

**Original Scientific paper**  
10.7251/AGRENG2101108T  
UDC 630\*28(498)

## **IMPLEMENTING THE HIERARCHY-ANALYTIC PROCESS WITHIN FOREST FRUITS FROM MURE COUNTY, ROMANIA**

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### **ABSTRACT**

Romanian forest ecosystems prove their true value through the complex diversity they offer. Varied relief forms, site conditions, temperate climate and the stand composition and structure elements sustain the apparition of vegetation layers and their population with diverse forest species that accentuate biodiversity. The economy from Romania’s forest area is improved by the increased potential of harvesting a limited number of wood or non-wood products in order to ensure the population’s needs and wellbeing. The activity of trading forest goods is encouraged by the maintenance of a good collaboration with international companies. The purpose of the present research is to analyse the most appreciated forest fruits from Mure County, Rom ănia. A total number of eight forest fruits were selected from the non-wood products category and were distributed in the following classes: achene (acorn, hazelnut), false fruits (rosehip), pluri-drupes (raspberry, wild strawberry), pseudo-beny (pulp cones from *Juniperus* L Genus.), drupes (*Prunus* Genus) and benyform drupes (black elder). The analytic hierarchy process was used in the evaluation of the qualitative and quantitative criteria. Based on it, eight alternatives were attributed to each analysed fruit using 19 evaluation criteria. The Expert Choice Desktop software was used in order to emphasize the performance efficiency. As such, the most valuable forest fruits from this area proved to be *Rosa canina*, *Rubus idaeus* and *Fragaria vesca*. In regard for the harvesting of non-wood products, managers from the forest sector must take into account analyses that can evaluate the offered economic potential, especially in particular cases.

**Keywords:** *analytic hierarchy process (AHP), Expert Choice Desktop, harvesting period, market, forest fruits.*

### **INTRODUCTION**

In some rural locations of Finland, the harvesting of edible mushrooms is used as an activity of recreation, supplying some small markets or for home consumption, being also a good income for disadvantaged rural inhabitants (Cai *et al.*, 2011).

In Africa, at the XIV World Forestry Congress in Durban, the forest resources were defined as multiple products which are indivisible in creating an evidence for

different investments in energy, lands or payments for environmental purposes (FAO, 2015). In some particular cases, some specific conglomerates from institutional structures have impacts in non-wood forest products innovations (Ludvig *et al.*, 2016). The variety of non wood forest products constituted from fruits (mushrooms, nuts etc), spices, herbs, medicinal plants or game were used for human wellbeing, assuring food, medicine and cultural or social demands for millennia, but today it is an evidence that these resources are underestimated because of the poorly information introduced in the international statistics (Sorrenti, 2017). For the advance of European bioeconomy, the non-wood forest products bring a specific attention in the public debate, being a part of changing something in their lifestyle. In some regions where the wood is not so demanded, non-wood forest products seems to bring a great potential in economies from rural populations, assuring viability and profitability in social and economic environment (Huber *et al.*, 2019).

Romania owns besides wood raw material, a considerable quantity of non-wood forest products which are introduced and commercialized especially on the external market (Brag and Dinc , 2019). Furthermore, Romania owns large areas with native species (maple, ash, sycamore, wild service tree) which are appreciated for its high quality of wood (Dinc and Dinc , 2019). The aim of the study is to emphasize the most important forest fruits from Mure County and the examine the modalities which can improve the harvesting management.

The total surface of Mure County is of 6.714 km<sup>2</sup> (figure 1) which represent 2,8% from the total surface of Romania. It is situated in the centre of Romania, the name coming from the river with the same name, Mure , which cross the county from the northeast at southwest. This county is characterized by the hilly and hilly plateau relief in a proportion of 50% from surface and the other half includes the Transylvanian Subcarpathian hills and the presence of C limani-Gurghiu volcanic mountains. In 2018, the total forest fund surface was of 220 thousand hectares, from which 213.6 thousand hectares represents the forest surface and 6.4 thousand hectares include another lands. In the same year, the land surface in which were executed artificial regenerations was about 295 hectares, from which 182 hectares were planted with seedlings of softwood species and 113 hectares using seedlings with hardwood species (<https://mures.insse.ro/>).

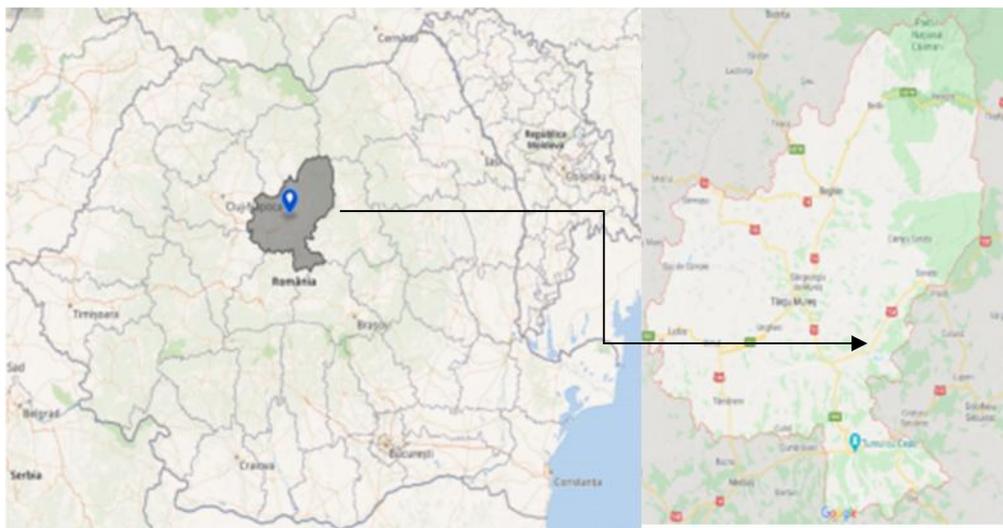


Figure 1. Study area Mureș County (source: [www.wikipedia.org](http://www.wikipedia.org))

## MATERIAL AND METHODS

The most widespread non-wood products, namely forest fruits were highlighted in some databases collected within the forest districts from this county, reports and documents of some projects implemented in the annual process of utilization. As methods, it was utilized the analytical hierarchy process (AHP), which was presented in COST 1203 action (European non-wood forest products network). This process bring an advanced analysis for evaluating the potential of forests fruits using 19 specific criteria and 8 types of alternatives promoted by the decision making process. The analytical hierarchy process was developed in 2008, by the expert Thomas Saaty, including the sequence of some “sub problems” that can be analyzed and resolved by independency (Saaty, 2008; Dinc *et al.*, 2020). The best decisions can be obtained by using this method, being a structured technique which has implications in psychology and mathematics. AHP model makes decision makers to find the solutions of the ”sub problems” choosing one of the best decisions which suits their goal and understanding.

There are few steps for comprising the decision problem:

- 1) the decision problem must be decomposed into a hierarchy of more easily division of sub-problems;
- 2) evaluating the elements of hierarchy and comparing them to each other two (pairwise comparison) at a time;
- 3) converting all of these evaluations to numerical values that can be processed and compared over the full range of the problem;
- 4) calculating the numerical priorities for each decision alternative.

This analysis include the 19-well established multi-criteria (table 1) such as: I) harvesting period, II) harvested quantity/ worker/8 hours, III) harvesting cost, IV) knowledge for harvesting, V) tools needed for harvesting, VI) complexity of the harvesting process, VII) development of the harvesting process, VIII) knowledge

for recognition, IX) distribution range, X) biotic threats, XI) abiotic threats, XII) perishability, XIII) market potential, XIV) market demand, XV) “celebrity” of the product on market, XVI) the price of the raw product, XVII) the price of the derived product, XVIII) portfolio of derived products and XIX) Transport (harvesting->storage centre). Each criterion have been evaluated by using a scale formed by arabic numbers summarized in the interval of (1...8), which represent the intensity of importance attributed for alternatives, alternative number 1 having equal importance (two actions contribute in equal mode for the same objective) and alternative number 8 having very strong importance intensity. However, for estimating the sensivity of the forest fruits it was used the Expert Choice Desktop software bringing the results about the importance of these fruits.

This kind of analysis was implemented in other similar studies from different counties of Romania, such as: Dolj (Cântar *et al.*, 2018), Bihor (Timi -Gânsac *et al.*, 2018), Gorj (Vechiu *et al.*, 2018), Arad (Ple ca *et al.*, 2019), Bacau (Blaga *et al.*, 2019), Dâmbovița (Brag and Dinc , 2019), Vrancea (Tudor and Dinc , 2019), Satu-Mare (Tudor *et al.*, 2019).

## RESULTS AND DISCUSSION

Based on the AHP we founded that the most demanded forest fruits classified by the intensity of importance are in order: rosehips (*Rosa canina*), raspberries (*Rubus idaeus*), wild strawberries (*Fragaria vesca*), hazelnuts (*Corylus avellana*), acorns (*Quercus sp.*), pulp cones (*Juniperus sp.*), bird cherries (*Prunus padus*) and elder berries (*Sambucus nigra*). The analysis was approved by the votes of 3 specialists who evaluated the actual contribution of each fruit and the behavior manifested in harvesting management. A very strong intensity of importance (figure 2) it was obtained in the case of rosehips, which is related to the range of distribution, harvesting and transporting operations (criterion 1, 3, 7, 9, 19). Harvesting periods of fruits are very important to be acknowledged, because if is not done in the perfect moment, the value of the fruit cannot be evaluated at the maximum potential. What is important to know is that the harvesting operations of forest fruits must be executed is the right moment of maturation (Vasile *et al.*, 2016). Rosehips are appreciated for their culinary and pharmaceutical properties, being rich in vitamins (\*C-1%) ( ofletea and Curtu, 2007). Raspberries and wild strawberries bring good results in the market including all the criteria regarding on demand and potential market, the multitude of derived products, raspberries being considered the ”Celebrity” of the product on market (criterion 13, 14, 15, 16, 17, 18, 19). Also, both of them are very perishable and sensible to the biotic and abiotic threats. Hazelnuts have a good distribution range in Mures county and for harvesting, many tools are needed. The market demand is increasing, being cheaper than other forest fruits and more resistant at the negative action of risky factors, because of the wood shell and the huge capacity of drying. Pulp cones from *Juniperus* Genus require to have a good knowledge for harvesting and recognition (criterion 4, 8). The pseudo-beny are appreciated very well in pharmacology, being diuretics, diaphoretic and hypnotic. Bird cherries bring a good intensity of

importance in knowledge for harvesting process and also for recognition. Bird cherry have an amazing ornamental and the fruits are black, bitter, shiny and inedible ( ofletea and Curtu, 2007).

Table 1. AHP alternative ranking (Mure County)

Criterion	Berries								
	<i>Rosa canina</i>	<i>Quercus</i> sp.	<i>Rubus idaeus</i>	<i>Fragaria vesca</i>	<i>Juniperus</i> sp.	<i>Prunus padus</i>	<i>Corylus collurna</i>	<i>Sambucus nigra</i>	
1	Harvesting period	8	7	4	1	5	3	6	2
2	Harvested quantity / worker / 8 hours	7	8	6	1	4	3	5	2
3	Harvesting cost	8	7	3	1	5	4	6	2
4	Knowledge for harvesting	5	6	1	2	8	7	4	3
5	Tools needed for harvesting	6	7	3	2	5	4	8	1
6	Complexity of harvesting process	4	8	3	1	5	7	6	2
7	Development of harvesting process	8	5	1	2	4	6	7	3
8	Knowledge for recognition	4	6	1	2	7	8	5	3
9	Distribution range	8	6	5	3	4	1	7	2
10	Biotic threats	5	6	7	8	1	2	3	4
11	Abiotic threats	3	5	7	8	1	2	4	6
12	Perishability	6	2	8	7	4	5	1	3
13	Market potential	5	1	8	7	3	2	6	4
14	Market demand	5	1	7	6	2	3	8	4
15	“Celebrity” of the product on market	6	1	8	7	3	2	5	4
16	The price of raw product	4	2	7	8	5	1	6	3
17	The price of the derived products	5	1	7	8	3	2	6	4
18	Portfolio of derived products	6	1	8	7	3	2	5	4
19	Transport (harvesting - storage center)	8	1	7	6	4	5	2	3

The higher mean (6) was obtained in the case of dog rose fruits (*Rosa canina*) because of the very strong importance intensity abundance in most of the criteria (figure 3) and the lower mean (3) was registered in the case of elder berry fruits (*Sambucus nigra*).

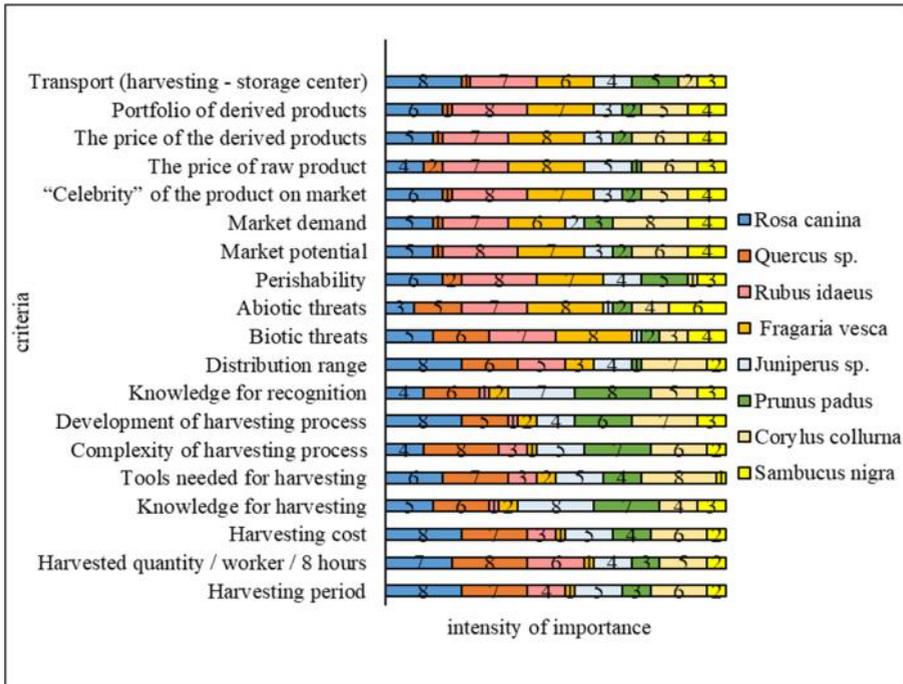


Figure 2. The intensity of importance for each criterion distributed on species

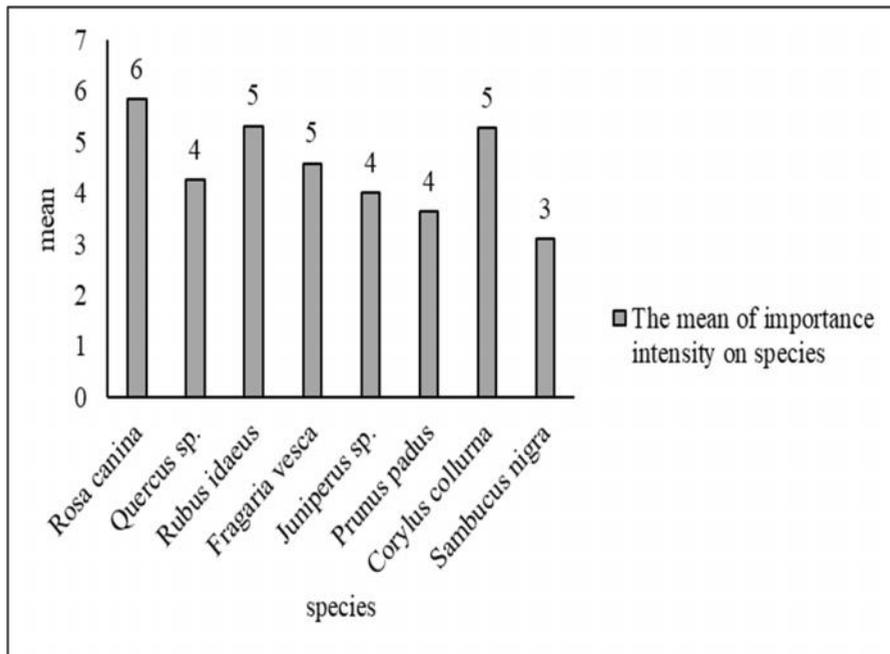


Figure 3. The mean of the importance intensity for each forest fruits species

The diagram of sensitivity (figure 4) showing that the best results are attained by the dog rose (*Rosa canina*) being on the first place in the hierarchy because of the uses multitude and which manifest a lot of requirements regarding on harvesting process. The elderberry, instead of the fact that is easy to be recognized and harvested, he is situated below in hierarchy bringing equal, slightly or weak importance.

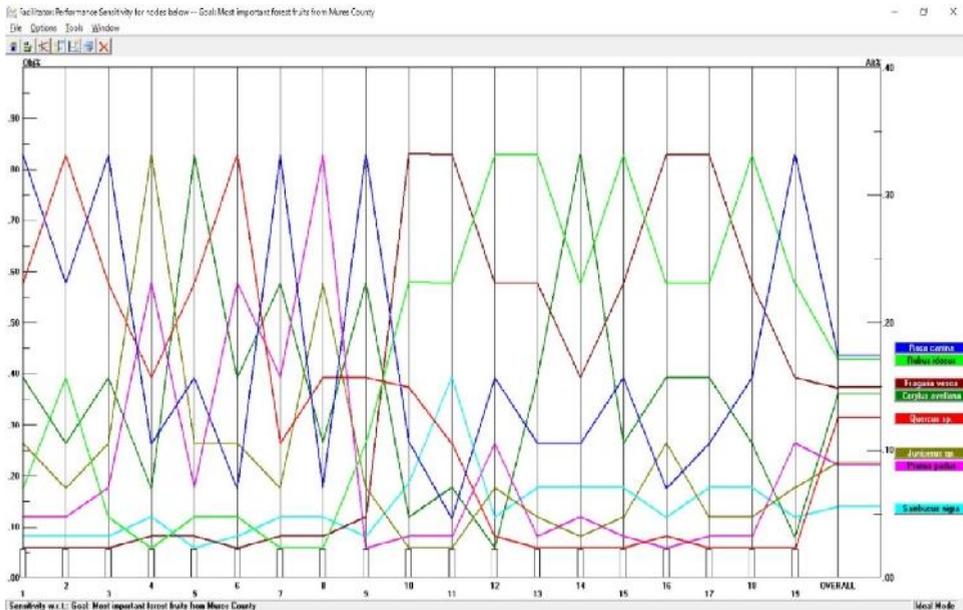


Figure 4. Diagram of performance sensitivity in AHP ranking

The AHP was developed in positioning the non-wood forest product and evaluating the importance, especially on forest fruits, such as in the study carried by Enescu *et al.*, 2017, in Maramures County, has positioned the raspberries on the first place in terms of importance, being very well represented in the external market (criterion 13, 14). In another study carried also by Enescu *et al.*, 2018, in Timis County, according to AHP test, has situated *Boletus* Genus being the most promising and representative from the hierarchy, registering the very strong importance intensity in 8 types of criteria from the total of 19. In Bihor county, in the study carried by Timi -Gânsac *et al.*, 2018, from the category of mushrooms, the truffles were the most important non-wood forest products receiving an equal importance in all the 19 well established criteria. In the study carried by Brag and Dinc , 2019, it was found that in Dâmbovită county, using the AHP, the most important forest fruits are raspberries, wild service tree fruits, dog rose and wild strawberry.

## CONCLUSIONS

The variety of non-wood forest products constituted from forest fruits (mushrooms, nuts etc), spices, herbs, medicinal plants or game were used for human wellbeing, assuring food, medicine and cultural or social demands for millennia. The AHP method shows the importance of the most promising forest fruits included in the accessory products category, as well as the way of improving the sustainable management in Mure County. According to the analysis implemented through AHP methodology, the most important forest fruits for this region are dog rose (*Rosa canina*), raspberries (*Rubus idaeus*), wild strawberries (*Fragaria vesca*) and hazelnuts (*Corylus avellana*). The results indicate that the study bring a lot of useful information about the way of exploiting the forest fruits, what kind of decision can be taken to implement an good harvesting management and how to build some strategies to improve the development of the economy in the rural areas by using the workforce of the local people favoring the positive effect for an sustainable management.

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