OKU Fen Bilimleri Enstitüsü Dergisi
9(1): 225-237, 2026

OKU Journal of The Institute of Science and Technology, 9(1): 225-237, 2026

Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi

Osmaniye Korkut Ata University Journal of The Institute of Science and Technology

Evaluation of Factors Affecting the Sustainability of Waste Management of Outdoor Ornamental Plant Nurseries by Analytical Network Process Method

Şeyda GÜR[1], Özgür KAHRAMAN[2*], Necmettin GÜR[3]

[1]Harran University, Faculty of Engineering, Department of Industrial Engineering, Şanlıurfa
[2]Çanakkale Onsekiz Mart University, Faculty of Architecture and Design, Department of Landscape Architecture,Çanakkale
[3]Çanakkale Onsekiz Mart University, School of Graduate Studies, Department of Landscape Architecture, Çanakkale

[1]https://orcid.org/0000-0002-4639-9657
[2]https://orcid.org/0000-0003-1336-9942
[3]https://orcid.org/0000-0002-8856-7188
*Corresponging author: ozgurkahraman@comu.edu.tr

Research Article

Article History:
Received: 26.02.2025
Accepted: 30.07.2025
Published online:13.01.2026

Keywords:
Outdoor ornamental plants
Nursery
İzmir
Analytical network process
Waste management
Sustainability

ABSTRACT

Waste management and sustainability have become important issues worldwide. The production of outdoor ornamental plants and the increasing amount of waste associated with production have taken their place in waste management, which has become important both in our country and around the world. Waste management and waste recovery in outdoor ornamental plant nurseries require serious strategic and economic planning. Waste control and management in the outdoor ornamental plant production and sales sector play an important role both financially and environmentally. There are factors that influence the sustainability of waste management in outdoor ornamental plant nurseries. In this study, the factors affecting the sustainability of waste management were determined through a literature review and expert opinions from 24 businesses located in 6 different districts of İzmir. The identified factors were then evaluated using the AAS method, which is frequently used in decision-making processes, again with expert opinions. Strategic recommendations were made based on the results obtained.

Dış Mekan Süs Bitkisi Fidanlıklarının Atık Yönetiminin Sürdürülebilir Olmasını Etkileyen Faktörlerin Analitik Ağ Süreci Yöntemi ile Değerlendirilmesi

Araştırma Makalesi

Makale Tarihçesi:
Geliş tarihi: 26.02.2025
Kabul tarihi:30.07.2025
Online Yayınlanma:13.01.2026

Anahtar Kelimeler:
Dış mekan süs bitkileri
Fidanlık
İzmir
Analitik ağ süreci
Atık yönetimi
Sürdürülebilirlik

ÖZ

Atık yönetimi ve sürdürülebilirlik tüm dünyada önemli bir konu haline gelmiştir. Dış mekan süs bitkisi üretimi ve üretime bağlı artan atık miktarı hem ülkemizde hem de dünyada önemli hale gelmiş olan atık yönetimi içerisinde kendi yerini almıştır. Dış mekan süs bitkisi fidanlıklarında atık yönetimi ve atıkların yeniden kazanımı ciddi bir stratejik ve ekonomik planlamayı gerektirmektedir. Dış mekan süs bitkisi üretimi ve satışı sektöründe atıkların kontrolü ve yönetimi hem finansal hem de çevresel açıdan önemli bir paya sahiptir. Dış mekan süs bitkisi fidanlık işletmelerinde atık yönetiminin sürdürülebilirliği üzerine etkili faktörler vardır. Bu çalışmada atık yönetiminin sürdürülebilirliği üzerine etkili olan faktörler, literatür taraması ve İzmir ilinde 6 farklı ilçede yer alan 24 işletmede görev alan uzman görüşleri alınarak belirlenmiştir. Daha sonra belirlenen faktörler karar verme sürecinde sıklıkla kullanılan AAS yönteminde yine uzman görüşleri kullanılarak değerlendirilmiştir. Elde edilen sonuçlara göre de stratejik önerilerde bulunulmuştur.

To Cite: Gür Ş., Kahraman Ö., Gür N. Evaluation of Factors Affecting the Sustainability of Waste Management of Outdoor Ornamental Plant Nurseries by Analytical Network Process Method. Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi 2026; 9(1): 225-237.

1.Introduction

If the concept of ornamental plants is defined in general, they are plants that aesthetically appeal to the eye, have many functional features and provide economic gain. In addition to being a general concept, the concept of ornamental plants is divided into 4 different subgroups. These are outdoor ornamental plants, indoor ornamental plants, cut flowers and geophytes (Ay, 2009). Outdoor ornamental plants are decorative plants that are used in landscape design and planning of various areas such as parks, gardens and various recreation areas, highways and landscaping of buildings, and are produced and sold for this purpose (Figure 1) (Çelik et al., 2014).

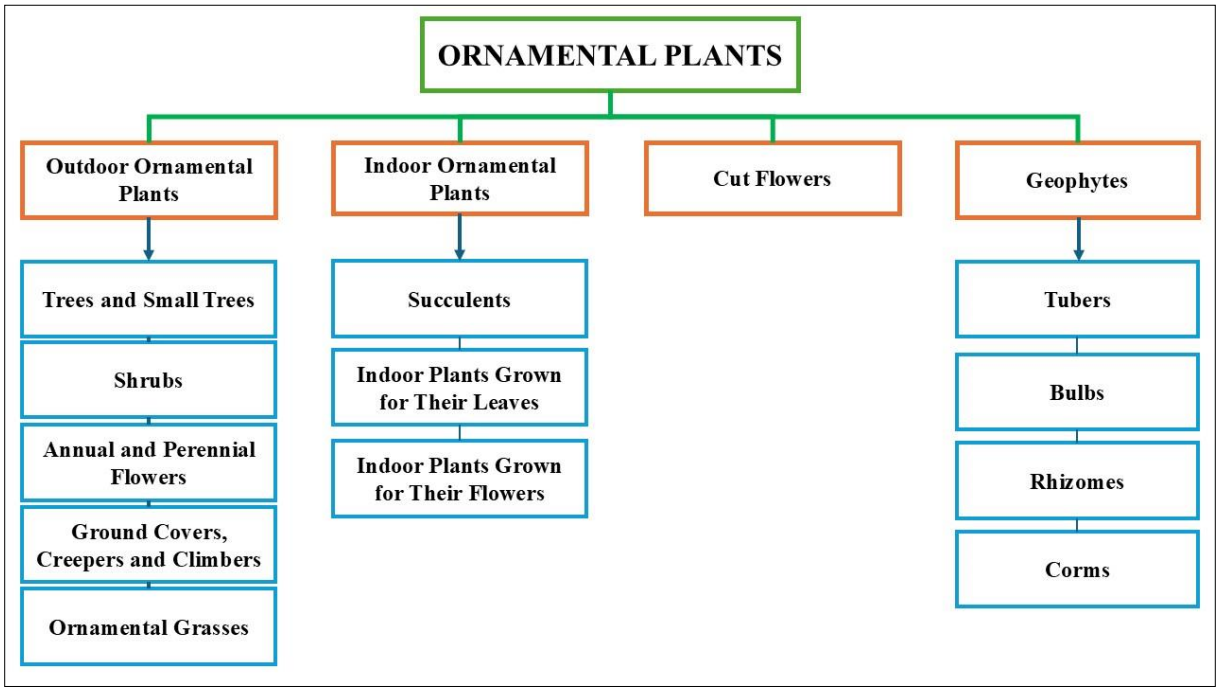

Figure 1. Classification of ornamental plants

The production of ornamental plants takes place in open areas or greenhouses. These production areas are generally called nurseries. Nurseries are private and commercial areas established on lands that are suitable for agriculture or not, where various plant species with different commercial importance and functions are grown and offered for sale (Kılıç and Yılmaz, 2020). Outdoor ornamental plant production is gradually increasing today. In 2009, ornamental plant production was around 57 million units, and in 2016, this number increased to around 412 million units. With the continuous increase in ornamental plant production over the years, it has increased to around 2.16 billion units in 2023. Even 525484.719 of this number was composed of outdoor ornamental plants. According to TÜİK data, ornamental plant production decreased by 6.1% in 2024 compared to the previous year and decreased to approximately 2.32 billion units. In outdoor ornamental plants, this number decreased to 441107.059 in 2024. Compared to the previous year, outdoor ornamental plant production decreased by 16.1% (TÜİK, 2025). In 2024, although there is a decrease in the amount of production compared to the previous year, it is

noteworthy that the amount of production is very high and reaching this high number in the production of outdoor ornamental plants leads to the conclusion that there is also an increase in waste in nursery enterprises. In other words, the increase in the production of outdoor ornamental plants means a direct increase in the waste generated by production in this sector.

Regardless of the sector, the correct management of the wastes of the enterprises is very important in terms of preventing environmental problems. The impact of crop production residues such as carbon, water and ecological footprints is high. The correct management of the collection, transport, storage, disposal or reuse of waste, etc., which cause many environmental problems, is crucial. For a sustainable life and environment, waste management must be sustainable (Şiriner Önver, 2019).

There are studies on waste management and outdoor ornamental plant nurseries in the literature. Morrissey and Browne (2004) examined waste management models and practices to determine sustainable waste management. They stated that there is a basis for considering environmental, economic and social aspects together for sustainable management in the management models they examined. Wilson et al. (2013), in their study, examined how cities in developing countries deal with the solid waste problem within the integrated sustainable waste management system. They defined the integrated waste management system as a method that examines both physical components and management elements together. As a result of their analyses, they stated that the integrated waste management system achieved 95% success in the collection of solid waste in middle-income cities and 50% success in low-income cities. Elsaid and Aghezzaf (2015), in their study, focused on the design and operation of a sustainable waste management system in urban areas. They evaluated some existing waste management models for waste management and to what extent they can be applied in the case of Cairo city. They stated that cost management should be done well to apply the models they examined in the basic dimension and ranked the suitability of the models according to these costs. As seen in the studies in literature, it is very important to plan waste management in a strategic sustainable way. When considered from this point of view, determining and evaluating the factors that ensure the sustainability of waste management is a multi-criteria decision-making problem. The ANP method is frequently used in decision-making problems of decision-makers in literature. The method presents qualitative evaluations to decision-makers in a quantitative way during the decision-making process. At the same time, it provides the opportunity to reflect real life by showing and considering the interaction and feedback between the criteria that are effective on the problem on the network structure. In this case, it shows that the results obtained by the decision-makers are suitable for real life.

This study was conducted to determine and evaluate the factors affecting the sustainability of waste management in outdoor ornamental plant nurseries. For this purpose, the ANP method, one of the multi-criteria decision-making methods, was used in the study.

2. Materials and Methods

In this study, the factors affecting the sustainability of waste management in outdoor ornamental plant nurseries were evaluated using the analytical network process method. To provide an example for the study and to obtain expert opinions, businesses operating in 6 different districts of İzmir province that produce and sell outdoor ornamental plants were selected from those willing to participate in the study. These nursery businesses operate in Aliağa, Bayındır, Çeşme, Menemen, Ödemiş and Urla districts (Figure 2).

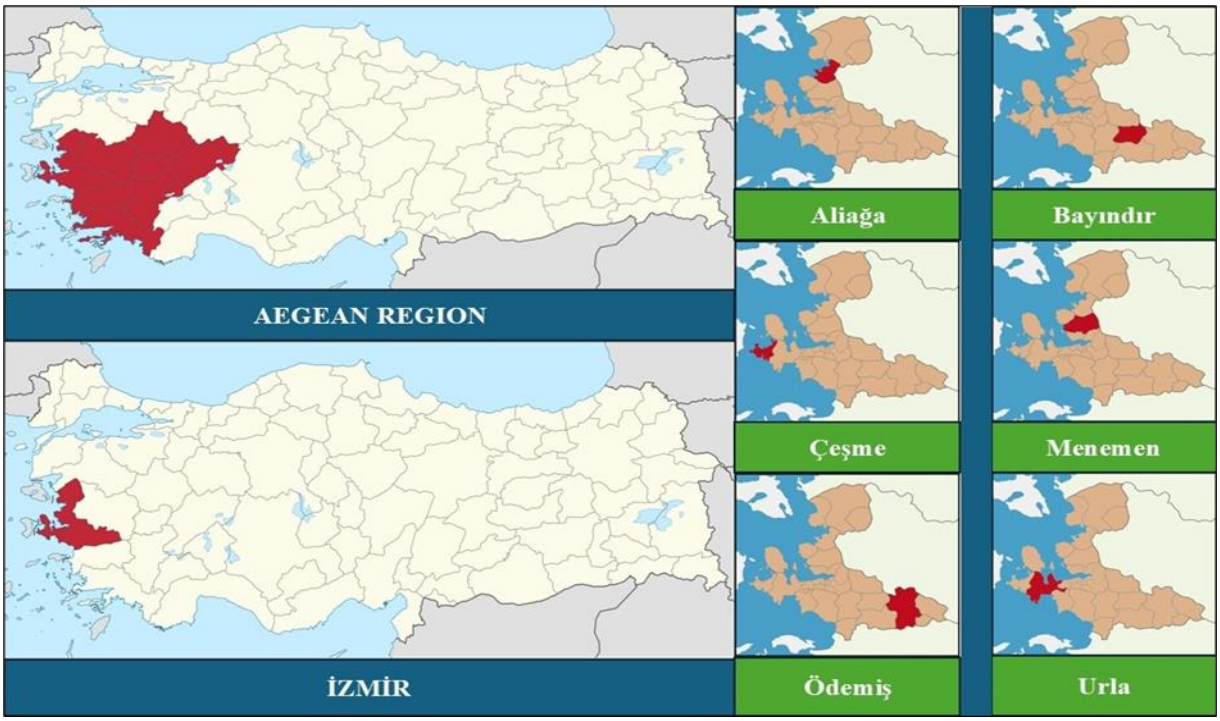

Figure 2. Districts where sample nursery enterprises are located in the study (Wikipedi, 2025a; Wikipedi, 2025b; Wikipedi, 2025c; Wikipedi, 2025d; Wikipedi, 2025e; Wikipedi, 2025f; Wikipedi, 2025g; Wikipedi, 2025h)

A total of 24 enterprises, 2 each from Aliağa and Menemen districts, and 5 each from Bayındır, Çeşme, Ödemiş, and Urla districts, participated in this study voluntarily. Expert opinions were obtained from the enterprise owners, landscape architects, and agricultural engineers.

- Stage 1: The factors affecting the sustainability of waste management in outdoor ornamental plant nursery businesses were determined through literature reviews.
- Stage 2: Expert opinions were obtained for the purpose of establishing relationships between criteria in the ANP method and determining the impact weights of the criteria.
- Stage 3: At the end of the ANP method, the factors were evaluated, and suggestions were made.

2.1. Analytical Network Process (ANP) method:

The analytical network process consists of four consecutive steps (Yang et al., 2010):

1. Definition of the problem: The definition of the problem to be addressed for the solution of the multi-criteria problem is made and expert opinions are obtained for the evaluation of the criteria, sub-criteria and alternatives in the evaluation process.
2. Creation of the network structure: In this stage of the method, the binary relationships, dependencies and interactions between the determined criteria are shown.
3. Establishment of binary comparison matrices: Binary comparison matrices are created to determine the levels of importance between the determined criteria and sub-criteria. The superiority of the criteria over each other is determined and Saaty's 1-9 scale is used when determining these superiorities. Saaty's 1-9 scale is shown in Figure 3. An example binary comparison matrix is shown in Figure 4.

Importance Level	Definition	Explanation
1	Equally Important	Both criteria are equally important.
3	Moderately Important	One criterion is slightly more important than the other.
5	Strongly Important	One criterion is strongly more important than the other.
7	Very Strong Degree Important	One criterion is strongly more important than the other.
9	Absolutely Important	One criterion is very strongly more important than the other.
2, 4, 6, 8	Intermediate Values	There are minor differences between the criteria compared.

Figure 3. Saaty’s 1-9 scale (Mkude and Peter, 2024)

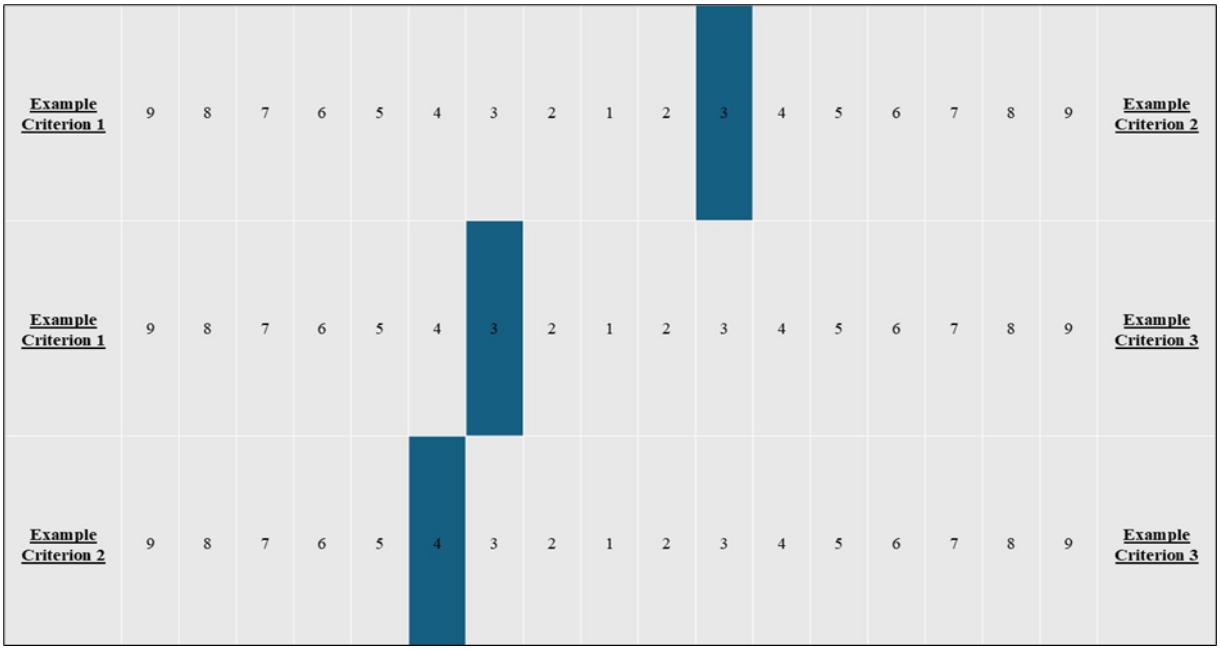

Figure 4. Example pairwise comparison matrix (Gür et al., 2024)

4. Determination of weights: After the creation of pairwise comparison matrices, the weights of the criteria are determined. In the literature, it is seen that researchers frequently use the Super Decision package program (Choi and Kwag, 2013; Song et al., 2018; Termeh and Vahıd, 2018; Wang and Yi, 2020; Aghmashhadi et al., 2022; Qiao et al., 2022). In this study, the Super Decision package program was used to ensure that the solution process can be continued quickly and without errors. In this program, the criteria weight results can be reached after the importance levels of the criteria are entered according to the pairwise comparison matrices. According to the application steps of the method, three super matrix structures are created to reach these weights theoretically. The rows of the super matrix structure are taken to the power of the largest degree until they have the same value, and the limit super matrix is created. The effect of the factors on the decision-making process can be shown with this matrix structure.

3. Results and Discussion

In the first stage of the method, the factors that ensure the sustainability of waste management of outdoor ornamental plant nurseries were determined by literature review. The finalized main and sub-criteria are given in Table 1.

Table 1. Main criteria, sub-criteria and explanations of the criteria (Yılmaz and Bozkurt, 2010; Gündüzalp and Güven, 2016; Ömürbek et al., 2019; Tezel and Yıldız, 2020; Gül and Yaman, 2021; Gürcan and Açıksöz, 2023).

Main Criterion	Sub-Criteria	Criterion Description
Supply Chain	Transport and Storage	In the process of waste management, it is important to separate, collect and stack waste according to its type and characteristics, as well as to store and transport it temporarily. During the transportation, stacking and storage process, the process must be carried out in a way that does not pollute the environment in terms of odor, dust, leakage, etc.
	Supply Chain Integration	Collecting waste from its source means being informed and transparent about every stage of the process until the last stage. Information flow and cooperation should be ensured throughout the chain, considering the targets by ensuring the integration of economic, social and environmental dimensions.
Technology and Automation	Digitization of Applications	Digitalization of the applications is used throughout the process to monitor and control processes throughout waste management and to ensure easy flow of information.
	Waste Monitoring and Analysis	To reduce the negative effects of waste collection, storage and disposal, it is necessary to carefully carry out monitoring, analysis and control activities such as reducing waste, ensuring effective reuse, and separating according to type and characteristics throughout the waste management process with technology-based applications.
Cost	Waste Costs	It is the total cost of activities such as collecting, transporting, separating and recycling waste within the waste management process.
	Circular Economy	Within the scope of waste management, resources are protected with a circular economy, environmental pollution is prevented, waste is prevented as much as possible, and unavoidable waste is recycled and reused.
Consciousness	Sustainable Material Use	For the sustainability of waste management, the materials used must be reusable.
	Waste Management Awareness	To act consciously and be informed about reducing waste or recycling by acting consciously against environmental pollution and protecting resources.
	Legal Regulatory Framework	These are the laws, directives and legislation developed by countries to protect the environment, which impose responsibilities on the parties involved in waste management.

After the first stage of the working method, which was completed with the determination of the criteria, the second stage was started. In this stage, expert opinions were obtained from the business owners, agricultural engineers or landscape architects in the 24 businesses specified in the material to establish bilateral relations between the criteria and to determine the criteria's weights. After the expert opinions were obtained, the ANP method was implemented.

Accordingly, in the first step of the ANP method, the problem definition was determined as the evaluation of the factors affecting the sustainability of waste management in outdoor ornamental plant nurseries. After the problem definition was made, the second step of the ANP method was started. In this step, the network structure and binary relationships between the main and sub-criteria determined by literature reviews were created. (Figure 5). To understand the binary relationships more easily, the sub-criteria were coded and shown. Accordingly, the codes of the sub-criteria;

- Transportation and Storage-A
- Supply Chain Integration-B
- Digitalization of Applications-C
- Waste Monitoring and Analysis-D
- Waste Costs-E
- Circular Economy-F
- Sustainable Material Use-G
- Waste Management Awareness-H
- Legal Regulatory Framework-I.

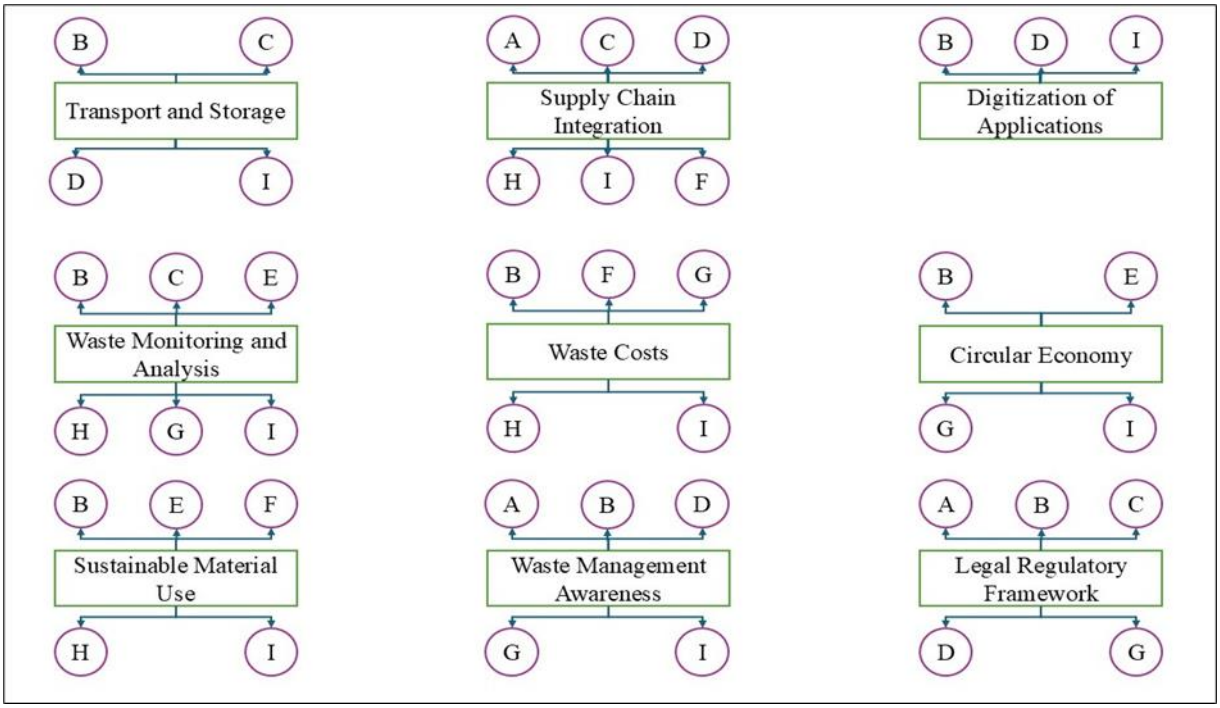

Figure 5. Binary relationships between criteria and network structure

After completing the first two steps in the ANP method, the third step was taken. In this step, pairwise comparison matrices were created according to the interactions in the network structure. After completing the pairwise comparison matrices, the fourth and final step was taken. In this step, the importance levels of the main and sub-criteria were calculated and weighted. It was determined that the

consistency rates were less than 0.1 in all comparisons made. This situation indicates that all comparisons and evaluations made were consistent. Table 2 shows the criterion weights obtained from the comparison matrices of the main and sub-criteria.

Table 2. Criteria weights and importance levels obtained from the ANP method.

Main Criterion	Main Criterion Weight	Sub-Criteria	Sub-Criteria Weight
Supply Chain	0.221	Transportation and Storage	0.375
		Supply Chain Integration	0.625
Technology and Automation	0.204	Digitization of Applications	0.361
		Waste Monitoring and Analysis	0.639
Cost	0.321	Waste Costs	0.475
		Circular Economy	0.525
Consciousness	0.254	Sustainable Material Use	0.295
		Waste Management Awareness	0.278
		Legal Regulatory Framework	0.427

When the weight values of the criteria are examined, it is seen that the values are very close to each other. In this case, it can be commented that the effect of all criteria on the waste management process is almost the same importance based on the main criteria. It is also seen that the cost criterion stands out in the main criteria. Today, the increase in the production and sale of outdoor ornamental plants every year also increases the size of the waste of nursery enterprises (Gür and Erduran Nemutlu, 2022). For this reason, although the main criterion of cost is very important in the waste management process for outdoor ornamental plant nurseries, it is necessary to resort to ways to reduce costs.

The main criterion of consciousness comes after the cost criterion with a weight value of 0.254. The consciousness criterion has shown that nursery enterprises should be conscious about the subject in both production and sales during the waste management process. It is envisaged that with the awareness gained, the level of waste will be reduced, or nursery waste will be recycled as much as possible by separating it at source.

The supply chain with a weight value of 0.221, and the technology and automation criteria with a weight value of 0.204 follow the other criteria. Optimizing the supply chain and ensuring information flow at every stage of the chain is very important for the waste management process. Including technology and automation applications in ensuring this information flows correctly and quickly will increase sustainability.

Table 2 also shows the weight values of the sub-criteria. The weight value of each sub-criteria should be evaluated within the main criterion it belongs to. For example; while the transportation and storage sub-criterion has a weight value of 0.375 within the supply chain main criterion, the supply chain integration sub-criterion has a weight value of 0.625. When the weight values of the sub-criteria are

examined, the sub-criteria within the cost main criterion are seen to be more important. In particular, the circular economy makes the recycling of waste from the producer to the consumer important in environmental, social and community dimensions. Sustainable planning and arrangements should be made for the waste management process according to the criterion weights obtained because of the evaluation of these criteria.

Kulaç (2006) used the ANP method in the selection of solid waste management system for Eskişehir Tepebaşı Municipality in his study. This study is like Kulaç (2006) in terms of using the ANP method in waste management. However, this study differs in that nursery operations in İzmir province were used as the sample area, sustainability was adopted as the problem definition in waste management, and private enterprises were preferred instead of public institutions. In addition, when the literature was examined, no study was found in which multi-criteria decision-making methods were used for waste management in outdoor ornamental plant nurseries.

4. Conclusion and Recommendations

In this study, the factors affecting the waste management process of outdoor ornamental plant nurseries were evaluated. ANP method was used in this process. 4 main criteria and 9 sub-criteria related to the waste management process were determined and evaluated in line with expert opinions.

According to the findings, in the outdoor ornamental plant production and sales sector, the first thing to be done is to raise awareness about waste, environmental health and its effects on humans through information in the recommendations to be given to nurseries for waste management. In this information, businesses can provide information about recycling such as separation at source to consumers through advertising on products, as well as through the public.

Considering the costs that businesses must bear, it is seen that it is necessary to act quickly, especially in terms of waste reduction. Care should be taken to reuse products such as pots, seedling bags, viols, seedling fixing rods made of plastic materials used in production and storage. Organic-based residues such as weeds, fallen leaves and pruning residues, especially after plucking, can be recycled into production by being evaluated as compost.

In order to avoid negative situations such as leakage during the transportation and storage of waste or during the fertilization and pesticide application of plants, and to be informed about such situations immediately, the integration of the entire process with technology makes it possible to intervene immediately in the event of any negative situations that may be encountered.

When viewed from all these points, sustainability of waste management in outdoor ornamental plant nurseries is closely related to the criteria determined in this study, the binary relationships of the criteria and the weight evaluations of the criteria. Nursery businesses can plan a long-term and sustainable waste management process by considering the criteria and suggestions in this study.

Conflict of Interest Statement

The authors declares that there is no conflict of interest.

Summary of Researchers' Contribution Declaration

The authors declare that they have contributed 100% to the article.

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