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Prioritization of Criteria and Tree Species in Agroforestry

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Abstract

Today, forests, which are one of the most important resources capable of naturally renewing themselves, are not considered and operated only as the resources of wood raw materials. The products and the protective services provided by forests are of greater importance in terms of intensive forestry approach that aims to meet the demands of the modern society. The different ecological conditions of our country as well as the wide range of species arising correspondingly increase the potential of agroforestry practices which are to make important contributions, especially in terms of food, chemistry, medicine and energy sectors. Within this scope, poplar, salix, robinia pseudoacacia, cupressus, juglans, chestnut and stone pine are the first species that spring to mind, when it comes to agroforestry practices in Turkey. In this study, it is aimed to identify the most suitable species, i.e. to make species prioritisation, in a potential agroforestry site for the agroforestry plantations to be established in the future by using the chestnut, stone pine and poplar species used in private and state afforestation in Bartin region in terms of the suitability of ecological conditions, with the use of the Analytical Hierarchy Process (AHP) Method, which is one of today's multidimensional and widely used decision making methods. For this purpose, taking the ecological, technical, social and economic criteria in the study area into consideration, a questionnaire study was conducted with 80 participants at different ages and educational levels, and the results were evaluated by AHP method. According to the analysis results, the species prioritization for the agroforestry plantations in Bartin region was found to be as follows: 1st Chestnut, 2nd Stone pine and 3rd Poplar. The ecological and economic criteria are the most important ones effective in this ranking. In terms of sub-criteria, Net Income Maximization received the highest value.

Keywords: Agroforestry, chestnut, stone pine, poplar, prioritization, AHP, participation, Turkey.

Agroforestry'de Kriterlerin ve Ağaç Türlerinin Önceliklendirilmesi

Öz

Doğal olarak kendini yenileyebilen en önemli kaynaklardan birisi olan ormanlar günümüzde sadece odun hammaddesi elde edilen kaynaklar olarak değerlendirilmemekte ve işletilmemektedir. Ormanların sağladığı ürünler ve koruyucu hizmetler modern toplumun taleplerini karşılamayı amaç edinen entansif ormancılık anlayışı yönünden daha da büyük bir önem taşımaktadır. Ülkemizin sahip olduğu farklı ekolojik koşullar ve buna bağlı olarak ortaya çıkan geniş tür yelpazesi özellikle gıda, kimya, sağlık ve enerji sektörü açısından önemli katkılar sağlayacak tarımsal ormancılık uygulamalarının potansiyelini arttırmaktadır. Türkiye tarımsal ormancılık uygulamalarında kavak, söğüt, yalancı akasya, servi, ceviz, kestane, fıstıkçamı gibi ağaçlar öne çıkan türlerdir. Bu araştırmada Bartın yöresinde yaygın olarak özel ve devlet ağaçlandırmalarında kullanılan türler ile gelecekte yapılacak olan tarımsal ormancılık çalışmalarının Analitik Hiyerarşi Prosesi (AHP) Metodu ile önceliklendirilmesi ve yöre için en uygun kriterlerin ve türlerin belirlenmesi amaçlanmıştır. Bu amaçla araştırma alanında bulunan ekolojik, teknik, sosyal ve ekonomik kriterler dikkate alınarak değişik yaş ve eğitim seviyelerinden konu ile ilgili olan 80 katılımcı ile anket çalışması gerçekleştirilmiş ve elde edilen sonuçlar AHP metodu ile değerlendirilmiştir. Analiz sonuçlarına göre Bartın yöresinde tarımsal ormancılık plantasyonları için tür önceliklendirilmesinde 1. Kestane, 2. Fıstıkçamı ve 3. Kavak yer almıştır. Bu sıralamada etkili olan en önemli kriterler, ekolojik ve ekonomik olanlarıdır. Alt kriterler açısından ise en yüksek değeri, Net Gelir Maksimizasyonu almıştır.

Anahtar Kelimeler: Agroforestry, kestane, fıstıkçamı, kavak, önceliklendirme, AHP, katılımcılık, Türkiye.

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1. Introduction

Today, forests, which are one of the most important resources capable of naturally renewing themselves, are not considered and operated only as the resources of wood raw materials. The other non-wood products and the protective services provided by forests for public health and order are of greater importance in terms of intensive forestry approach that aims to meet the demands of the modern society. It is also very important to ensure the continuity of natural resources, which are the basic elements of sustainable life, in accordance with the principles of conservation and use (Sen et al., 2019). As a result of this understanding, forests have begun to be considered together with agricultural and animal production.

The land use system, which is called agroforestry, is actually defined as "a land use system or practice in which forestry production is carried out along with agricultural and animal production by taking the economic and ecological impacts and relationships in the same management and production unit into consideration" (Nair, 1993). Through this definition, agroforestry practices can be perceived as a production technique that is situated between agricultural production and forestry production, which are soil-based production techniques, and it has similarities with them (Filiz and Tolunay, 2003).

Agroforestry has emerged due to the problems experienced in the developing countries (Gholz, 1986; Raintree, 1987; Nair, 1993;) and has been widely accepted by the developed countries since the 1990's. In developed countries such as England, France, Spain, the United States, Australia and New Zealand, successful examples of agroforestry practices are rapidly becoming popular (Geray and Gorcelioglu, 1983; Alanay, 1989; Konig, 1992; Roose and Ndayizigiye, 1997; Ayberk, 1992; Ayberk et al., 1996; Apichatvullop, 1997; Diner and Kocer, 1999; Carfagna and Gallego, 2005; Liu and Wang, 2006; Rutunga et al., 2007; Verchot et al., 2007; Battisti and Naylor, 2009; Garrity et al., 2010; Quinion et al, 2010; Reubens et al., 2011; Stainback et al., 2011; Ahmad et al., 2012). In these countries, agroforestry is not only a land use practice, which is rapidly becoming popular, but also emerges as an independent field of education within universities along with successful scientific researches (Filiz, 2002; Tolunay et al., 2002; Stainback and Masozera, 2010; Ahmad et al., 2016).

Natural resources cannot fully provide the income that is necessary to sustain the lives of local communities. For this reason, a great number of forest pheasants carry out small-scale agricultural and livestock activities in order to meet their needs (Toksoy et al., 2008). The afforestation and agroforestry activities carried out with species such as poplar, willow, acacia and eucalyptus by the pheasants and farmers on private lands, along the fields and the creeks are at considerable levels (around 150,000 ha). In general, these afforestation works are outside the forest regime, and the annual wood production of this kind of afforestation is estimated to be approximately 3.5 million m3. This production meets a significant portion of the wood demand at both the local and national level, and profoundly reduces the pressure on the natural forests. Within the framework of these studies, in the coming years, the inducement of afforestation works with fast growing species such as calabrian pine should also be taken into account in some parts of the 3rd and 4th class agricultural lands located in suitable regions. In the afforestation works carried out by both the state and the private sector, the use of quality seeds of suitable provenances and the use of quality seedlings in compliance with the standards are of great importance for success. For this purpose, strengthening of the necessary incentives and supervision services are among the important needs (Montagnini and Nair, 2004). The General Directorate of Forestry (OGM), which is responsible for the management of forests in Turkey (COB, 2004), acts within the framework of the principle of sustainability in order to meet the demand for wood products increasing due to population growth, developing industry etc., and tries to develop forests both structurally and spatially. Within this scope, various activities from afforestation works such as the conservation of natural forest lands, increasing existing forest lands and rehabilitation of degraded forest lands (Sivacioglu and Sen, 2019) to certification works (Sen and Genc, 2017; Sen and Genc, 2018; Sen and Gungor, 2019) are carried out. In this context, agroforestry activities are also supported by the forest administration for the purposes of preserving natural forests, ensuring the continuity of the timber supply, and assuring food security (Sen and Gungor, 2018a).

The different ecological conditions of our country as well as the wide range of species arising correspondingly increase the potential of agroforestry practices which are to make important contributions, especially in terms of food, chemistry, medicine and energy sectors. Within this scope, the prominent species in agroforestry practices in our country are listed as poplar (*Populus tremula*), salix (*Salix alba* L.), robinia pseudoacacia (*Robinia pseudoacacia* L.), cupressus (*Cupressus sempervirens* L.), walnut (*Juglans regia* L.), chestnut (*Castania sativa*) and stone pine (*Pinus Pinea* L.).

Despite having highly qualified studies conducted on agroforestry in the literature, there exist studies, where multi-criteria decision systems are used especially in forestry, (Pereira et al., 1993; Store and Kangas, 2001;

Yilmaz, 2007; Ozel et al., 2014; Yilmaz and Surat, 2015 ; Aguirre-Salado et al., 2015), as well as studies on agroforestry, particularly the selection and prioritization of species (Apichatvullop, 1997; Liu and Wang, 2006; Reubens et al., 2011; Stainback et al., 2011; Ahmad et al. , 2012; Ahmad et al., 2015; Carfagna and Gallego, 2005; Gungor, 2018; Gungor and Sen, 2018; Sen and Gungor, 2018b).

This study aims to develop a new and contemporary understanding on the planning of the future agroforestry activities to be carried out with the chestnut, stone pine and poplar species, which are commonly used in both the private and state afforestation works of Bartin region, and to investigate the reflection of this understanding on practice. In this way, a structure, which takes the opinions of stakeholders into account, responds to the evolving and diversifying needs of the society, and able to respond to issues such as rural development and sustainable development, in which societies become sensitive, is developed. The study results are thought to contribute to decision makers and to private entrepreneurs, who are willing to carry out this activity, in making use of agroforestry studies to be carried out both in Bartin province and in other areas with similar characteristics.

2. Materials and Methods

The study was carried out in Forestry Operation Directorate of Bartin province which is rich in species for agroforestry (Figure 1).

Figure 1: Location of Bartin province and the study area.

In the first stage of the study, the current situation of Bartin province was examined in terms of its agricultural forestry potential. Within this context, many scientific publications, projects and statistical information were utilized from. Thus, various numeric values regarding agricultural forestry (tree species, ecological, technical, social and economic values) were obtained in Bartin region. As a result of the literature review conducted and the expert meetings held in the second stage of the study, the forest tree species suitable for agricultural forestry activities in Bartin province were identified. These species are chestnut, stone pine and poplar. On the other hand, the species suitable for agroforestry were prioritized using the Analytical Hierarchy Process (AHP). For the related analysis, a questionnaire study was conducted according to the face-to-face interview technique.

2.1. Analytical Hierarchy Process

AHP (Analytic Hierarchy Process) was developed by Thomas L. Saaty in 1977 as an easily understood and applied technique due to its mathematical simplicity in order to be used in solving complex decision-making problems. AHP is the implementation of decision makers' process of understanding, structuring, analysing and ending problems in different fields. Due to its nature of being practical, it is used in studies in various fields such as resource allocation, estimation, risk analysis, planning, performance management etc. (Saaty, 1980).

AHP allows modelling as a hierarchical structure that indicates the relationship between the complex problems of decision-makers, the main objective of the problem, the criteria, sub-criteria and alternatives. One of the most important characteristics of AHP is that the decision maker can participate in the decision-making process both objectively and subjectively. AHP is an application in which the acquired knowledge, experience, personal thoughts and intuitions of people are logically combined. AHP method is based on binary comparison of alternatives according to a certain criterion. AHP method guides the decision maker in ending of the model. This method is also established with a hierarchical structure consisting of multiple stages (Saaty, 1990).

In the first stage of creating a hierarchy, the decision making problem should be defined first. The work begins by identifying the options in order to define the decision-making problem. As a result of this identification, it is found how many results to be used to evaluate the decision. After this process, the main criteria affecting the options are determined. The process is continued by identifying the sub-criteria, and even the lower criteria of the main criteria are determined in accordance with the hierarchical order. In the first stage of AHP application, a hierarchy should be developed by dividing the problem into sections (Saaty and Vargas, 2001; Forman and Selly, 2001).

By examining the scientific studies and documents related to the subject of the study, the criteria and sub-criteria to be used in identification of the priorities of each interest group in terms of agricultural forestry potential were determined (Table 1).

Table 1. Priorities related to criteria and sub-criteria in AHP.

Criteria		**Ecological**	**Technical**	**Social**	**Economic**
Sub-criteria	**1**	Climate	Quality and Improved Seedlings	Experienced Labour Force	Production Maximization
	2	Soil	Correct Plantation Technique and Ease of Nursing	Social Demand	Cost Minimization
	3	Physiography	Accessibility	Improving Inter-sectoral Relations	Net Income Maximization

According to Table 1, the criteria to be used in Level 3 in AHP decision hierarchy are divided under four main headings as ecological, technical, social and economic criteria, and in Level 4, sub-criteria are developed for related to each criterion. By defining the scope and making the definition of the criteria and sub-criteria, it is made easy to understand, apply and quantitatively calculate.

While setting forth a problem, it should be as detailed as much as possible. However, detailing should be at the limit that will enable to lose sensitivity, when changes are made in the factors (Saaty, 1990). In this respect, it is very important to make binary comparisons of criteria correctly, consistently and effectively. As the last step, the alternatives are at the lowest level of the hierarchy (Braunschweig and Becker, 2004), which is presented in Figure 2.

The binary comparisons matrix (n × n) as a second step of the AHP method is the basis of AHP technique (Saaty, 2005). In order to be able to make binary comparisons, there is a need for a scale indicating how important or dominant one factor is compared to another factor in terms of the criteria compared (Saaty, 2008).

In creating the binary comparison matrixes to be used in AHP method, and in determining their significance levels, the 1-9 significance scale given in Table 2 and recommended by Saaty is used (Saaty, 1990).

Table 2: 1-9 Scale used in binary comparisons (Saaty, 1990).

Significance Level	**Definition**	**Remarks**
1	Equally Significant	Two activities serve the purpose equally.
3	Weakly Significant	Experience and judgments are weakly in favour of one of the two activities.
5	Strongly Significant	Experience and judgments are strongly in favour of one of the two activities.
7	Very Strongly Significant	Experience and judgments are very strongly in favour of one of the two activities.
9	Very Significant	Evidences suggest that one activity is as superior as possible to another.
2,4,6,8	Intermediate Values	Values to be used when undecided between the above values.

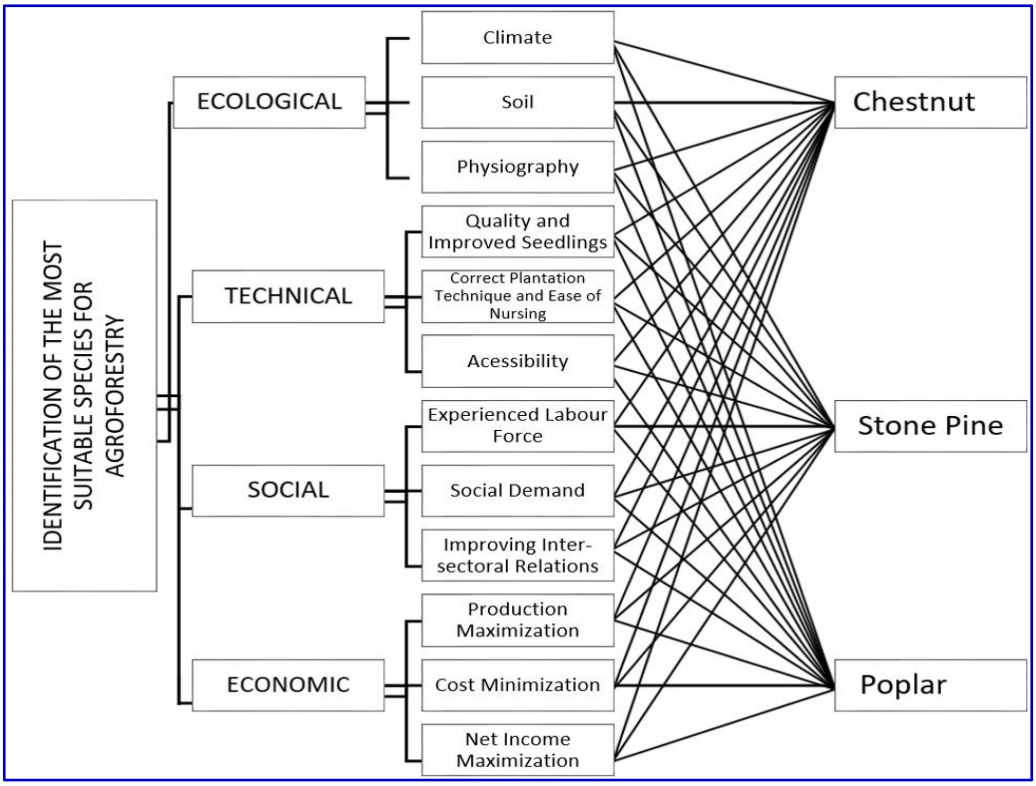

Figure 2. A simple AHP decision hierarchy consisting of objective, criteria and options in species selection for agroforestry.

Binary comparisons should be made by the person or persons who are experts on the subject. While making these comparisons, the levels are subjected to binary comparisons among themselves and are sorted from top to bottom of the hierarchy. In the evaluations made according to the tables, matrix A is obtained in case of comparing the decision criteria and decision options of decision criteria. In the comparison of any two criteria or decision options, if x value is the comparison value, its opposite would be 1/x. If $A_{12}=3$, $a_{21}=1/3$ (Saaty, 1990).

$$A = \lfloor a_{ij} \rfloor_{(n \times n)} \tag{1}$$

A new matrix B is obtained by applying the formula 2 to the binary comparison matrixes of decision criteria.

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{2}$$

$$B = |b_{ij}|_{(n \times n)} \tag{3}$$

By using formula 4, the weight vectors of decision criteria are obtained from the newly obtained matrix B.

$$W_i = \frac{\sum_{j=1}^{n} b_{ij}}{n} \tag{4}$$

$$W_i = |W_i|_{n \times 1} \tag{5}$$

$$\lambda = AB \tag{6}$$

A consistency analysis should be carried out in order to measure whether the values determined as a result of binary comparisons are consistent.

$$CI = (\lambda max - n)/(n-1) \tag{7}$$

The consistency rate is obtained by dividing the obtained value by the randomness index. If the consistency rate obtained is less than 0.10 or equal to it, the analysis performed can be regarded as consistent. However, if the result obtained is greater than 0.10, a consistent result cannot be obtained, and the analysis should be reviewed (Saaty, 1990).

$$CR = CI/RI \quad (8)$$

In the binary comparison matrix, the sum of the columns are calculated for each column separately, and the matrix is normalized by dividing the other factors in the matrix by the related column sum. In the normalized matrix, the means of rows are calculated for each alternative or criterion separately. The calculated values are the priority values for the criteria. This matrix formed by the priority values is the priority vector matrix. The priority matrix obtained by the priority vector is found by multiplying each priority values, from which a criterion is obtained, by the factors in the column in the binary comparison matrix of that criterion or option. The values obtained as a result of the multiplication form the weighted total matrix. The row sum values of the weighted total matrix are divided by the priority matrix row values, and the arithmetic mean of the last matrix values (nx1) is calculated. With this arithmetic mean, the λmax value is calculated (Saaty, 1990).

Randomness indicators (RI) and their calculations according to different n values are given in Table 3 (Saaty and Tran, 2007).

Table 3: Randomness Indicators in AHP.

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56	1.57	1.59

In the study, AHP was analysed using SPSS (Statistical Package for Social Science) 21.0 and MATLAB package program.

2.2. The Questionnaires Conducted within the Scope of AHP

Regardless of the distribution of the universe, the sample mean for n≥30 is distributed approximately normal. If the universe has a normal distribution, the sample mean is normally distributed regardless of the sample size (Toscano et al., 2001). No matter how the universe is distributed in practice, the sample distribution is observed to be converging to the normal distribution, when n≥30 (Armutlulu, 2008).

Within the scope of the study, the interviews were conducted with the locals and the representatives of public institutions and producers in Bartin in 2018. The number of participants was found by means of the formula (Orhunbilge, 2000) giving the sample size in limited societies. Accordingly, a total of 80 participants were interviewed including 30 participants representing the local community, 20 participants representing public institutions and 30 participants representing producers. In the study, a questionnaire form, which refers to the species to be considered within the scope of agroforestry and the Agroforestry Implementation (TOU) site as required by AHP, was prepared, and presented to the participants through a personal interview technique. The participants were asked to rank these species from the best to the worst in the TOU site within the framework of the relevant criteria. By this means, the most suitable species was tried to be identified.

3. Findings

3.1 AHP Calculations

As a result of the questionnaire study conducted with a total of 80 participants, the TOU site was ranked from best to worst in terms of potential species within the framework of the relevant criteria. In this way, the most suitable species was identified for the TOU site (Table 4-9).

Table 4. The summary of the AHP questionnaire results for the priorities of the criteria (for level 2).

Criteria	General	Ranking
Ecological	0.252	2
Technical	0.244	4
Social	0.249	3
Economic	0.255	1
Consistency Rate = 0.091		

As can be understood from Table 4, the criterion weights differ in terms of agroforestry. The participants of the questionnaire attached priority to the economic criteria with a coefficient of 0.255. Likewise, economy, in other words Benefit-Cost Analysis, plays an important role in agroforestry activities. Issues such as the economic return period of the investment, the cost of the activity and the amount of the investment are the ones that must be overcome first. The participants attached the least priority value to technical criteria with 0.244. In fact, when Table 4 is examined closely, the criterion weights are seen to contain very close values. In planning, strategical, tactical and operational planning are carried out, respectively. When the subject is approached from this aspect, the participants take the economic, ecological and social criteria into consideration at the strategic stage of planning, while the technical criteria are generally taken into consideration at the operational planning stage, which is the last stage of planning.

Table 5. The summary of the AHP questionnaire results for the priorities of the ecological sub-criteria (for level 3.1).

Ecological Criteria	General	Ranking
Climate	0.352	1
Soil	0.319	3
Physiography	0.329	2
Consistency Rate = 0,082		

When Table 5 is examined, the climate criterion is the first priority with 0.352 according to the ranking in terms of ecological sub-criteria. This is followed by physiography criteria with 0.329 and soil criteria with 0.319, respectively. In this case, climate is the most important ecological criterion for the implementation of agroforestry practices in the region. Likewise, the appropriateness of climate data affects both the success of the species diversity to be created and the quality and efficiency of the product.

Table 6. The summary of the AHP questionnaire results for the priorities of the technical sub-criteria (for level 3.2).

Technical Criteria	General	Ranking
Quality and Improved Seedlings	0.360	1
Correct Plantation Technique and Ease of Nursing	0.341	2
Accessibility	0.299	3
Consistency Rate = 0.079		

According to Table 6, the first priority in terms of technical sub-criteria is “Quality and Improved Seedlings” with 0.360. It is followed by the criteria of "Correct Plantation Technique and Ease of Nursing" with 0.341 and "Accessibility" with 0.299, respectively. In this case, the supply of quality and improved seedlings is of great importance for the success of agroforestry practices to be implemented in the region. In fact, it would be a better approach to evaluate the technical criteria as a whole. Likewise, the most important condition to be met for intensive forestry is the provision of technical conditions.

Table 7. The summary of the AHP questionnaire results for the priorities of the social sub-criteria (for level 3.3).

Social Criteria	General	Ranking
Experienced Labour Force	0.340	2
Demand for Agroforestry Activities	0.362	1
Improving Inter-sectoral Relations	0.298	3
Consistency Rate = 0.080		

When Table 7 is examined, it is seen that the most important criterion in terms of social criteria is "Demand for Agroforestry Activities" (0.362). This is because the society living in the region, especially those living in rural areas, should attach importance to agroforestry for a wide-spread effect of agroforestry practices, and their level of demand for this activity should be at reasonable levels.

Table 8. The summary of the AHP questionnaire results for the priorities of the economic sub-criteria (for level 3.4).

Economic Criteria	General	Ranking
Production Maximization	0.292	3
Cost Minimization	0.338	2
Net Income Maximization	0.370	1
Consistency Rate = 0.091		

According to Table 8, the top priority of the Economic sub-criteria is "Net Income Maximization" criterion with 0.370. As a matter of fact, good economic feasibility is a must for agroforestry. An economically successful project is a project with continuance. If a good agroforestry activity is desired, the cost, duration, recycling rate, net profit and income of the investment are of importance. The economic structure, which is deemed important for a good and successful project, emerges as an important criterion as a result of this study as well.

Table 9 shows the general summary of AHP results obtained from the calculations of all levels starting from Level 4 to Level 1 (upwards) in AHP.

Table 9. General summary of AHP results for tree species.

Species for the Tou Site	AHP Analysis	
	Function Priorities	**Ranking**
Chestnut	0,501	1
Stone pine	0,300	2
Poplar	0,199	3
Consistency Rate = 0,071		

When Table 9 is examined, the top function priority for TOU site is chestnut species with 0.501. Stone pine is ranked second (0,300), whereas poplar ranked third (0,199) in the overall evaluation. There are similar forestry studies available on the selection of tree species. In a study conducted in China, the increment, adaptation, planting characteristics and economic features in the selection of species for industrial afforestation were the criteria set in the selection of tree species. According to the results of the AHP analysis performed on 20 tree species determined as a result of field research and literature review, *Toona ciliate* var. *pubescenes*, *Choerospondias axillaris*, *Toona sinensis*, *Alnus cremastogyne* and *Populus deltoides* were identified as suitable species for industrial afforestation (Liu and Wang, 2006). In another study conducted for the Northern Ethiopian plateaus with multi-criteria decision systems, it is stated that local afforestation works should focus on the species that perform a wide range of functions. In the study, *Cordia africana, Dodonaea angustifolia, Eucalyptus spp.*, *Acacia abyssinica*, *Acacia saligna*, *Olea europaea* and *Faidherbia albida* species were identified as the priority species in afforestation studies to be performed in the field as a result of the analysis performed according to 45 attributes determined in the light of local and ecological information among 91 species that were potentially valuable (Reubens et al., 2011).

4. Results and Discussion

As a result of the AHP calculations made under the scope of the research, the highest numerical values were found in the economic criteria, when the functions and priorities of the TOU site were evaluated as a whole (Table 4). These results showed that agricultural forestry activities were shaped according to the ability of nature on the one hand, and the economic reasons of the investments on the other hand. However, the highest rate among the criteria was found to be in the economic criteria with 0.255 (Table 4). This situation makes it is necessary to bring the economic criteria to the fore in the feasibility studies to be conducted for agroforestry activities than the other three criteria. When an evaluation is made in terms of species within the scope of agroforestry, it is understood that the chestnut species with a high economic return come to the fore with 0.501 (Table 9). In fact, this study serves the purpose of ensuring people to get maximum benefit and the highest yield from the land by using the land, which is a scarce resource in the agroforestry works of Bartin region, in accordance with the ecological, technical, social and economic conditions.

In another study conducted under the scope of species priority in terms of agroforestry (Ayaz, 2019; Ayaz and Gungor, 2019), NBD calculations were made in a 1-hectare field of Agroforestry Implementation (AU). To carry out this, first of all, the alternative tree species, garden and forage plants were determined, and then these were scored using Ranking Technique, and alternative AU combinations were created from the association of species with the highest value (tree, field and forage). In the study, chestnut, stone pine and poplar were selected as the forest tree species, tomato and savoy cabbage as the agricultural plants, and common vetch and corn as forage plants. In this way, 15 Alternative Agroforestry Implementation (AAU) scenarios (production combination), in which the species were assessed together, were developed. Afterwards, the scenario with the highest economic return was found by calculating each AAU scenario in line with the NBD criterion. As a result of the calculations made, the highest economic return in one hectare of AU field was found in the "Chestnut + Tomato" AAU scenario with 695.203 TL, and the lowest return in the "Poplar + Common Vetch" AAU scenario with 25.386 TL. These results also showed that chestnut species was a profitable species with high economic return in terms of agroforestry.

In another study conducted both within the aspects of prioritizing agroforestry criteria as well as species prioritization and field ranking (Gungor et al., 2018), the agroforestry activities of Yenice region were identified with Dynamic Analytical Hierarchy Process (DAHP), and according to these results, the species prioritisation for agroforestry plantations in Yenice region were found to be as follows: 1. Anatolian walnut, 2. Tilia and 3. Stone Pine. The most important factor effective in this ranking was an economic factor, the income factor. According to the analysis results, the ranking for agroforestry plantations in the region in terms of potential filed was found to be as follows for Anatolian walnut: 1. Yenice Center, 2. Kavakli, 3. Karakaya, 4. Kayadibi, 5. Sariot and 6. Bakraz; for tilia: 1. Kavakli, 2. Karakaya and 3. Kizilkaya; for stone pine: 1. Yenice Centre, 2. Balikisikli and 3. Kizilkaya. The factors effective in making this species and location prioritization were found to be as follows: 1. Ecological conditions, 2. Profitability, 3. Accessibility, 4. Obtaining high quantity and quality product, 5. Sufficient and experienced labour force for picking the product, 6. Supply of quality seed material and 7. The Establishment and nursing of the afforestation areas. According to these results, it can be stated that economic criteria come to the fore in decision-making process for agroforestry, and that the chestnut species is an important species for agroforestry practice.

In another study conducted on this subject (Apichatvullop, et al., 1997), the functional priorities related to agroforestry production techniques were researched in order to bring into balance the situation disturbed as a result of incorrect land use practices and destructions of the forest lands in Thailand. As a result of the study, it was discovered that the economic and social criteria should be taken into consideration primarily in regulating agroforestry activities. Stainback et al. (2011) conducted a questionnaire study with government officials, NGOs and junior partner farmers in order to define the agroforestry activities of Rwanda and to develop a strategy. In the study, the perception of the society on agricultural forestry was tried to be discovered by using SWOT and AHP techniques. When the results were examined, it was understood that the economic and social evaluations came to the fore in agroforestry activities. Through agricultural and forestry production likely to increase with agroforestry, it was considered possible to develop a positive policy that supported sustainable agriculture in Rwanda. The obtained results also showed that various efforts should be made with better coordination in order to encourage small-scale forest farmers regarding forestry and stronger publication services. Particularly carbon balancing markets and other environmental service markets around the world and in our country should be considered as a potential opportunity for small-scale agroforestry. In addition to this, it can be stated that a large number of entrepreneurs adopting agroforestry, especially for rural development, is needed, that the legal regulations and afforestation regulations need to be revised, that it is necessary to prepare effective feasibility reports for each region and each agroforestry activity, and to present the efficiency of the investment to the practitioner through economic criteria such as Net Present Value and Benefit/Cost Analyses, and thus the uncertainty and scepticism towards agroforestry activities will be eliminated.

5. Recommendations

Considering the findings obtained, agroforestry afforestation for chestnut, stone pine and poplar species can be promoted in some parts of the 3rd and 4th class agricultural lands in suitable regions of Bartin province. However, in the afforestation works carried out by both the state and the private sector, the use of quality seeds of suitable provenances and the use of quality seedlings in compliance with the standards are of great importance for success. For this purpose, reinforcing the necessary incentive and supervision services are among the important needs. On the other hand, agroforestry can help small-scale producers to cope with many socio-economic, ecological and technical challenges. For instance, while agroforestry systems can prevent landslides, they can also rejuvenate soil nutrients such as nitrogen, phosphorus, calcium and magnesium, and thus help the agricultural production to increase (Konig, 1992; Roose and Ndayizigiye, 1997; ICRAF, 2010). On the other hand, the studies conducted on agroforestry in many underdeveloped and developing countries show that, including certain trees in agricultural systems, agroforestry considerably increases the annual crops production by adding fixed nitrogen to the soil, enclosing other nutrients and by providing more organic content to the soil (Garrity et al., 2010; Quinion et al, 2010).

When making a recommendations regarding agroforestry in terms of ecological and technical criteria, it should be noted that in addition to the existing agricultural difficulties faced, climate change negatively affects food production as well (Battisti and Naylor, 2009; Working Group on Climate Change and Development, 2006). At the same time, agroforestry has an effective potential of helping small-scale farmers to adapt to the impacts of climate change. Agroforestry provides considerable advantages comparing to the other farming systems in assisting small-scale farmers to cope with the estimated changes. Agroforestry helps the production of agricultural and forest products to diversify to a wider range, and thus buffers against expected climate variability caused by climate change.

On the other hand, agroforestry can improve agricultural productivity in both dry and wet seasons by increasing soil porosity, reducing flows and by utilizing from it. For instance, deep-rooted trees will reduce the evaporation and perspiration rates during the drought periods, and the soil will remain moist (Verchot et al., 2007). Considering that the small-scale farmers often experience drought periods, it should be noted that agroforestry activities are considered as a good source of income and the economic congestion caused by climatic problems can be alleviated in this way, by reducing the vulnerability of small-scale farmers to increased climate change.
Considering the agroforestry activities from the social aspects, they offer important services to producers through wood, building material, fruit and other wood production. In the forest villages, wood or wood-based charcoal are used by most of the growers as their main source of energy. However, the decrease in tree planting, deforestation and poor management policies threaten this important natural resource. On the other hand, there is an ever-increasing demand for timber products and wood bioenergy around the world (Rutunga et al., 2007). Agroforestry can play a constructive role in eliminating this threat by providing producers with multi-purpose products such as timber, mast and other wood products as well as wood or wood charcoal (Ndayambaje, 2005; Rutunga et al., 2007). Producing these products will also help reduce the pressure on protected areas by lowering the tendency to enter protected areas in order to collect these resources (Bhagwat et al., 2008).

In addition to aforementioned socio-economic, ecological and technical activities, agroforestry can also contribute to various environmental services of global importance (Jose, 2009). Including agroforestry, it can be said that agriculture-forest systems significantly balance the carbon compared to treeless agricultural systems (Nsabimana, 2009; Nair et al., 2009). For instance, the studies show that the agroforestry industry creates 1.5-3.5 Mg carbon (Montagnini and Nair, 2004) per hectare annually. This rate is much higher than treeless agriculture. In addition, agroforestry can also increase both the quality and quantity of water by reducing soil erosion and increasing water filtration (Jose, 2009; Stainback and Masozera, 2010). These environmental services have the potential of generating income for producers, especially forest pheasants, through environmental service markets (FAO, 2007).

In order to be successful and obtain the highest value in agroforestry practices, it is necessary to be aware of the habitat characteristics of the species to be used in the applications and the socio-cultural structure of the society as well as the ecological and silvicultural characteristics. Likewise, through researches to be conducted on this and derivative subjects, the development of scenarios, where forest products, agricultural products and forage crops can be evaluated together, will be ensured in agroforestry implementations. In this way, the life standards and income levels of the local people and, especially those living in rural areas in or close to the forests, can be increased.

In this study, the socio-economic, ecological and technical activities of agroforestry practices in Bartin in Turkey region were evaluated and prioritized by AHP. In line with the findings obtained, which criteria would be prioritized in the activities to be carried out per unit area were also identified. Within the scope agroforestry in both Turkey and the world, during the strategic planning stage before the feasibility studies, the mentioned criteria should be examined, evaluated and prioritized. In this way, the success, the impact area, the way of use, the shape and life of the projects to be prepared will be better understood and evaluated. By this means, contribution will be made to the economy of the region and the country. By combining the analyses of this type of studies with time-series methods, where price estimations for future logs (Sen and Gungor, 2018c) and agricultural product are made, more effective decisions can be ensured in such studies. Also, by assessing the local people carrying out agroforestry activities by SWOT analysis (Toksoy et al., 2009), the strengths, weaknesses, opportunities and threats of agroforestry activities can be determined. Thus, contribution can be made to both the success of agroforestry and the increase in economic and ecological contributions to be provided.

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