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Expert-Based Assessment of the Potential of Agroforestry Systems in Plain Regions across Bihor County, Western Romania

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Abstract: Agroforestry systems are gaining increasing attention worldwide due to their several benefits both for landowners and also for the environment. Even though Romania has a great potential for adopting these systems on a large scale, only a few examples exist. The aim of this research was to highlight the main agroforestry systems that could be introduced in plain regions across Bihor County, Western Romania. A selection of the most suitable woody species and cereals was carried, based on available data and information. In order to select the most suitable combination, a set of eight criteria was considered and an Analytical Hierarchy Process Analysis was performed, with the aid of the Expert Choice Desktop (v. 11.5.1683) software package. The combinations that had the black locust as the main tree species scored better in comparison with the ones that had pedunculate oak as a main species. This research should be regarded as a first and important step in the analysis of several combinations of agroforestry systems that could be implemented across plain regions of Bihor County. Lastly, this proposed model could be replicated in similar studies aimed at selecting the most suitable agroforestry systems for certain sites. Future research should also consider criteria that account for various aspects, including the functional relationships of these future green spaces with nearby areas.

Keywords: Analytical Hierarchy Process; black locust; green spaces; land management; maize; pedunculate oak; sunflower

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1. Introduction

Agroforestry (AF) systems include several land-use practices in which agricultural crops or pasture are integrated with woody plants (both tree and shrub species), which are regarded as an important component of agricultural land development [1,2].

There are several categories of common agroforestry practices worldwide and also in Europe [3–5] such as wood pastures, riparian buffer strips, hedgerows, windbreaks, grazed forests, intercropped and grazed orchards, forest farming and more novel silvoarable and silvopastoral practices and systems such as alley coppice, alley cropping and woodland chicken [6]. All these practices have the combination of trees and shrubs with crops and/or livestock in common, offering an integrated land-use system to landowners [7,8].

As this study is focused on agroforestry systems in Bihor County (Western Romania), an overview of the current practices across Europe is required to emphasis its relevance. The development of AF systems in Europe did not take off until now because of the different regulatory systems of the member states and a lack of knowledge on this issue that could enforce more EU regulation. In the European Union, agroforestry is mainly supported through the Common Agriculture Policy (CAP) [9]. The practices of the CAP in the 20th century discouraged agroforestry practices as CAP payments for crops or pastures were often reduced for parcels with scattered trees [10]. But as time passed, land-users and policymakers needed to adapt the CAP to the EU's climate agenda and to the growing enthusiasm in agroforestry around the world, including North America. Therefore, there has been a remarkable turn-around in the perception of the role and importance of trees on farmlands during the past two decades [10].

According to Burgess and Rosati [11], there are two CAP mechanisms for farm support in the EU: direct payments in Pillar I, which is completely financed by the European Commission, and payments that support rural development in Pillar II, whose measures have to be co-financed by the member states. However, different national legal constrains are slowing down the fund uptake for agroforestry systems. For examples, German farmers claiming Pillar I payments need to subdivide agroforestry areas into area containing trees and areas which do not have trees [12]. The possibility of registering the land as agroforestry would reduce bureaucracy and would allow farmers to operate more efficiently. There are also issues regarding the support for the maintenance of lone trees and hedgerows within rural development programs. The difficulties in monitoring the extent and quality of lone trees and hedgerows make payments in Pillar I difficult [13]. Within Pillar II there is one specific agroforestry measure in which the funds are dedicated for this kind of projects, and other 27 measures that may support agroforestry systems to some extent. Therefore, the recognition of agroforestry would be increased if the measures were collated together in one place.

Recently, due to its several benefits as many scientific studies have revealed, agroforestry has gained an increasing interest worldwide, including in Europe [14–17]. For example, within the recently adopted Common Agricultural Policy 2023-27, which entered into force on the 1 January 2023, agroforestry will be supported directly by four countries, namely Portugal, Germany, Greece and the Czech Republic, and indirectly through the support of landscape features from seventeen European countries, including Romania [18]. The higher importance of agroforestry in the CAP 2023-27 can also be understood as a mechanism to reach the objectives of the European Green Deal as agroforestry could increase carbon sequestration alongside cover crops. Therefore, the recent developments within the EU Green Deal show that the European Commission is realizing the potential of agroforestry and tries to take advantage of it.

Considering the fact that AF systems are a sustainable land management option that delivers market and non-market goods and services and the increasing support from the CAP programs, governments need to develop policies and actions that foster agroforestry within an EU policy framework [19]. In addition, a European AF strategy is needed to provide a proper framework that is recognized by the member states, although, the implementation of such strategy would require knowledge of these types of practices at the European level [19].

Besides the Common Agricultural Policy, agroforestry is a key element in other EU policy areas as it is reflected in the following strategies: the Farm to Fork Strategy, 2030, and the Biodiversity Strategy and EU Forest Strategy for 2030. The Farm to Fork Strategy (F2F) addresses the challenges of sustainable food systems, setting ambitions such as reducing the use and risk of chemical pesticides by 50%, decreasing the use of fertilizers by 20% and decreasing nutrient losses by 50%, having at least 25% of the EU's agricultural land under organic farming, or reducing EU sales of antimicrobials for farmed animals and in aquaculture by 50%, all of which aim to be achieved by 2030 [20]. All these objectives will need nature-based solutions and, along with storing carbon in soil, emphasize agroforestry as one of the most important tools.

The 2030 Biodiversity Strategy aims towards the protection and restauration of nature and putting the biodiversity on the path to recovery by 2030. The objectives of this strategy are to halt and reverse the decline of farmland birds and insects, halt soil degradation and to plant 3 billion trees by 2030 [21]. Thus, the 2030 Biodiversity Strategy strongly focus on making agriculture more nature-inclusive and nature-friendly, and mentions agroforestry as being a key tool [21]. The EU Forest Strategy for 2030 is more action-oriented and tries to accelerate the roll out of carbon farming practices through eco-schemes on agroforestry or rural development interventions and to boost research and innovation on agroforestry systems and other trees outside the forests [22].

Considering the new European developments on agroforestry, such as the CAP 2023-27 or the Forest and Biodiversity strategies, Romania has the potential to become one of the most important actors on the continent. Forest shelterbelts, grasslands with sparse trees, alley cropping, orchard meadows for both fodder and fruit production or even home-gardening are among the most common agroforestry systems worldwide and also in Romania [23–28].

These combinations of agricultural crops and forest plantations generate a broad range of benefits, such as: the development of rural communities and farms due to a sustainable production and livelihood improvement [29–33], increased biodiversity and biological control of the pests [34,35], improved and healthier soils [36,37], food production [38,39], carbon sequestration [1,40] and a veritable strategy to fight against changing climatic conditions. It was recently reported [41] that most of these benefits could be also provided by promoting agroecology techniques. In all these cases, special attention should also be given to water resource management which is critical for sustainable development of any type of social–ecological system [42].

In Romania, with the exception of field-protective forest shelterbelts that had their highest expansion during the middle of the last century, agroforestry systems represent a new concept, that is not perceived, for example, as an independent science [43]. In regards to the forest sector, the focus is on the natural regeneration of the stands and the maintenance of the composition of the stands as close as possible to the composition of natural forest types; by limiting the introduction of allochthonous tree or shrub species, for example [44]. In this context, in the last two decades, the areas afforested at national level decreased significantly [45]. But, by taking also into consideration the circular-bioeconomy transition which interferes with the forest sector [46], and the uneven distribution of forest lands across Romania, with the lowest presence in plain regions, of about 6.5% [47], we consider that agroforestry systems will play a significant role in rural development in several counties across Romania, especially in plain regions.

The aim of this study was to highlight one of the most important agroforestry systems that could be implemented in plain regions across Bihor County.

2. Materials and Methods

2.1. Study Design and Case Description

Bihor County (Figure 1) is situated in the north-western part of Romania, it has all the types of relief units, with an altitude ranging from 90 m a.s.l. (Ateaș-Cefa area) to 1849 m a.s.l. in the Bihorului Mountains. In this relief context, in regard to the forest land, Luvisoils and Cambisols are the representative soil classes. Luvisols (25%), eutric cambisols (22%), dystric cambisols (20%), preluvisols (17%) and entic podzols (5%) represent the most common forest soil types in Bihor County [48]. Across the county, 205,800 hectares are occupied by forests (around 27% of the total area of Bihor), of which 85% are occupied by deciduous forests. The National Forest Administration ROMSILVA, through the Bihor Forestry Department, manages an area of 115,260 hectares, of which 61,170 hectares are the property of the Romanian state [49].

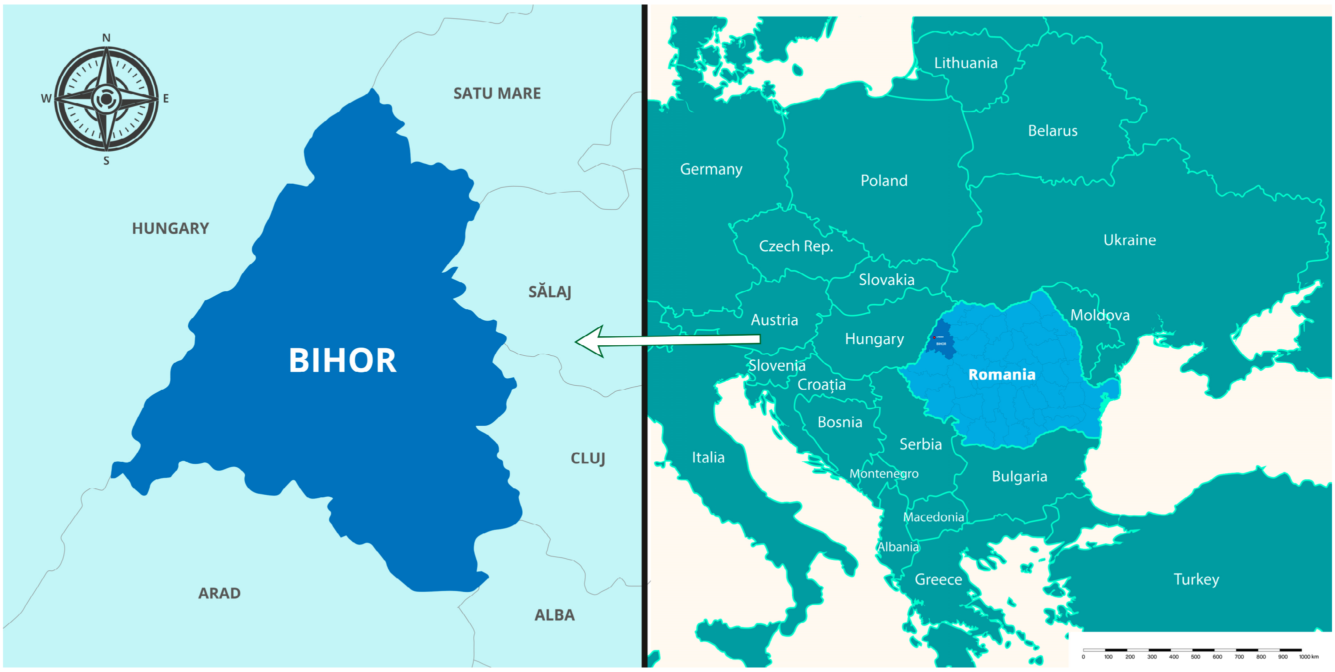

Figure 1. Location of Bihor County.

Bihor County belongs to the historical region of the Crișurilor Plain, which represents almost one quarter of the West Plain [50]. As the second largest plain by surface in Romania, the West Plain is bordered on the east by the West Hills and Occidental Carpathians, on the west by Hungary and Republic of Serbia, on the north by the Tur River, and on the south by the Republic of Serbia [51,52]. The altitude is generally low, predominantly under 100 m, and the groundwater level generally ranges between 0.5 and 3 m [53]. The region has a moderate, temperate continental climate, with strong oceanic influences generated by the dominant westerly winds. According to the meteorological data from the last five decades, the climate is characterized by average rainfall values of 620.0 mm, with a varying between 411.0 mm and 889.8 mm. The average air temperature values is 10.7 °C, with a minimum of 8.9 °C and a maximum of 12.45 °C, respectively [54]. The monthly average values ranged from −1.4 °C in January at Chișineu Criș meteorological station to 21.5 °C in July at Salonta meteorological station. The maximum and the minimum absolute temperature values recorded at Oradea meteorological station were 40.4 °C (in July 2007) and −22.5 °C (in January 1987), respectively [55]. All three meteorological stations are located along the studied area. Pedunculate oak (*Quercus robur* L.), Turkey oak (*Q. cerris* L.), Hungarian oak (*Q. frainetto* Ten.), European ash (*Fraxinus excelsior* L.), black locust (*Robinia pseudoacacia* L.), hornbeam (*Carpinus betulus* L.) and sessile oak [*Q. petraea* (Matt.) Liebl] represent the most common tree species across the Western Plain [51,52,56,57].

2.2. Case Study: Implementation of the Expert Model

To select the most suitable agroforestry system for plain regions across Bihor County, an Analytical Hierarchy Process (AHP) was performed.

AHP represents a multi-criteria decision analysis which is based on a theory of measurements focused on pairwise comparisons. Its aim is to decompose complex decision problems (i.e., the aim of this study: choosing the most suitable agroforestry system for the plain regions across Bihor County) into a hierarchy of sub-problems (i.e., the considered set of criteria), which can be deeply and independently analyzed. Thus, the alternatives (i.e., the proposed agroforestry systems) are compared one to each other and a scoring system is used [58–60].

Being simple to use, flexible and cost effective [61], AHP was widely used in several research fields in the last five decades. For example, in Romania, AHP was used to choose different tree and shrub species for the establishment of field shelterbelts [62] or to propose the most suitable solution for afforestation of sandy soils in Oltenia Plain and Carei Plain [47].

In this study, eight agroforestry systems were proposed, each of them being composed of a main tree species, a cereal, a secondary tree species and a shrub species. A 50 × 200 m rectangle, divided into 4 equal squares, was considered (Figure 2). We proposed this standardized model in order to be easy to assesses the concrete values regarding the yield, wood production, etc.

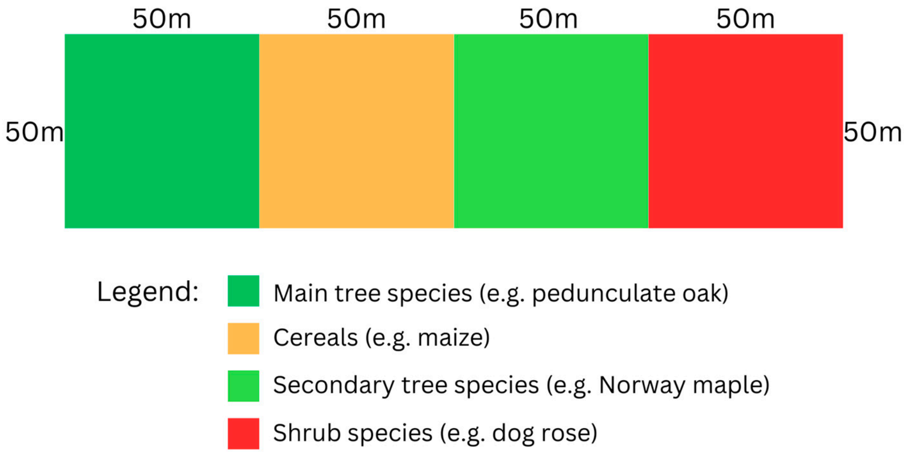

Figure 2. Design of the experimental plots.

Based on experts' opinions, eight alternatives of agroforestry systems were proposed (Table 1). The considered species were the following ones: pedunculate oak (*Quercus robur* L.)—Q.r., common sunflower (*Helianthus annuus* L.)—H.a., European ash (*Fraxinus excelsior* L.)—F.e., saskatoon berry (*Amelanchier alnifolia* Nutt.)—A.a., maize (*Zea mays* L.)—Z.m., Norway maple (*Acer platanoides* L.)—A.p., dog rose (*Rosa canina* L.)—R.c., common wheat (*Triticum aestivum* L.)—T.a., blackthorn (*Prunus spinosa* L.)—P.s., black locust (*Robinia pseudoacacia* L.)—R.p. and honey locust (*Gleditsia triacanthos* L.)—G.t., respectively. The selected woody species are also among the most often used in the afforestation of several categories of degraded terrains across Romania [63].

Table 1. The eight considered alternatives of agroforestry systems.

Alternative	Species			
1	Q.r.	H.a.	F.e.	A.a.
2	Q.r.	Z.m.	A.p.	R.c.
3	Q.r.	T.a.	F.e.	P.s.
4	Q.r.	H.a.	A.p.	A.a.
5	R.p.	Z.m.	G.t.	P.s.
6	R.p.	T.a.	G.t.	R.c.
7	R.p.	H.a.	F.e.	A.a.
8	R.p.	P.s.	F.e.	R.c.

In the case of tree and shrub species seedlings, according to the technical norms, a distance of 2 m between the rows and a distance of 1 m between the seedlings on the same row were adopted, which means that 1250 seedlings were considered to be planted in each square.

For cereal crops the average sowing density was 55,000–80,000 plants/ha for maize, 50,000–65,000 plants/ha for sunflower, using the 20 × 70 cm sowing scheme in both cases, and 450–550 plants/m^2 (180–280 kg/ha) in the case of wheat that is sown at an average distance of 12.5 cm between rows.

Moreover, in the case of the three selected cereals, concrete data regarding the yields/hectare and the costs/kilogram are available from the Romanian Institute of Statistics for the timeframe 2013–2022 [64] (Table 2).

Table 2. Yields and costs for common wheat, maize and common sunflower crops for the timeframe 2012–2022.

Species	**Year**									
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Yield/hectare [kg/ha]										
Triticum aestivum	3985	3763	3783	2935	4110	4176	4361	4072	4173	3833
Zea mays	4781	4276	3106	4217	6117	7503	7519	6582	6300	2934
Helianthus annuus	1822	2003	1567	1978	2505	2069	2887	2369	2132	1620
Cost/kilogram [Euro/Kg]										
Triticum aestivum	0.16	0.14	0.15	0.12	0.12	0.13	0.14	0.15	0.20	0.30
Zea mays	0.15	0.11	0.11	0.12	0.11	0.12	0.12	0.13	0.20	0.28
Helianthus annuus	0.23	0.21	0.29	0.26	0.25	0.24	0.24	0.31	0.52	0.56
Cost/hectare [Euro/ha]										
Triticum aestivum	654	542	552	340	493	551	628	627	826	1150
Zea mays	698	479	342	506	697	900	887	882	1247	810
Helianthus annuus	419	421	454	522	636	492	699	739	1104	901

In order to select the most suitable agroforestry system for plain regions across Bihor County, a set of 8 criteria was proposed as follows:

1. The cost for planting/sowing (1—the highest cost . . . 8—the lowest cost). This criterion considers the price of seedlings, the number of seedlings per hectare and the needed operations for planting manually and/or mechanized. According to the National Recovery and Resilience Plan, in a plain region, the cost for planting 1 ha of oak-dominated culture is 6379 EUR, while in the case of a black locust plantation, the cost is 5060 EUR, respectively [65]. In the case of cereals, there are minor differences, with the cost being 1100 EUR per hectare for wheat and 1200 EUR per hectare for maize and sunflower, respectively. These costs include plowing, land preparation, herbicide, seed cost, treatments, weeding in the case of maize and sunflower, fertilization and harvesting.
2. Yearly maintenance costs for the first 3 years (1—the highest cost . . . 8—the lowest cost). This criterion includes the cost of grass cutting between the rows with trees/shrubs, soil mobilization around the tree/shrub seedlings and applying fertilizers/pesticides, where needed. In the case of an oak-dominated culture, the cost for the first year accounts for 2025 EUR/ha, which is similar to that of a black locust plantation. Differences between the two plantations appear in the second and third years: with 4089 EUR/ha and 2854 EUR/ha, in the case of an oak-dominated culture, and 2310 EUR/ha and 1226 EUR/ha for black locust, respectively.
3. Woody biomass production after 5 years (1—the lowest quantity . . . 8—the highest quantity). This criterion is also correlated with the speed of growing of the woody species considered within this research.
4. Fruit and cereal production after 5 years (1—the lowest price . . . 8—the highest price). In order to create the hierarchy, the number of fruits produced by the considered shrub species and the yield of the three cereal crops were taken into account.
5. Honey production (1—the lowest quantity . . . 8—the highest quantity). In regard to this criterion, concrete data about honey production exist in the Romanian literature for the woody species, respectively: between 10–20 kg/ha for dog rose, 20 kg/ha in

the case of European ash and pedunculate oak, between 25–40 kg/ha for blackthorn, up to 250 kg/ha in the case of honey locust and around 1000 kg/ha for black locust plantations [66,67].

6. End product diversity (1—the lowest diversity . . . 8—the highest diversity). This criterion takes into account the number and the diversity of derived products which may be obtained from certain morphological parts of the plants (e.g., leaf extracts, juice, etc.).
7. Resistance to abiotic/biotic threats (1—the lowest resistance . . . 8—the highest resistance). The resistance to a broad spectrum of abiotic and biotic threats was assessed (e.g., drought, frosts, bugs, fungi, etc.).
8. Level of biodiversity (1—the lowest level . . . 8—the highest level). This criterion takes into consideration the number of flora and fauna species that could appear and live in the environment generated by the proposed combinations of agroforestry systems.

2.3. Modeled Scenarios

In this study, like in the one used to assess the potential of certain non-wood forest products in six European Regions [68], the Expert Choice Desktop (v. 11.5.1683) software package was used and three scenarios were proposed.

In the first scenario, all 8 criteria received equal shares (i.e., 12.5%), meaning that they have an equal contribution in selecting the most suitable agroforestry system for plain regions across Bihor County.

In the second scenario, criterion "the cost for planting/sowing" and criterion "yearly costs for maintenance in the first 3 years" received a share of 20% each, while the remaining 6 criteria only 10% each, respectively.

Within the third scenario, criterion "fruits and cereal production" and criterion "level of biodiversity" received a share of 25% each, while the remaining 6 criteria received a share of 8.33% each, respectively.

One of the shortcomings of this method consists of the fact that, instead of dictating the 'right' choice, AHP assists decision-makers in identifying the option that aligns most effectively with their objectives and their perception of the issue. Therefore, AHP offers a logical structure for organizing a decision challenge, and the outcomes are associated with the expertise of the individuals who devised the hierarchy.

3. Results and Discussion

By summarizing the information from specialized manuals and studies, a brief description of the considered species was performed in accordance with the eight considered criteria. The following information is crucial for creating the hierarchy, by taking into consideration the considered criteria in different scenarios.

Pedunculate oak is one of the main hardwood species across Bihor County, covering one fifth of the forests managed by the Bihor Forestry Department. In the last few decades, it has been intensively studied across Europe and also Romania thanks to its great economic, ecological and social importance [69–71], being one of the most valued tree species in temperate forests [72]. It is a light-demanding species and it can tolerate a broad spectrum of site conditions, being resistant to dry winds and droughts [73,74]. In particular, its seedlings can grow in a wide range of shade levels, from heavy shade to direct light [75]. They also have a very good drought stress adaptive mechanism, by increasing their root system or by restricting their growth [76]. Pedunculate oak is also very appreciated in forest farming, being a key element for the production of truffles. Last but not least, it has been demonstrated that the content of soil organic matter was higher in a chernozem from an oak plantation in comparison with the same soil from a black locust plantation [77].

European ash is widespread across Central Europe, being a species which occurs in various types of broadleaf mixed forests [78]. In Bihor County it appears in mixed hardwood forests dominated mainly by oak species. It is a fast-growing species, which is able to grow in various sites with mean year temperatures ranging from 6.4 to 10.7 °C or annual amount of precipitation ranging from 400 to 760 mm, for example [79]. In regard to soil conditions, it prefers soils with pH values from 5 to 7.5, rich in moisture and well drained [80]. It was recently reported that, in mesic sites with acidic soils and lower content of soil organic matter, the crown defoliation was lower [81]. In several European countries, in the last few decades, crown defoliation was caused by the invasive pathogen *Hymenoscyphus fraxineus* [81]. Ash is sensitive to late spring frosts, severe winters and long-term drought events [82]. It was successfully used for the afforestation of several categories of degraded lands [83–86].

Norway maple is a widespread tree species across Central and Northern Europe [87–89]. It was introduced in North America where it become invasive, being a serious threat to native forests [87,90]. It has a vigorous juvenile growth rate, it is a shade- and drought-tolerant species and it is able to grow across a broad range of soil conditions, including soils rich in carbonates [87,89–93]. Across its natural distribution range, Norway maple is a good companion for pedunculate oak, where it creates a continuous secondary layer [73]. In the current context of climate change, which generates large-scale vitality loses and dieback in some of the main timber species, the importance of this species is expected to increase [94].

Black locust is native to North America, being the most planted allochthonous species in Romania, especially in sandy soils across south-western part of the country, but also across Bihor County [95]. It is regarded worldwide as a multipurpose tree, mainly due to its great adaptability to face different kinds of environmental stresses [96]. It has a very fast juvenile growth rate, a high annual production of fast-decomposing leaves which generate a high quantity of organic matter and a very good vegetative propagation system. It is a very shade intolerant and a thermophilous tree species [95,97–100]. Moreover, black locust plantations offer several ecosystem services, such as landscape rehabilitation, fuel wood and carbon sequestration [101].

Honey locust is also native to North America. In Romania, it is usually planted in association with black locust, as is the case in the plantations installed in sandy soils in southern Romania, for example, or in the composition of field protective forest shelterbelts. It can grow in differently degraded lands, including salt-affected terrains. It prefers direct exposure to sunlight and a mild climate [102,103], but it requires deep soils, with a moderate humus content [104]. In comparison to black locust, the honey locust also provided good results in carbonated soils [85].

Saskatoon berry is also a species originating from North America, which recently received an increasing amount of attention for cultivation in Romania, especially across western parts of the country [105]. This species can tolerate a broad range of site conditions, being able to grow in different soil types, with a pH ranging from 5.6 to 8, for example [106]. Moreover, it can easily be propagated both in vegetative and generative ways [107]. An adult shrub is able to produce between 4500 and 10,000 berries [108], which represent a good source of vitamins, nutrients, bioactive components and other micro- and macro-elements [105].

Blackthorn is one of the most common shrub species across Romania, including Bihor County. It is a light-demanding species, and it has a slow growing rate, usually reaching a height of 2–3 m. It can reproduce in both generative and vegetative ways, and its roots are deeply developed in depth, with numerous lateral branches [109]. It can grow in several types of soils [109], including acid soils [110]. Its fruits are very appreciated, due to their rich content of vitamins, sugars, minerals, organic acids, polyphenols, tannins, etc. [111].

Dog rose is a light-demanding and a drought-tolerant shrub species, with low requirements for soil conditions [62,112]. It is also very appreciated thanks to its reddish fruits, which have high content of vitamin C, carotenoids and polyunsaturated fatty acids [113]. In Romania, its berries are mainly used to produce juice, jelly, jam, wine and tea [114].

Maize is one of the most widely cultivated cereals worldwide, being famous for its economic value and superior nutritional properties [115,116]. It was introduced to Europe from Central America at the end of 15th century [117]. Particularly, in Romania, maize is of great interest, being a strategic cereal crop both for internal and foreign markets [118,119].

For example, more than 96,000 hectares were cultivated in 2022 across Bihor County [64]. Even if its cultivation is dependent on fertilizers [120], maize has several agrotechnical and agrobiological properties, such as: high yield, high resistance to drought and also to some pests and diseases, high economic benefits and total mechanization of agrotechnical and harvesting works [121,122].

Common wheat plays an important role in human nutrition worldwide [123,124], being the second or the third largest crop in the last two decades [125]. Thanks to its geographical location, climate and soils, Romania is cultivating wheat on approximately one quarter of its arable land [126], being one of the most important wheat producers in the European Union [127] after countries with higher areas (i.e., France, Germany and Poland) [128]. In Bihor County, the area cultivated with common wheat accounted for more than 83,000 hectares in 2022 [64]. In the current context of increasing temperatures, water deficit represents a major challenge to wheat productivity [129]. In this context, in order to protect the crops against drought, several techniques have recently been experimented, with arbuscular mycorriza—wheat association or applying biochar amendments—being among them [130,131]. However, nitrogen fertilization is mandatory to increase wheat yield [132].

Common sunflower crop is the third largest agricultural crop, after maize and wheat in Romania [133], being also one of the main crops across the West Plain [57]. A total area of 31,000 hectares was cultivated in 2022 across Bihor County [64]. In recent years, among the European Member States, Romania ranked first in terms of both production and cultivated area [134,135], and particularly in regards to the organic production area [136]. It is very appreciated as a honey plant and also due to its several industrial and food uses, such as the production of edible oil, bio-fuel and fodder [136,137].

An alternative AHP ranking for the eight criteria in the case of the eight alternatives (agroforestry systems), based on the information available in specialized manuals, scientific papers and authors' expertise, is given in Table 3.

Table 3. AHP alternative ranking.

Criterion No.	Alternative							
	Q.r.H.a. F.e.A.a.	**Q.r.Z.m. A.p.R.c.**	**Q.r.T.a. F.e P.s.**	**Q.r.H.a. A.p.A.a.**	**R.p.Z.m. G.t.P.s.**	**R.p.T.a. G.t.R.c.**	**R.p.H.a. F.e.A.a.**	**R.p.P.s. F.e.R.c.**
1	2	3	4	1	7	8	5	6
2	2	3	4	1	6	5	7	8
3	4	1	3	2	6	5	8	7
4	6	2	7	4	3	8	5	1
5	4	1	2	3	8	7	6	5
6	2	6	8	3	7	5	1	4
7	1	4	2	3	8	7	5	6
8	6	8	7	5	1	2	3	4

According to the AHP results, when all eight criteria received an equal share, the combination R.p.Z.m.G.t.P.s. (*Robinia pseudoacacia* + *Zea mays* + *Gleditsia triacanthos* + *Prunus spinosa*) proved to be the best alternative in terms of agroforestry systems that could be adopted in plain regions across Bihor County, accounting for 18.9% of the total global priority with respect to the goal (Figure 3, right part of the graph).

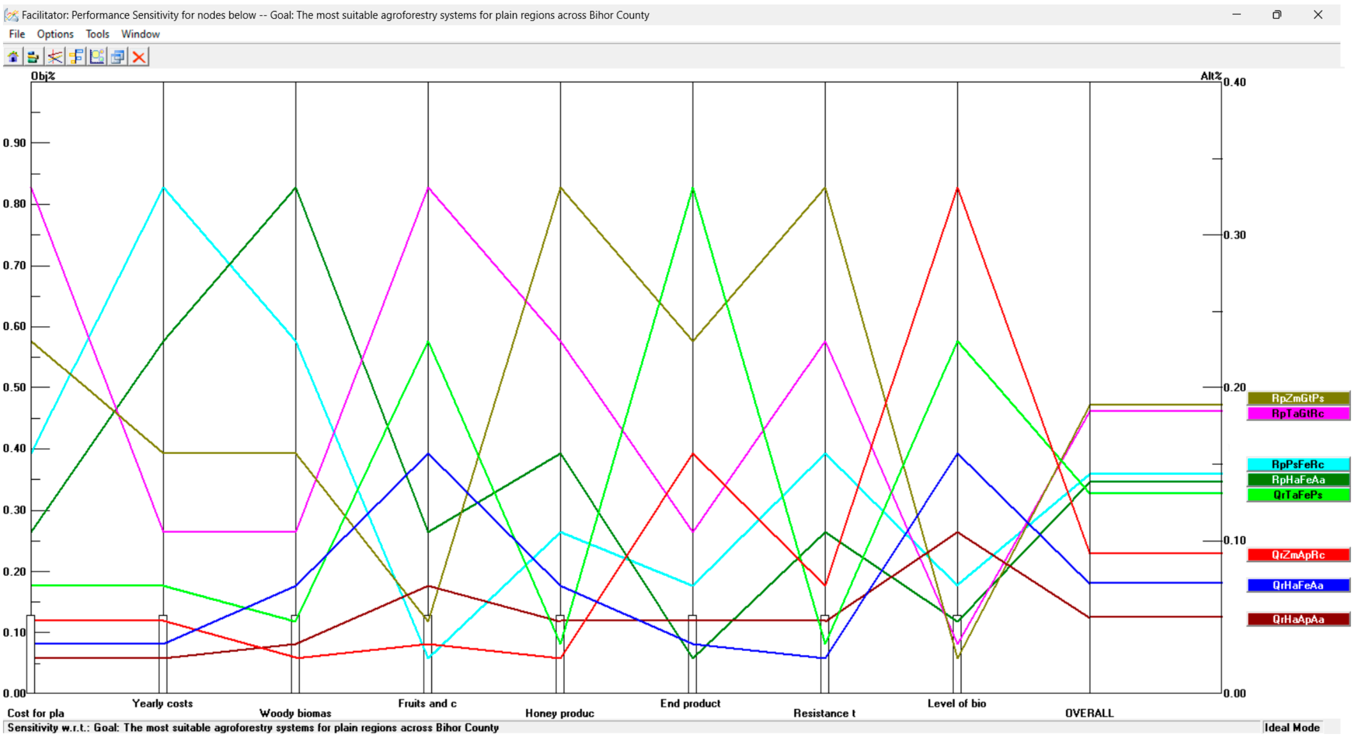

Figure 3. The ranking of the eight proposed agroforestry systems in the first scenario.

The second option was R.p.T.a.G.t.R.c. (*Robinia pseudoacacia* + *Triticum aestivum* + *Gleditsia triacanthos* + *Rosa canina*), which accounted for 18.4% of the total global priority with respect to the goal. Moreover, the four combinations with black locust as the main species scored in the first positions, while the agroforestry systems having pedunculate oak as main tree species situated in the last positions.

Within the second scenario, a switch in the first two proposals from scenario 1 was recorded, namely the combination R.p.T.a.G.t.R.c. (*Robinia pseudoacacia* + *Triticum aestivum* + *Gleditsia triacanthos* + *Rosa canina*) ranked first (Figure 4, right part of the graph), accounting for 19.1% of the total global priority with respect to the goal. However, the four combinations with black locust as main tree species were ranked in the first positions, meaning that the costs for planting and maintenance of these agroforestry systems are cheaper in comparison with the combinations based on pedunculate oak as main tree species. The combination Q.r.H.a.A.p.A.a. (*Quercus robur* + *Helianthus annuus* + *Acer platanoides* + *Amelanchier alnifolia*) was ranked in the last position.

In the third scenario, with two criteria accounting for 50% of the decision of choosing the most suitable agroforestry system, R.p.T.a.G.t.R.c. (*Robinia pseudoacacia* + *Triticum aestivum* + *Gleditsia triacanthos* + *Rosa canina*) was ranked first, accounting for 18.4% of the total global priority with respect to the goal, being followed by Q.r.T.a.F.e.P.s. (*Quercus robur* + *Triticum aestivum* + *Fraxinus excelsior* + *Prunus spinosa*) and R.p.Z.m.G.t.P.s. (*Robinia pseudoacacia* + *Zea mays* + *Gleditsia triacanthos* + *Prunus spinosa*), respectively (Figure 5).

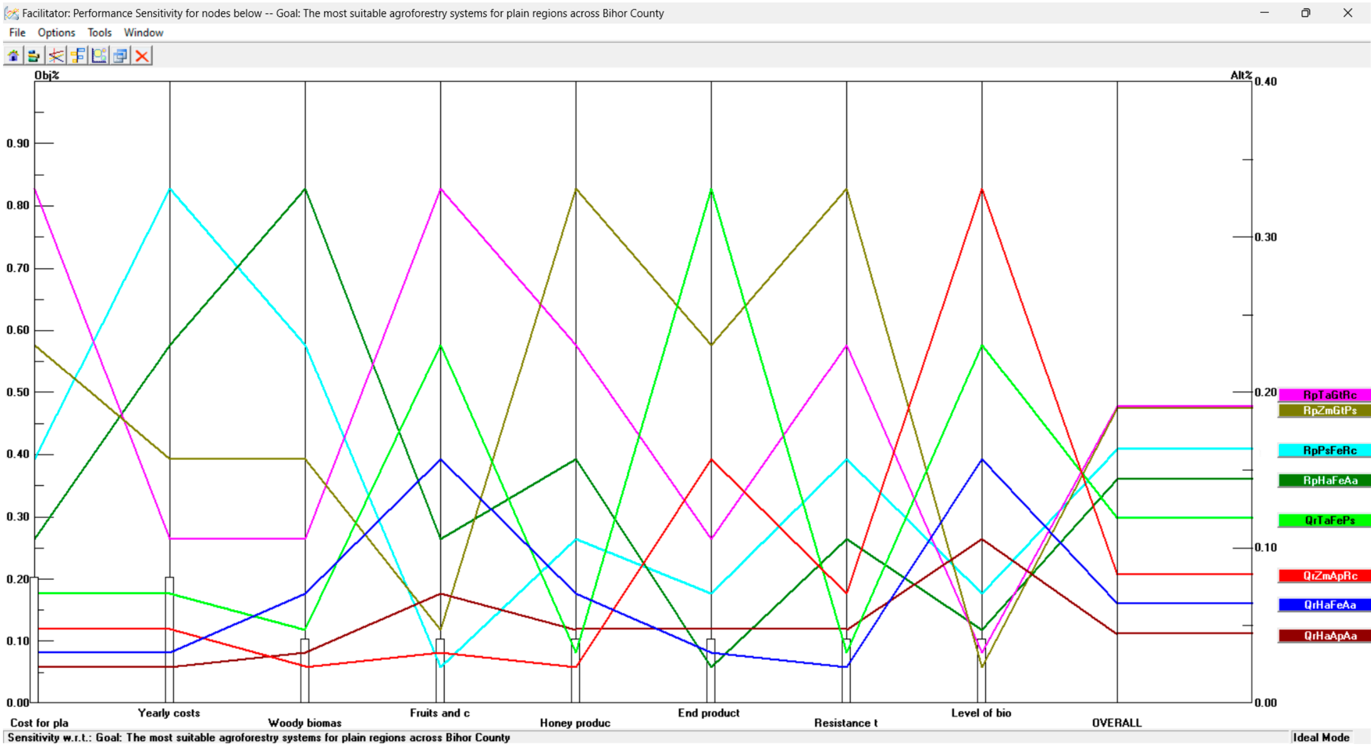

Figure 4. The ranking of the eight proposed agroforestry systems in the second scenario.

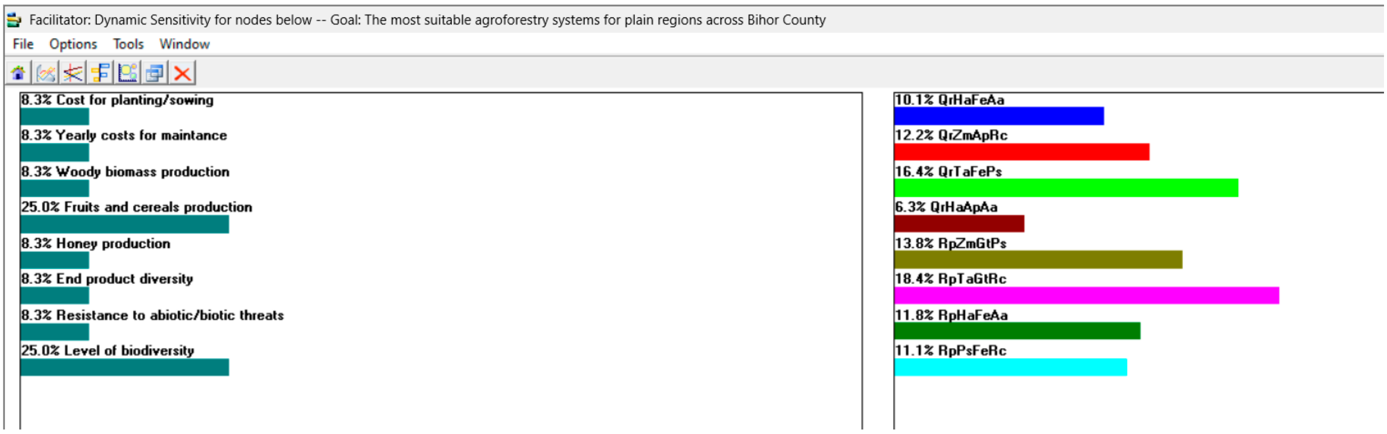

Figure 5. The ranking of the eight proposed agroforestry systems in the third scenario.

4. Conclusions

According to the literature review presented above, corroborated with the results of this study, we conclude that the plain region across Bihor County has a great potential for agroforestry systems. This potential could be better capitalized upon, for example, if more landowners will be aware of the benefits of these systems, on one hand, and if a favorable normative framework existed, on the other hand.

With respect to establishing agroforestry systems across the plain regions of Bihor County, combined with the goal of diversification, and addressing the effects of climate change, as well as addressing food crises or simply enhancing green spaces near localities, there is a pressing need for flexibility in choosing the species to be planted. However, this selection should be science based. Future research should also consider criteria that account for various aspects, including the functional relationships of these future green spaces with nearby areas. This holistic approach is crucial for integrated and sustainable development, with a primary focus on the development of rural communities.

Finally, it can be concluded that the combination of the Analytic Hierarchy Process and the Expert Choice Desktop (v. 11.5.1683) software package has proven to be a viable solution for selecting an agroforestry system that meets all the necessary criteria.

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