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PERCEPTION OF ROMANIAN STATE FOREST MANAGERS ON THE USE OF DIFFERENT TIMBER HARVESTING SYSTEMS

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Abstract: *In timber harvesting operations, the degree of mechanization depends on many factors. Among these, the institutional and social acceptances are considered to be key factors which could restrict some harvesting systems irrespective to the availability of equipment and technology. This study evaluated the perception of state forest managers relative to the use of 12 timber harvesting systems characterized by various levels of mechanization, based on a quantitative questionnaire. More than 150 questionnaires were retrieved from the state forest districts. The results indicated that cable yarding systems were among the most preferred ones, being closely followed by those systems involving forwarding operations and chute systems.*

Key words: *visual perception, state forest management, timber harvesting system, key performance indicators.*

1. Introduction

The Romanian forests cover cca. 6.9 mil. hectares [25] and they are managed in two distinct categories: forests fulfilling protection functions and forests fulfilling production and protection functions. For those forests included in the last category, an important attention is given to wood production.

The use of wood for various applications such as energy procurement and construction dates back to the beginning of humankind history. Today, wood is one of the most used materials in industry, contributing to the economic development and growth, providing at the same time many employment opportunities. In the UE alone, 58% of the harvested lignocellulosic biomass is processed by the forestry-related industries accounting for 7% of the EU's processing industry GDP and employing 3.5 million of people [9].

At the same time, wood delivery to industry may be seen as being a complex activity which includes but is not limited to technical, economic, social, legal and environmental issues. For instance, harvesting operations can be carried out

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by implementing one option from a quite extensive set of timber harvesting systems [16].

In general, a timber harvesting system is defined as the machines, tools and workforce used together to extract the timber under a specified harvesting method [1]. Therefore, a timber harvesting system may bring together various machines and tools to extract the wood for given operational conditions and harvesting methods. Depending on the mechanization level (mechanization integration), timber harvesting systems may be categorized either as fully or partly mechanized [16] while the degree of mechanization depends on several factors, including the type of forest management and social acceptation [23].

On the one hand, forest managers aim to preserve the services provided by forests and their resilience tending this way to be more restrictive to some practices (harvesting systems) related to forest operations, even if sometime they are supporting their stand by subjective views. In addition, the Romanian forest owners and the general public might be sometime reluctant to the introduction or to the use of some harvesting systems. Obviously, this has consequences also in the legislation related to forest management because such standpoints coming also from forestry professionals and experts are likely to affect the law development process, making it more restrictive. On the other hand, the general public has limited knowledge on forestry and it might have no knowledge on forest operations, a reason which should support its education on basic forestry issues and trends. Irrespective to the category of persons, the general perception of different groups of subjects on forests and forestry activities becomes crucial in the attempt to design and use adequate forestry practices.

Apart of the general public, the most frequent interactions in Romanian forestry are among the forest managers and the timber harvesting companies. The first category aims to maximize its profit from the wood selling and to preserve the functionality of forests based on normative approaches, while the second one tries to increase its profit margin and struggles to survive in the actual economic context which is very difficult. This situation results often in a vigorous selection of the type of equipment and harvesting systems to be used as a compromise between the two views. In addition, to be able to purchase expensive equipment, harvesting companies need to be certain that they would be able to fully use and operate such equipment to recover their investment. This is particularly important as most of the Romanian timber harvesting companies are small-medium enterprises [20] which may be characterized by low investment capacities and a lack of ability to associate themselves to be more competitive [21].

A study carried out by [19] has showed that some of the major problems in Romania are that related to the old technology used in timber harvesting operations and the lack of trained personnel. Indeed, to be able to implement sustainable forestry practices the timber harvesting systems should be bio-physically effective, economically efficient, compatible with the workforce, environmentally friendly, and institutionally accepted [11].

Therefore, one step to be taken is that aiming to see what are the perceptions and expectations of different stakeholder

groups relative to the use of different timber harvesting systems.

This study evaluates the perception of state forest managers related to the possibility to implement or use a set of timber harvesting systems, in a national attempt, based on responses related to a set of key indicators that were evaluated by a quantitative questionnaire.

2. Material and Methods

2.1. Survey

This study is based on a quantitative questionnaire that was designed and built in three sections - A, B and C.

Section A was designed to collect forest management data regarding the wood resources and some of the wood procurement operational conditions. It included the location of forest districts, forested area of each forest district, forested area on major topography features, share of major tree species in the forest managed by each forest district, as well as descriptions of operational conditions such as the extraction distance, estimations on harvested wood volume in the last ten years and the volume harvested per year within the implemented silvicultural systems and tendering operations.

Section B of the questionnaire was designed to capture data about the frequency of using given harvesting methods and equipment. In particular, the share of various harvesting methods and of the use of specific equipment in relation to major topography features, were included in this section of the questionnaire.

Finally, section C was designed to evaluate the perception of the respondents on key performance features (indicators) for a list of commonly used timber harvesting systems.

To this end, a set of 12 timber harvesting systems (hereafter *S1*-*S12*) were included for evaluation in the section C of the developed questionnaire. A description of the component equipment for each of the included timber harvesting systems is given in Table 1. The choice of timber harvesting systems included in the study was supported by the provisions of the national [2], [4], [20], and international [15] literature describing the state of forest operations mechanization in Romania and in countries characterized by a similar level of mechanization integration in such operations.

Before the release of the questionnaires to the prospective respondents, the chosen harvesting systems were evaluated both, in terms of use in Romania and in terms of mechanization level. This step was done based on the existing literature and subjective ratings of the authors.

Only one harvesting system was evaluated as never used in Romania, but it was described as being used in the neighboring countries.

The prospective respondents were chosen from each forest district as those persons being in charge with the activity related to wood selling, forestry mechanization and timber harvesting operations based on the provisions that such forest management personnel have knowledge on the type of equipment used in forest operations and it also can objectively assess and give pertinent opinions on the selected key performance indicators. In fact, such personnel are required by law to have graduated higher education in forestry; therefore, it was

assumed that the questioned subjects had an extensive knowledge on forest operations.

To support the decision, the section C of the questionnaire was designed by including visual descriptions of the harvesting systems under evaluation (*e.g.* Figure 1).

A special section of the questionnaire was designed to state the informative nature of the timber harvesting depictions, guiding the respondents to imagine the real conditions related to the use of each harvesting system in their own managed forest.

Description of timber harvesting systems under the evaluation Table 1

Description of the evaluated timber harvesting system	**Subjective rating of use in Romania**	**Rating of mechanization level**
Motor-manual tree felling and processing + animal forwarding of short wood (S1)	Never	Very low
Motor-manual tree felling and processing + animal skidding (S2)	Often	Very low
Motor-manual tree felling and processing + chute logging (S3)	Rarely	Low
Motor-manual tree felling and processing + manual sliding and bunching (S4)	Often	Very low
Motor-manual tree felling and processing + skidding using farm tractors (S5)	Very often	Medium
Motor-manual tree felling and processing + forwarding using farm tractors (S6)	Rarely	Medium
Motor-manual tree felling and processing + skidding using specialized winch skidders (S7)	Most often	Medium
Motor-manual tree felling and processing + forwarding using specialized clam-bunk skidders (S8)	Rarely	High
Motor-manual tree felling and processing + forwarding using specialized forwarders (S9)	Often	High
Motor-manual tree felling and processing + cable yarding using tower yarders (S10)	Rarely	High
Motor-manual tree felling and processing + cable yarding using sledge yarders (S11)	Often	Medium
Tree felling and processing using harvesters + forwarding using specialized forwarders (S12)	Rarely	Very high

Fig. 1. *Visual description of S6*

2.2. Questions and Key Performance Indicators

For each of the evaluated harvesting systems, a set of 16 questions (items) were included right after its visual depiction (Table 2). Each item was formulated as a closed question, enabling the respondents to choose between five alternatives measured on a Likert scale. Technical (economic, productive) performance of the included harvesting systems was assessed from the respondents' standpoint through questions 1 to 4, even if such questions or indicators have also environmental implications.

Table 2

Items used to evaluate the perception of state forest managers on the performance of selected timber harvesting systems

Question (item)	**Evaluation on a Likert scale***				
	1	**2**	**3**	**4**	**5**
1. Timber harvesting costs are low	…	…	…	…	…
2. Productivity of the harvesting system is high	…	…	…	…	…
3. Fuel and lubricant consumptions are low	…	…	…	…	…
4. Maintenance costs are low	…	…	…	…	…
5. Work force is well trained	…	…	…	…	…
6. Work conditions are safe	…	…	…	…	…
7. Work conditions are ergonomic	…	…	…	…	…
8. Timber harvesting has no impact on the soil	…	…	…	…	…
9. Timber harvesting has no impact on the existing seedling	…	…	…	…	…
10. Timber harvesting does not affect the water resources	…	…	…	…	…
11. Timber harvesting does not affect the slope stability	…	…	…	…	…
12. Timber harvesting does not affect the visual appearance of the landscape	…	…	…	…	…
13. Timber harvesting does not affect the wildlife	…	…	…	…	…
14. Timber harvesting complies to the FSC requirements	…	…	…	…	…
15. This harvesting system is adequate for use in protected areas	…	…	…	…	…
16. I would like that this harvesting system to be used frequently in the forest district in which I am working	…	…	…	…	…
Note: *1 – I strongly disagree, 2 – I disagree, 3 – I don't know, not decided, 4 – I agree, 5 – I strongly agree					

Nevertheless, the forestry practicing personnel tends to associate fuel intake and maintenance with costs rather than environmental impact. The last one is easier to evaluate by them because of its tangible effects such as soil disturbance, damaging of residual trees and seedling etc. which were evaluated based on the questions 8 to 13. Ergonomics, experience of operational personnel and work safety were evaluated using the items 5 to 7. Questions 14 and 15 were designed to evaluate the compliance of the analysed timber harvesting systems with forest certification system predominantly used in Romania [10] as well as with the potential use in forest protected areas since such areas gained a significant importance

nowadays in the Romanian forestry [18]. While the institutional acceptance of different kind of timber harvesting systems may cover almost all of the included items, in this study we used as an indicator only the item no. 14 since the provisions of the forest certification systems need to be obeyed both, by the forest managers selling the wood and by the timber harvesting contractors.
The last item tried to evaluate to a deeper extent the personal, subjective opinion of each respondent relative to the analysed timber harvesting systems.

2.3. Data Processing and Statistical Analysis

Likert scales are used to capture a psychometric response related given subjects' perception. Most commonly, this is implemented as a 5-point scale of ordinal data and for each level on the scale is assigned a numerical value [12]. Therefore, one can use both, parametric or nonparametric tests to evaluate the differences between responses as an effect of perception, but the appropriateness in use of one technique over the other is still debated [24], especially for using parametric tests for ordinal data which is seen as a major problem [14].

Therefore, after sending the questionnaires as word documents to the respondents from all of the Romanian state forest districts, followed by the retrieval of filled in questionnaires (both activities were carried out through the headquarters of the National Forest Administration), data analysis consisted of the following steps:

- Building a database in MS Excel, designed to contain the original information retrieved from the respondents;
- Checking the retrieved data for consistency. This step was required to identify missing data or outliers as well as to refine the dataset to those observations that were complete in terms of information provided;
- Data recategorization that consisted of grouping the responses in two categories after excluding the undecided answers. The two categories were "*I agree*" for those responses categorized as 4 and 5, respectively "*I do not agree*" for those responses categorized as 1 and 2.
- Calculation of shares of agreement and disagreement for each harvesting system and item relative to the total number of valid responses corresponding to each item;
- Grouping of item shares on relevant categories: productivity & costs; training, safety & ergonomics; impact; compliance and personal opinion;
- Graphical representation of the shares per item and per assessment categories using ''radar diagrams" to show the perception trends relative to each harvesting system.

Data checking, refining, analysis as well as all the required calculations were carried out in MS Excel.

3. Results and Discussion

3.1. Number of Questionnaires and Valid Responses

The valid responses included in this study came from 160 Forest Districts and 2 local Forest Management Directorates evenly distributed across the Romania.

However, valid responses used to compute the shares for each of the analysed items varied between 65 and 153. This dataset was obtained after excluding between 1 and 11 responses categorized as 3 - "*I don't know, not decided*".

3.2. Perception on Productivity and Cost

Figure 2 shows the response share on the productive and economic performance of the evaluated timber harvesting systems as perceived by the questioned experts. In terms of productivity, the results clearly indicate that those systems characterized by a very low integration of mechanization (*S1*, *S2* and *S4*) were perceived as being characterized by a low productivity. Such results are in fully backed up by scientific research which indicates productive performances that are low for those timber harvesting systems which integrate the use of animal power for forwarding [13] or for skidding [3], [16]. The respondents ranked correctly the productive performance of chute systems among the evaluated harvesting systems even if such equipment is rarely used in Romania; therefore a practical interaction with it was likely to be absent. The same was true in the case of animal powered forwarding, an extraction system that, in our knowledge is absent in Romania. As the analyzed timber harvesting systems were characterized by higher degrees of mechanization, the respondents' perception was that of increments of productivity. Therefore, those timber harvesting systems characterized by capability to haul increased loads and were additionally characterized by handling capabilities were perceived as being more productive (*S8*, *S9*, *S12*), being in full accord with the general view of productivity increment as a result of mechanization integration [16]. Even if technically constrained to limited loads per turn, cable yarding systems (*S10*, *S11*) were evaluated as being highly productive. More than 80% of the respondents ranked them in this category.

Operational costs were rated as being low by more than 60% of the respondents in the case of both, low and highly mechanized timber harvesting systems. From the first category, the chute system was perceived as being characterized by low operational costs. Probably this was related to the reduced effort to haul the wood as such extraction systems use an infrastructure able to make use of the gravitational energy in sloped terrains [16]. Interestingly, the use of farm tractors for forwarding operations was perceived as a low-cost performing harvesting system by more respondents compared to the traditional winch skidder system. Highly mechanized systems, including also the sledge yarding were also seen as being characterized by low operational costs but this could be in disagreement with the general practice and scientific results [22].

Fuel and lubricants costs depend largely on the type of machine used to extract the wood [17]. From this point of view, the most performant timber harvesting system, as evaluated by the respondents, was that integrating chute logging, probably based on the assumption of using intensively the gravitational energy. In general, the low mechanized harvesting systems were evaluated as being more performant from this point of view, probably on the assumption that fuels and lubricants were used only in tree felling and processing. The lowest maintenance

costs were attributed to harvesting systems *S2*, *S3* and *S4* and more than 70% of the respondents evaluated these systems as being characterized by lower maintenance costs. Such systems are characterized by very low or low levels of mechanization.

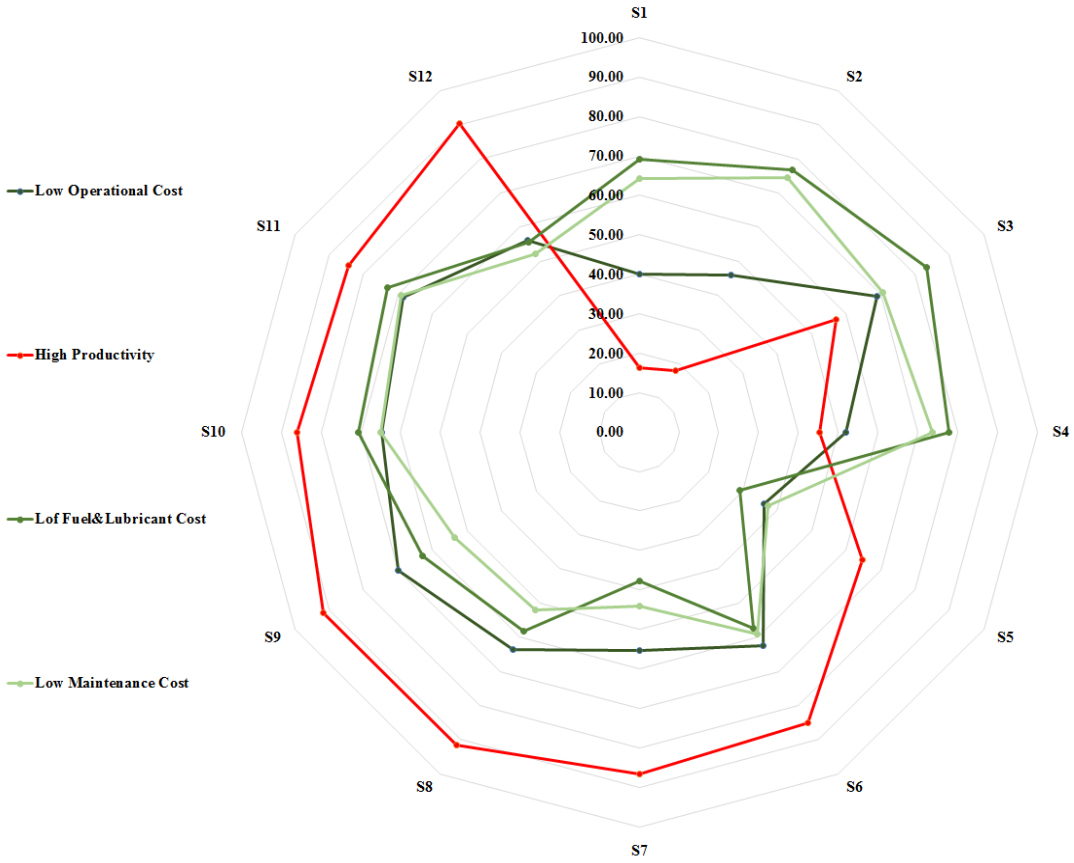

Fig. 2. *Ratings of productivity and costs*

Motor-manual tree felling and processing and farm tractor skidding was evaluated as the least performant in terms of costs. Less than 40% of the respondents agreed that this harvesting system is characterized by low costs (operational, fuel and lubricants, maintenance). There was an evident (direct) relation in terms of productive and cost performance for some of the medium and for all of the highly and very highly mechanized timber harvesting systems, as shown in Figure 2.

3.3. Perception on Ergonomics, Safety and Training

Figure 3 shows the ratings of safety, training and ergonomics of the analyzed timber harvesting systems. Irrespective of the analyzed timber harvesting system, the respondents (>50%) indicated that the personnel working in such harvesting systems is well trained. However, this is, contradictory with the results published in other studies. For instance, [19] found

that one of the current bottlenecks in the wood procurement supply chain is the lack of well trained personnel. Also, field studies indicated that the motor-manual fellers disregard at a high rate the operational procedures in such operations [6], a fact that may have serious implications on the work safety.

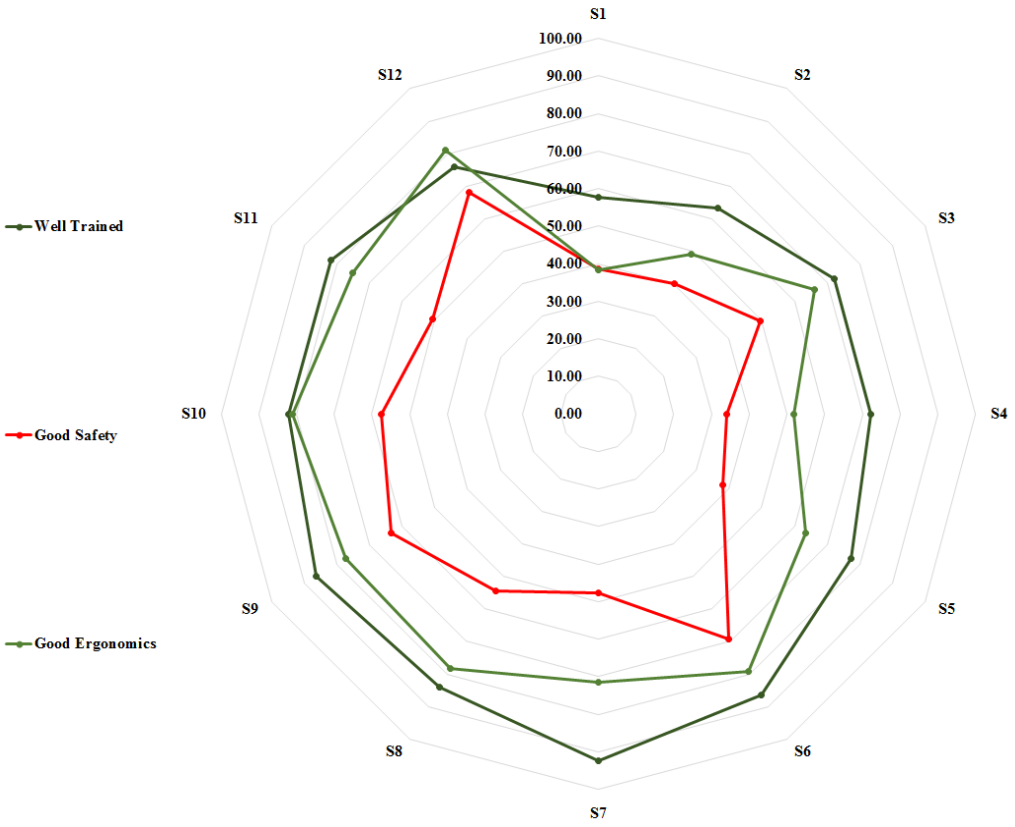

Fig. 3. *Ratings of ergonomics, training and safety*

Nevertheless, it is difficult to evaluate the training of the workers without actually measure or verify key features to indicate how well a given worker is trained. Such evaluations cannot be done solely on the fact that the workers followed training courses. The respondents included *S6* and *S12* among the safest timber harvesting systems (Figure 3). In particular, such systems are characterized by a mechanized handling of wood during parts of the operations. Nevertheless, good ratings were obtained also for the rest of highly mechanized systems, as well as for the chute extraction system. However, those systems that included intensive manual work was evaluated as less safe (*S1*, *S2*, *S4*). This was also the case of farm tractors and sledge yarders. First of them may be characterized by safety problems when deployed in steep terrain, given the usual characteristics of farm tractors which are developed for flat terrain operations. On

the other hand, cable yarding systems are known for their work-related safety issues [16]. Serious issues in terms of ergonomics were found in the case of those timber harvesting systems using exclusively manual labor into the hauling operations. Such results are supported by the scientific literature given the fact that manual labor into the forest is heavy. Often, people that carry on manual work are required to take uncomfortable work postures [8] and to walk significant distances over a working day. For instance, in horse skidding operations, work tasks include manual bunching and supervising the horses during the loaded and empty turns [16]. Such tasks involve worker movements along the extraction paths that may cover high distances [3]. Then, manual bunching, load attachment and detachment include back bending and (or) kneeling. Animal forwarding includes also manual loading of wood pieces on the horses, a fact that involves movement of heavy loads at a considerable height. Manual sliding of wood involves also the use of a considerable force to exert by the workers.

3.4. Perception on Environmental Performance

Lately, the environmental impact of timber harvesting systems has gained a lot of consideration in the forest engineering research and practice. In particular, the ground-based timber harvesting systems are among those impacting the soil, seedling and water resources. An extensive development of skidding roads may affect the stability of slopes in steep terrain and it can cause changes in the visual aspect of the landscape [16].

Figure 4 shows the perceptions of the respondents in terms of environmental performance of the analyzed timber harvesting systems. Impact on the soil was perceived as being the highest in the case of mechanized (*S5* and *S7*) and animal skidding (*S2*). Truly, the mechanized skidding equipment requires often bladed skid roads, especially in steep terrain [3], a fact that has an effect mostly by triggering erosion processes [7]. Also, animal skidding may impact the soil when the wood is dragged on the soil. Nevertheless, the effects of erosion are easier to see compared with that of compaction. Therefore, the evaluation of the three harvesting systems as causing a greater soil impact is not arbitrary, since such systems are often seen in the Romanian forest operations. Chute logging system was evaluated as being the best in terms of soil impact. Obviously, this is the effect of perceiving the soil protection by the extraction infrastructure itself which acts as an interface between the soil and the transported wood.

Small-scale forwarding technology was also evaluated among the most effective soil protection harvesting systems, as well as both of the analyzed cable yarding systems. This was quite opposite to the harvester-forwarder system that could have been perceived in terms of machine size. Nevertheless, in terms of soil impact, the harvester-forwarder system seemed to be preferred compared to those involving skidding.

The evaluation in terms of impact on the existing seedling, water, slope and landscape, followed almost the same pattern as in the case of soil impact (Figure 4). The impact on the wildlife was evaluated as being the lowest in the case of very low and low mechanized

harvesting systems (*S1-S3*). Obviously, such systems do not make the use of engines in hauling operations and, probably, fit better in the forestry landscape. From the environmental performance standpoint, timber harvesting systems *S3* and *S6* seemed to keep a relative uniformity of perception indicating the highest scores of low impacts.

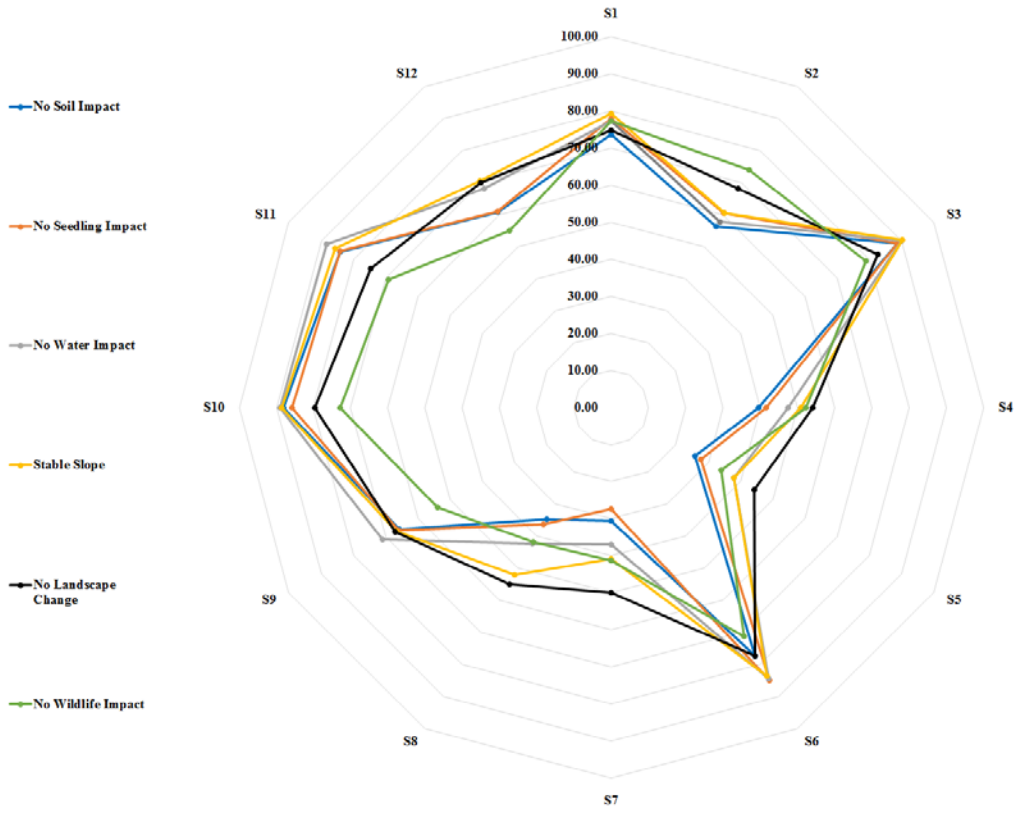

Fig. 4. *Ratings of environmental impact*

3.5. Compliance to FSC Standards, Effectiveness in Protected Areas and Personal Acceptance

Figure 5 shows the response rates related to the questions of FSC compliance, effectiveness for protected areas and personal acceptance. FSC compliance and effectiveness for protected areas were evaluated as personal perceptions based on the respondents' experience in such endeavors.

Cable yarding and chute systems were sought to be amongst the best fits to the FSC standards. From this point of view, the lowest score was attributed to the manual sliding of wood, followed by those systems involving animal and mechanical skidding. A similar response was obtained when evaluating the effectiveness for use in protected areas. Even if the timber

harvesting system *S1* was among those complying to FSC standards and it was adequate for use in protected areas, in terms of personal preferences it was the least appreciated. Probably this is correlated to the perception of a low productivity, poorer safety and ergonomics conditions and limited capability to extract wood in higher lengths. Manual sliding of wood was the next in the personal preferences, probably for the same reasons. As a rule, the very low and low mechanized timber harvesting systems were not amongst the first options of the respondents. Probably, their experience related to smaller productivities and timing of forest operations affected their personal preferences. Among the best evaluated harvesting systems in terms of preference was the systems *S6*. Indeed, farm tractors working as forwarders can be adapted to a wide range of operational conditions and they can be quite productive. The same was true in the case of coupling motor-manual tree felling and processing with forwarding using specialized forwarders, a solution that is used increasingly frequent in Romania. Cable yarding systems were amongst the top preferences but some of them require gravitational setups. On such reasons, it is possible for some of the respondents coming from flat-lands forest districts not to see the utility of such harvesting systems in their working areas.

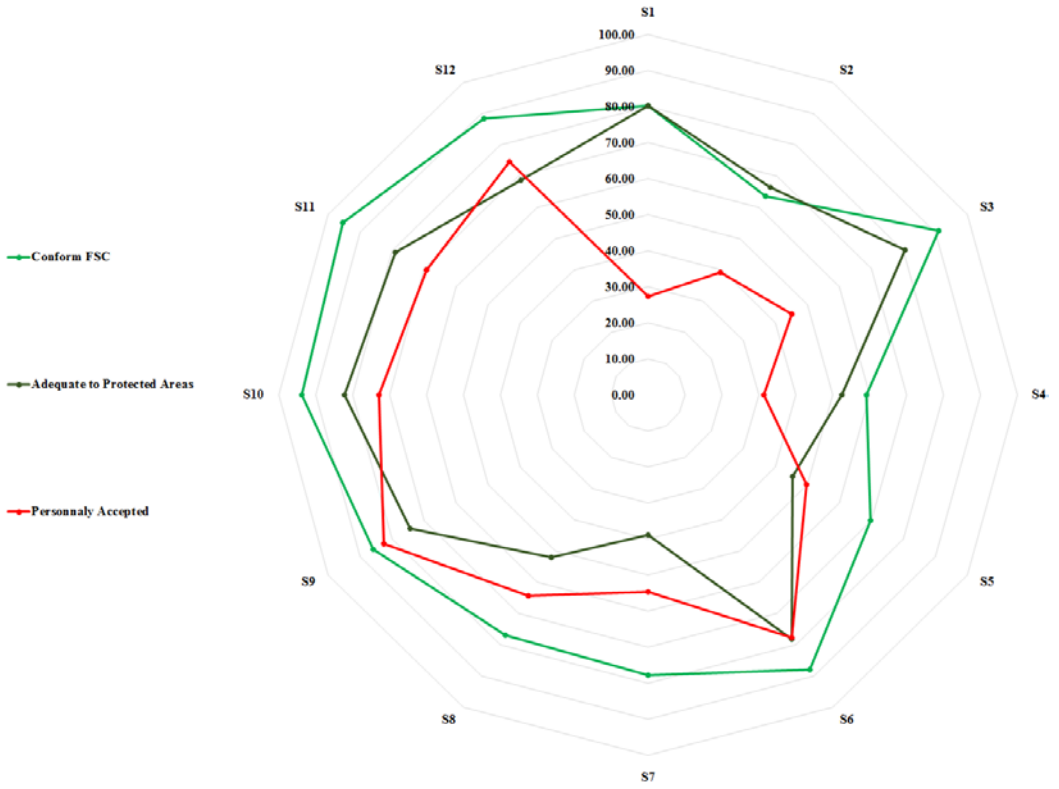

Fig. 5. *Ratings of compliance and personal preference*

3.6. The Ideal Timber Harvesting System Based on Respondents' Perception

Figure 6 shows a summary of perception on timber harvesting systems taken into study. As shown, most of the respondents believed that higher productivities are related to the increasing mechanization levels. Harvesting systems including winch skidders were perceived as being characterized by low costs in fewer cases compared to the rest of the analyzed harvesting systems. It was also the case of the harvester-forwarder system. Cable yarding and chute logging were ranked amongst the cheapest timber harvesting systems.

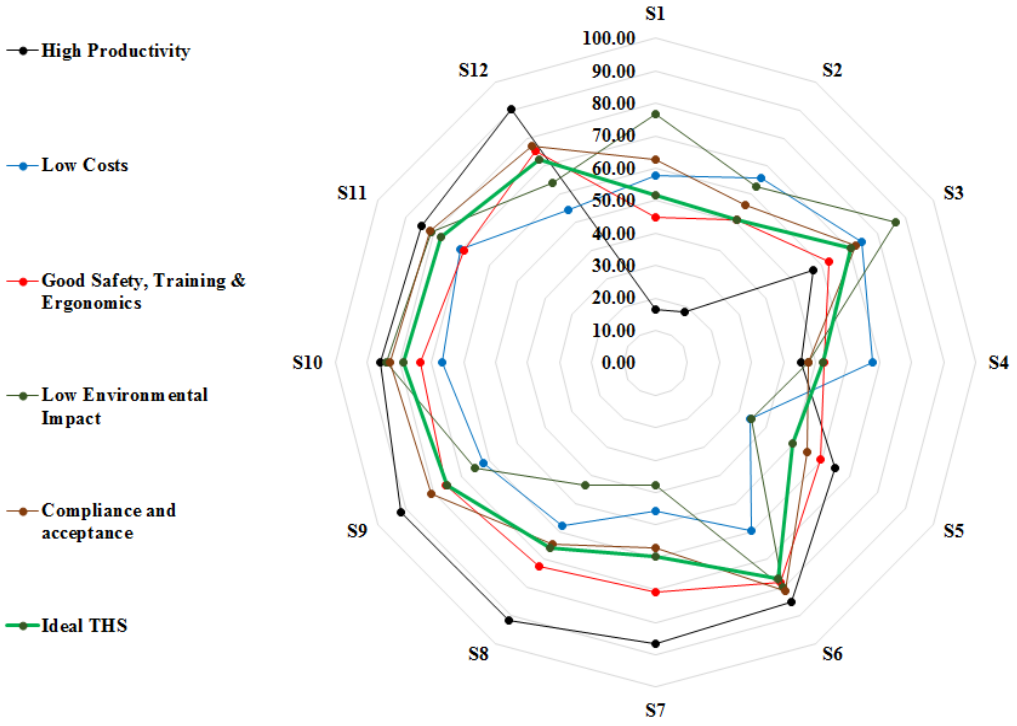

Fig. 6. *The ideal timber harvesting system as seen by the state forest managers*

The ideal timber harvesting system was developed based on the average scores per categories and per study. Timber harvesting systems *S10*, *S11*, *S6*, *S9*, *S12* and *S3* were rated in the first half of preferences. *S10* seemed to be the ideal timber harvesting system, meaning that tower yarders were the most preferred. Nevertheless, their use is still technically limited in Romania due to the lack of forest roads [5]. Next in line were the harvesting systems that supposed the use of sledge yarders. Such systems are able to operate on distances of up to 2000 m [16] and they could be seen as a good option for steep terrain harvesting in Romania.

Those systems that included forwarding were also located among the top preferences of the respondents (*S9* and *S12*), being closely followed by chute system.

4. Conclusion

This study evaluated the perception of state forest managers on the use of various timber harvesting systems. Contrary to expectations, the mechanized harvesting systems were rated as highly preferred. In particular, cable systems were among the first preferences of the respondents, being followed by those systems involving forwarding operations. From the low-mechanization systems chute logging seemed to be among the top preferences of the respondents.

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References

1. Borz, S.A., 2004. Evaluarea eficienței echipamentelor și a sistemelor tehnice în operațiunile forestiere (Evaluation of equipment and technical systems' efficiency in forest operations). Lux Libris Publishing House, Braşov, Romania.
2. Borz, S.A., 2015. A review of Romanian and international practices in skidding operations. In: World Forestry Congress, Durban, South Africa, 7-11 September 2015, 11 p.
3. Borz, S.A., Ciobanu, V.D., 2013. Efficiency of motor-manual felling and horse logging in small-scale firewood production. In: African Journal of Agricultural Research, vol. 5(22), pp. 3108-3115.
4. Borz S.A., Popa B., 2014. The use of time studies in Romanian forestry: importance, achievements and future. In: Bulletin of the Transilvania University of Braşov, Series II, vol. 7(56), no. 1, pp. 1-6.
5. Borz, S.A., Bîrda, M., Ignea, Gh. et al., 2014. Efficiency of a Woody 60 processor attached to a Mounty 4100 tower yarder when processing coniferous timber from thinning operations. In: Annals of Forest Research, vol. 57(2), pp. 333-345.
6. Borz, S.A., Ignea, G., Vasilescu, M.M., 2014. Small Gains in Wood Recovery Rate when Disobeying the Recommended Motor-Manual Tree Felling Procedures: Another Reason to Use the Proper Technical Prescriptions. In: Bioresources, vol. 9(4), pp. 6938-6949.
7. Borz, S.A., Ignea, Gh., Popa, B. et al., 2015. Estimating time consumption and productivity of roundwood skidding in group shelterwood system - a case study in a broadleaved mixed stand located in reduced accessibility conditions. In: Croatian Journal of Forest Engineering, vol. 36(1), pp. 137-146.
8. Corella Justavino, F., Jimenez Ramirez, R., Meza Perez, N. et al., 2015. The use

of *OWAS* in forest operations postural assessment: Advantages and limitations. In: Bulletin of the Transilvania University of Braşov, Series II, vol. 8(57), no. 2, pp. 7-16.
9. European Commission, 2014. A New Strategy of EU for forests and forestry sector.
10. Hălălişan, A.F., Enescu, R.E., 2015. Procesul de certificare a managementului forestier în România (The Certification Process of Forest Management in Romania). In: Revista Pădurilor, no. 3-4, pp. 37-42.
11. Heinimann, H.R., 2007. Forest operations engineering and management - the ways behind and ahead of a scientific discipline. In: Croatian Journal of Forest Engineering, vol. 28(1), pp. 107-121.
12. Jamieson, S., 2004. Likert scales: how to (ab)use them. In: Medical Education, vol. 38, pp. 1217-1218.
13. Jourgholami, M., Majnounian, B., Feghhi, J. et al., 2010. Timber extraction with mules: A case study in the Hyrcanian Forest. In: African Journal of Agricultural Research, vol. 5(22), pp. 3108-3115.
14. Kuzon, W.M., Urbanchek, M.G., McCabe, S., 1996. The seven deadly sins of statistical analysis. In: Annals of Plastic Surgery, vol. 37, pp. 265-272.
15. Moskalik, T., Borz, S.A., Dvorak, J. et al. 2017. Timber harvesting methods in Eastern European countries: a review. In: Croatian Journal of Forest Engineering, vol. 38(2), pp. 231-241.
16. Oprea, I., 2008. Tehnologia exploatării lemnului (Timber harvesting technology). Transilvania University Press, Braşov, Romania.
17. Oprea, I., Borz, S.A., 2007. Organizarea șantierului de exploatare a lemnului: îndrumar de proiect (Organization of Timber Harvesting Sites). Transilvania University Press, Braşov, Romania.
18. Popa, B., Pascu, M., Niţă, M.D. et al., 2013. Value of forest ecosystem services in Romanian protected areas – a comparative analysis of management scenarios. In: Bulletin of the Transilvania University of Braşov, Serie II, vol. 6(55), no. 2, pp. 53-62.
19. Rauch, P., Wolfsmayr, U.J., Borz, S.A. et al., 2015. SWOT analysis and strategy development for forest fuel supply chains in South East Europe. In: Forest Policy and Economics, vol. 61, pp. 87-94.
20. Sbera, I., 2007. Resursele de lemn şI potențialul pieței din România (Wood resources and the market potential in Romania. In: Meridiane Forestiere, no. 2, pp. 3-7.
21. Spinelli, R., Schweier, J., de Francesco, F., 2012. Harvesting techniques for non-industrial biomass-plantations. In: Biosystems Engineering, vol. 113(4), pp. 319-324.
22. Spinelli, R., Visser, R., Thees, O. et al., 2015. Cable logging contract rates in the Alps: the effect of regional variability and technical constraints. In: Croatian Journal of Forest Engineering, vol. 36, pp. 195-203.
23. Vusić, D., Šušnjar, M., Marchi, E. et al., 2013. Skidding operations in thinning and shelterwood cut of mixed stands - Work productivity, energy inputs and emissions. In: Ecological Engineering, vol. 61, pp. 216-223.

24. Wadgave, U., Khairnar, M.R., 2016. Parametric tests for Likert scale: For and against. In: Asian Journal of Psychiatry, vol. 24, pp. 67-68.

25. ***, 2018. The National Forest Inventory. Available at: http://roifn.ro/site/rezultate-ifn-1/, accessed: 10.01.2018.