by "Slow return on investments", *O* by "High potential of forest resource", and *T* by "Unprepared regulatory environment". Priority vectors, W_{swot}, and the consistency ratio, CR_{swot}, for the SWOT groups are shown in Table 1. The results show that strengths are the most important SWOT group for future development of NIFMS in Karelia, threats are important, and weaknesses and opportunities are the least important group.

In terms of overall scores, two of the highest global priorities represented strengths; "Improving quality and value of timber" (gw = 0.116) and "Support for principles of sustained yield" (gw = 0.104) (Table 1). Next in order was the threat "Unprepared regulatory environment" (gw = 0.077). The remaining factors had lower global priorities (Fig. 6). Positive factors were predominant.

Table 1. Local weighting (LW)[a] and global weighting (GW) of SWOT factors of NIFMS transfer to Karelia (the factors are ranked in decreasing order from highest to lowest weightings with respect to each SWOT group, the factor with the higher weighting is located above 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] The group priority was calculated as following: Strengths 0.398; Weaknesses 0.174; Opportunities 0.180; Threats 0.249.
[b] The consistency ratio (CR) of the comparisons between four SWOT groups was 0.043.

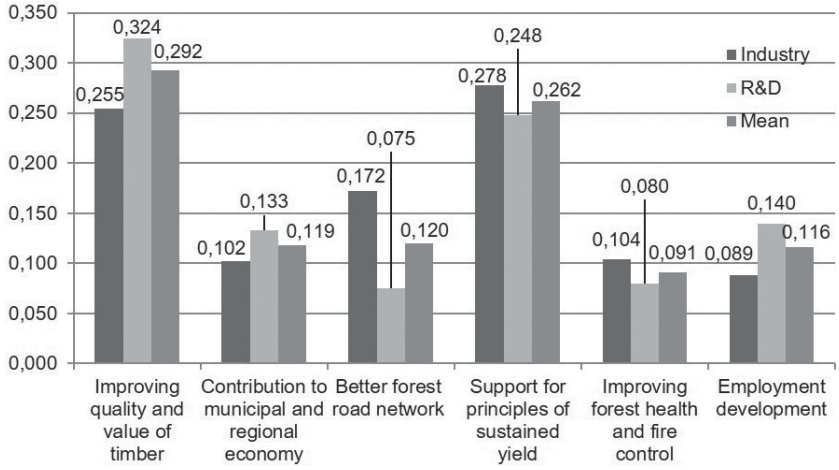

Fig. 1. Descriptive statistics for local weightings (LW) for strengths by respondent group obtained with the analytic hierarchy process (AHP) procedure.

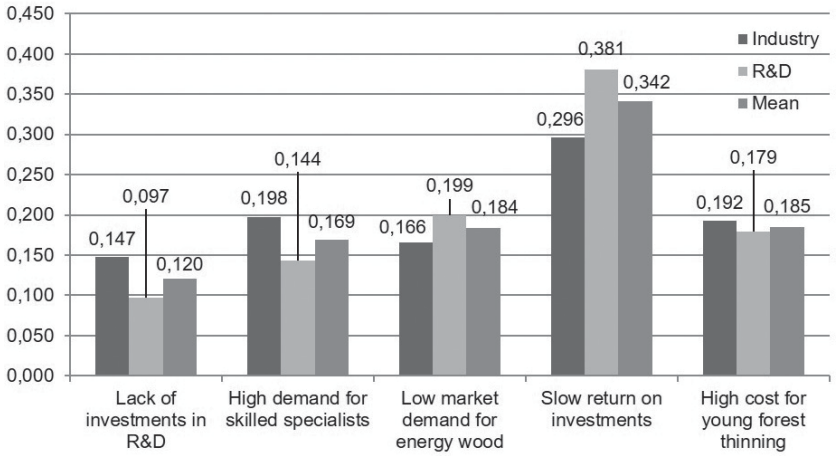

Fig. 2. Descriptive statistics for local weightings (LW) for weaknesses by respondent group obtained with the analytic hierarchy process (AHP) procedure.

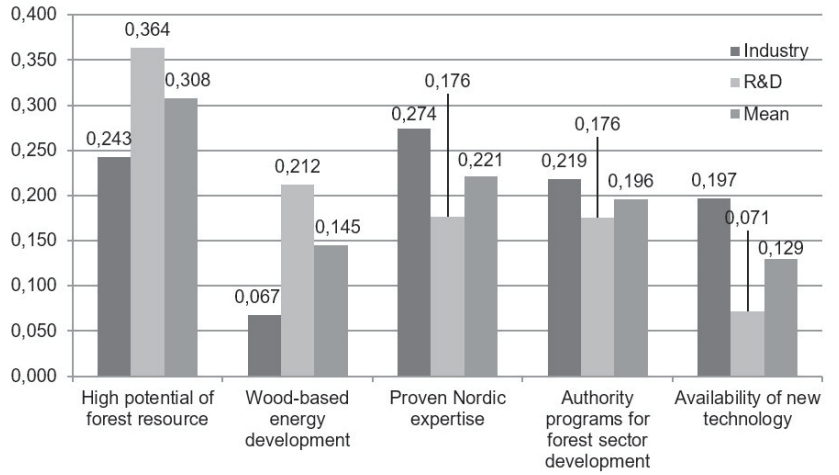

Fig. 3. Descriptive statistics for local weightings (LW) for opportunities by respondent group obtained with the analytic hierarchy process (AHP) procedure.

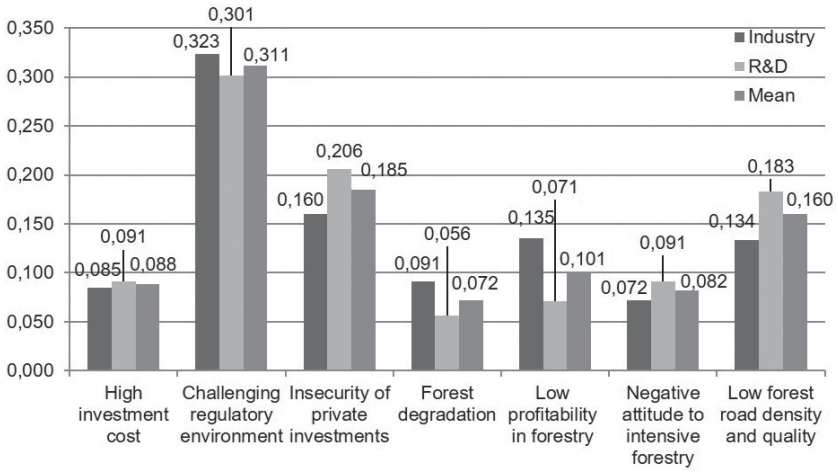

Fig. 4. Descriptive statistics for local weightings (LW) for threats by respondent group obtained with the analytic hierarchy process (AHP) procedure.

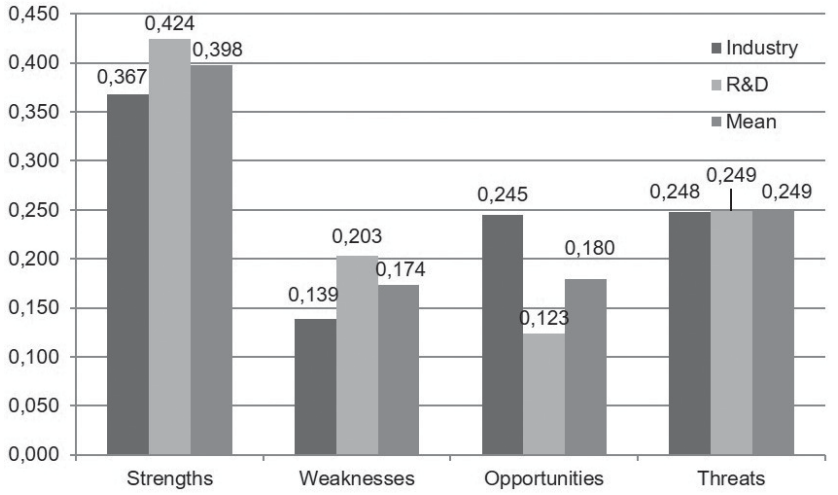

Fig. 5. Descriptive statistics for local weightings (LW) for the SWOT groups by respondent group obtained with the analytic hierarchy process (AHP) procedure.

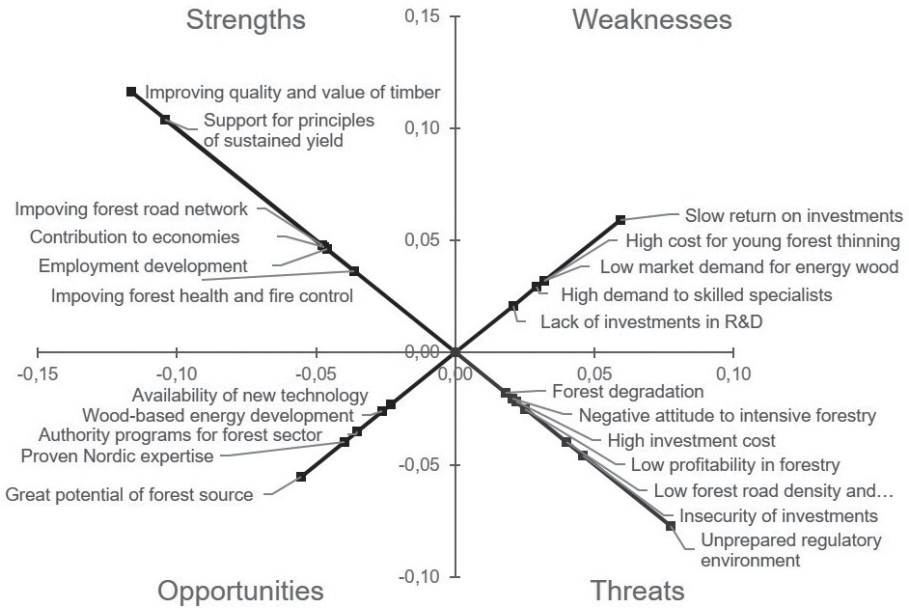

Fig. 6. Graphical interpretation of the global priorities for factors with respect to each SWOT group (the higher the priority, the outermost the point).

3.3 Analysis of opportunities and threats

Strategic *O* (i.e. high potential of forest resources (lw = 0.308) and relevant *T* (i.e. unprepared regulatory environment (lw = 0.311) were assigned to the high host priority group as crucial factors that need to be taken into account for the further development of NIFMS in Karelia. Medium priority group included *O* factors, i.e. proven Nordic expertise (lw = 0.221) and authority programs for forest sector development (lw = 0.196) and *T* factors, i.e. insecurity of private investments (lw = 0.185), low forest road density and quality (lw = 0.160) and low profitability in forestry (lw = 0.101). The *O* factors, i.e. wood-based energy development (lw = 0.145) and availability of new technology (lw = 0.129) and *T* factors, i.e. high investment cost (lw = 0.088), negative attitude to intensive forestry (lw = 0.082) and forest degradation (lw = 0.072) were assigned to the low priority group.

The most common argument for the highly prioritized strategic *O* factor was high potential of forest resources. It is evident that there is a possibility to increase the use of allowable harvest, which would increase supply of roundwood in the market. Realization of strategic *O* factors requires availability of strong investment capital because investments in infrastructure, technology, forest management and silviculture are critical.

The most common arguments for the high priority threats include an unprepared regulatory environment that currently prevents appropriate silvicultural activity in Karelia. This has been a widely discussed topic among local experts in recent times. Relevant *T* factors require careful attention and constant monitoring by the top management.

Medium priority *O* and *T* factors require self-financing or negotiated external funding and continuous control by senior and middle managers. Intensive forest management could be promising in Karelia because the region has similar natural and climatic conditions to Finland and Sweden having long experience for intensive forest management. Consequently, only the best practices developed for intensive management and silviculture of forest resources could be utilized. However, the proven Nordic expertise factor is merely conceptual and requires significant practice, marketing and financing from the stakeholders. Authority programs for forest sector development could help in the current economic climate, where the state might be an external source for funding forestry business. However, the programs mainly create distrust among industry stakeholders.

Due to bottlenecks in the leasing of forests, long-term investments in state-owned forests are insecure. Wood harvesting companies, including Nordic-owned enterprises have suffered in this regard. Increased attention on relevant forest legislation by state, industry and R&D organizations is required. The low density of forest roads in Karelia is partially a consequence of not investing in forest road construction. The low profitability in the forest sector prevents a stable financial environment for companies involved in the supply chain. However, most of the existing companies have worked under these conditions for a long time and may have developed their own procedures to cope with this difficulty, which may explain why this factor has been ranked lower.

The remaining *O* and *T* factors have rather low weightings and should be under the control of middle managers and use the company's own sources of funding. Some of these factors were explained that utilization of wood-based energy is well developed in Nordic countries, but in Russia there is no comprehensive experience in this field; availability of new technology should be taken into account only when the NIFMS is in the implementation phase; forest degradation was not regarded as a critical *T*, because logging companies work mainly in areas which are ecologically less sensitive.

4 Discussion

Previous Russia-related studies (FAO 2012; Karjalainen et al. 2007, 2008) have pointed out that 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 forest sector in Russia, also in Karelia. Poor forest management and silvicultural practices have been a reason for low productivity and profitability in the forest sector. Therefore, improvements in forest management practices are necessary in Karelia.

The experience of the Nordic countries, in particular Finland and Sweden, could be used to improve the situation in forestry in Karelia. With this study, the strengths, weaknesses, opportunities and threats that influence the transfer of NIFMS to Karelia have been identified and priorities for them sorted out. The results can be further utilized for structuring of the problem, formulating the strategy alternatives for the NIFMS transfer to Karelia and also for the evaluation process of them. Described approach could be applied to other regions of Russia, too.

The NIFMS clearly shows that successive performance of the silvicultural operations may improve forest productivity and support the sustained yield of forest and non-wood forest products and services. Responsibly managed forests are critical to provide a reliable supply of raw material for industry, which in turn is important to the Karelian economy. Intensive forest management requires a dense-enough road network for the intensified use of available forest resources, including dead and infested or damaged trees. There are also positive perspectives in terms of new jobs and enterprises, and for forest health and fire control.

Despite the positive attributes, the study also showed that the slow return on investments is the principal weakness for implementation of intensive forest management in Karelia. As such, reform of the forest sector through NIFMS requires an economic tailoring of those solutions to local conditions. A cost-benefit analysis for silvicultural operations, as well as construction of an optimal density of road network, should be undertaken as the next operational steps to the introduction of NIFMS to local conditions. It is also necessary to consider the development of a market for energy wood. In order to plan forest management operations in the long term and to determine their profit potential, relevant technology and approaches, especially forest inventory and planning, need to be investigated. Otherwise, the forestry sector in Karelia will continue to be difficult to evaluate economically and private investment in forestry will remain low.

Consideration of identified opportunities and threats are important in further development of NIFMS in Karelia. Crucial factors are the high potential of forest resources (opportunity) and unprepared regulatory environment (threat). However, in order to identify the strategy of the NIFMS in Karelia, the main interdependent groups "*O-S/W*" and "*T-S/W*" need to be allocated and thereafter analyzed in more detail. For example, it can be done with the use of a SWOT matrix of interactions. The SWOT matrix allows different scenarios to be recognized via a number of approaches (see Dyson 2004; Parraga et al. 2014 for details). It is this stage of the A'WOT analysis that may help to define the alternative strategies of the NIFMS transfer. Thus, further research is necessary.

In many situations, it was not possible to differentiate factors clearly into *S*, *W*, *O* or *T* and give a certain determination to one vector. For example, the high potential of forest resources is an *O*, while it could also be designated a *S* or even a *T*, because it may lead to inaction and depression in the business. Authority programs for forest sector development are an *O*, but issue of implementation and continuation of these programs and their comprehensiveness may be considered as a *T*. Furthermore, proven Nordic expertise can be both an *O* (external effect) and *S* (internal effect) etc. Such difficulty in interpretation occurs when the issue is viewed from different perspectives, and the valuation is, therefore, likely to be highly subjective.

On some points, the responses from industry and R&D radically diverged. This may be due to the approach employed in the estimation of the challenges and issues. For example, the high potential of forest resources is a major *O* for R&D specialists. However, industry experts suggest that this might be a reason for the escalation of the crisis in the forest sector, and that the proven Nordic expertise and modern technologies should instead be considered. Another example is that wood-based energy development was considered a more solid *O* for R&D, while industry experts were more skeptical due to the lack of normal business and the operational environment that supports the utilization of woody biomass. In other words, the opinions of the industry experts were mainly based on practical issues and shorter planning horizon, while the academic responses tended to be more general, considering longer planning horizon and often used theoretical and statistical frameworks to form a judgment. In practice, this demonstrates the low interaction between theoretical (institutions) and practical (companies) backgrounds, which is a common situation in Russia.

Currently, forestry in Karelia is on the path from extensive to intensive forest management, but success of the transition may be limited for many reasons. In particular, government policy in relation to the development of long-term forestry is unclear. More precisely, the forestry regulations are not well prepared, forest leasing contracts are currently only issued for a maximum of 49 years, and the investment climate is uncertain. It seems that strategy and plan are not clear. In addition, the Nordic experience would indicate that when intensive forest management is practiced, it is extremely important to follow the principles of sustainable forest management and to consider how best to employ them in practice. In this sense, intensive forestry in Russia may have a higher potential than in the Nordic countries, since there is a huge area of forest land, which could be utilized more efficiently on a sustainable basis, and also addressing biodiversity conservation. However, it is obvious that there is a need for clear strategy and prompt implementation with strong management to fulfil this potential. At the same time, the transfer of NIFMS can benefit from the use of modern forest technology, including decision-support systems, to help the stakeholders analyze the probable benefits and costs from different management regimes.

This study has addressed reforming of the forestry sector in Karelia further. The study has provided a broad overview on challenges in forestry in the region, in particular from the perspective of Nordic experience. The results and conclusions can be used by policy-makers, who are planning to develop forest management, as well as by local wood procurement organizations for the identification of factors in their development process. The main findings of this study may also provide a robust framework for estimating the risks and benefits of the forestry business in Karelia and in other regions, as the most important *O* and *T*, *S* and *W* factors emphasized in SWOT are based on the actual situation in the forest sector.

The method applied in this paper is also applicable for other regions in Russia. The use of A`WOT might be useful for exploring the opportunities for new programs and identifying ways of developing the forest sector, both at federal and regional levels. In order to evaluate future opportunities or challenges a systematic approach was used in A'WOT analysis. The planning of decision-making should be based on utilizing *S*, minimizing *W*, implementing *O* and minimizing *T*. If the operational environment changes rapidly, e.g. in Russia where decisions and actions are made with constant uncertainty and with a poor interaction between science and business that aggravates the subjective views, then an analysis of the operational environment should be updated regularly. The creative use of A'WOT can provide the basis for useful development plans for wood procurement organizations, where decision-making based on intuition and subjective judgments could be avoided.

In conclusion, it should be noted that, some of the Nordic logging and processing companies have operated in Karelia for a long time and have already brought many of the original aspects of

Nordic practices to Russian forest management. Therefore, possibilities for a favorable transition to intensive forest management exists to some extent. However, further research and analysis of the applicability of alternative intensive regimes by forest users in a sustainable manner are necessary.

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Total of 77 references.

Supplementary files

S1.pdf; Forest metrics relevant to the transfer of Nordic intensive forest management solutions to Karelia used for literature review.

S2.pdf; Description of the key operational environment factors that enable/hinder the implementation of NIFMS transfer to Karelia and that were selected for the interviews and further analyzes.

, available at https://doi.org/10.14214/sf.7763.