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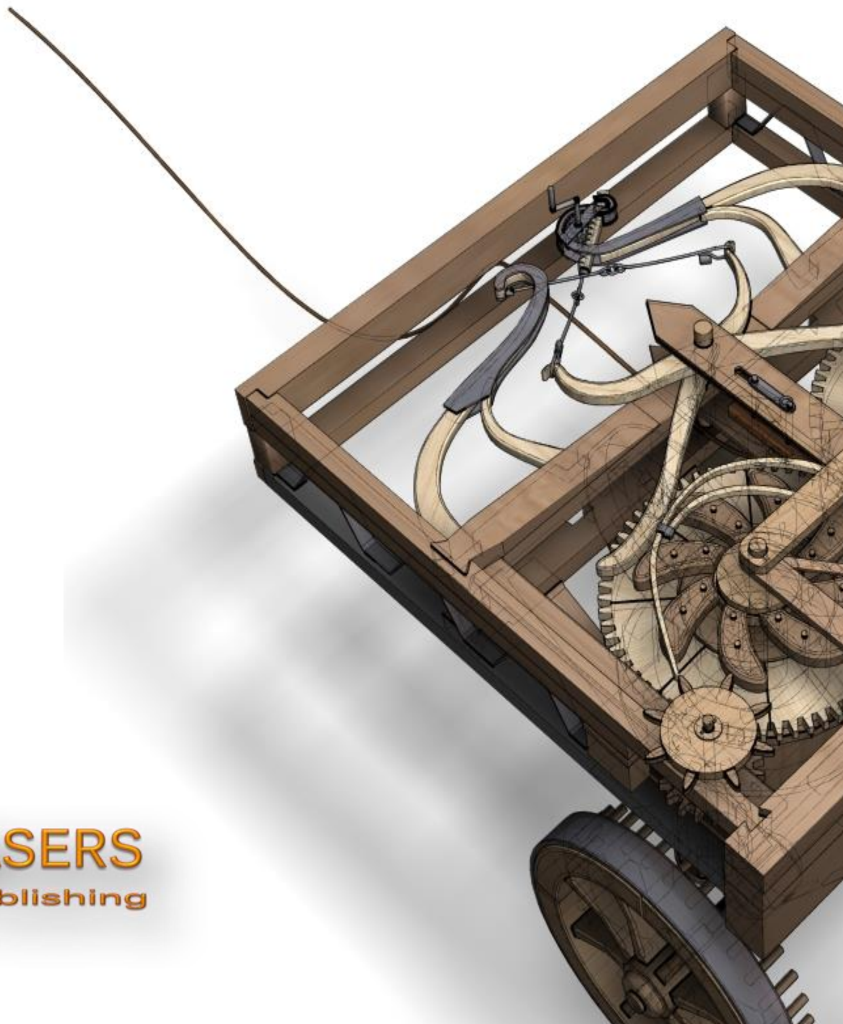

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Table of Contents:

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Fuzzy Analytical Hierarchy Process Evaluation of Stakeholder Groups Involvement in Forest Management Situations

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Abstract: Decision-makers frequently face numerous complex, unforeseen, and irreversible problems when choosing forest management for a given situation. In these kinds of circumstances, a multitude of stakeholders or interest groups may be involved, and it may be necessary to consider a variety of criteria. In a case study of Prespa Park, we employed an approach that integrates the Fuzzy Analytical Hierarchy Process (FAHP), extended goal programming (ExtGoalProg), and "Saaty-type" surveys to rank five forest management scenarios selected through a participatory process. We also looked at three techniques for normalizing stakeholder preferences to see if they affected FAHP scenario rankings. The study was based on different empirical analyses and conducted in three parts. The first part involved identifying the key stakeholders involved in the process, establishing the "stakeholders' panel," dividing it into four "interest groups," and creating a "study/professional panel." The next step involved the identification of five alternative forest management scenarios and their associated criteria. The second part involved applying the FAHP-ExtGoalProg approach, which combines FAHP and *ExtGoalProg*, to rank the scenarios. In the third part of this study, we looked at how the ExtGoalProg, geometric mean, and weighted arithmetic mean techniques compared when it came to combining the preferences of different stakeholders into a single preference for all five forest management scenarios. The techniques produced varying scenario rankings, indicating that stakeholders should consult and consider the situation before selecting the optimal normalization technique to prevent bias or misleading results. The suggested approach is suitable for addressing comparable issues in forestry and environmental management.

Keywords: analytic hierarchy process; extended goal programming; fuzzy analytic hierarchy process; geometric mean technique; participatory planning; Prespa Park; weighted arithmetic mean technique.

JEL Classification: Q23; C51; C65.

Introduction

Forest management has commonly served a variety of purposes. More people now recognize forests for their non-timber forest value, such as biodiversity and recreation, in addition to their timber and financial returns (Davis *et al.* 2001). This shift in focus from maximizing timber production, financial returns, and technical processes, which has occurred over the course of several decades, to recognizing forests as sources of other forest values is ongoing. For this reason, as Diaz-Balteiro and Romero (2008) point out, many forest management scenarios are complex and require balancing economic, environmental, and social aspects. As well, according to our reviewed literature (Karjalainen *et al.* 2003; Bolte *et al.* 2006; Diaz-Balteiro and Romero 2008; Krcmar and van Kooten 2008; Khadka *et al.* 2013; Grošelj *et al.* 2016), planning for forest management is complex because you have to think about what will happen in the long term, biophysical and socioeconomic factors that are hard to predict, and the interests and priorities of many actors who have different knowledge, experiences, and goals, which often conflict with each other. This study effectively addressed the problem.

Forest management, as mentioned above, frequently involves many stakeholders and/or interest groups with different needs, preferences, and ideas about how to manage the forest. Various participatory methods, like organizing workshops, can facilitate this involvement by allowing actors to express themselves and engage in discussions. We can also use surveys to gather qualitative and/or quantitative information about actors' preferences. In this study, we used three one-day workshops and "Saaty-type" surveys. The main aim of the first one-day workshop was to identify stakeholder representatives who represent the interests of all relevant groups in the Prespa Park case study and must have a sufficient level of expertise and experience to ensure a comprehensive understanding of all discussed topics and organize them in interest groups, which must be as effective as possible in facilitating the implementation of "Saaty-type" surveys. To address the later issue, we took into account the findings of Mattsson *et al.* (2019) that a trans-border protected area, as in our case study, can achieve effective planning with as few as 15 stakeholders organized into six groups. So, in this workshop, first we identified a "stakeholders' panel" of the 26 most relevant stakeholders and then organized it into four "interest groups." Additionally, we also formed a "study/professional group" that aimed to generate a collective decision through direct debate.

Numerous studies (Nordström *et al.* 2010; Grošelj *et al.* 2016; Grazhdani 2017; Gunduz and Alfar 2019; Marques *et al.* 2020) demonstrate the importance of employing multiple-criteria decision-making analysis (MCDA) methods to understand forest issues, given their complexity and the involvement of numerous criteria and stakeholders. Furthermore, these methods can foster a participatory process by guaranteeing transparency, fairness, and comprehensibility, all of which are crucial for the process to gain legitimacy and acceptance from all involved stakeholders. A lot of other research, like Nordström *et al.* (2012) and Gunduz and Alfar (2019), shows that the Analytic Hierarchy Process (AHP) is one of the most extensively used multiple-criterion decision-making methods in forest field. It can also work well with participatory methods to mathematically depict the complicated processes involved in real-life forest management decisions. As a result, we established a three-level AHP hierarchical structure in this study.

Meanwhile, the AHP has certain drawbacks, particularly in its inability to capture the ambiguities or mistakes associated with group decision-making. Meanwhile, it can effortlessly integrate with various techniques, including fuzzy logic. To address these deficiencies and capabilities, Zadeh (1965) developed the integration of AHP and fuzzy theory. The fuzzy AHP (FAHP) (Saaty 1987) addresses these issues, making it a robust and flexible decision-making tool, as highlighted by Torfi *et al.* (2010). In light of this, we used the participatory FAHP approach in place of AHP to evaluate and ranked the five selected forest management scenarios in Prespa Park.

As noted by Nordström *et al.* (2012), choosing the normalization technique to combine the preferences of individual stakeholders into a collective preference is one debatable aspect of AHP modeling. The geometric mean technique (*GeoMeanTech*) (Ananda and Herath 2008; Nordström *et al.* 2012; Srdjevic *et al.* 2013), the weighted arithmetic mean technique (WeighArithMeanTech) (Nordström 2010; Grazhdani 2017), and the extended goal programming (*ExtGoalProg*) technique (Ignizio and Romero 2003; González-Pachón and Romero 2007; Nordström *et al.* 2012) are the three most common ways to solve this problem. Naturally, the question of whether the type of normalization technique affects the FAHP results is intriguing. To address this question, we compared the outcomes of three abovementioned normalization techniques in the third part of the study in the participatory FAHP process for ranking forest management scenarios**.**

In sum, for this study, we developed an approach that combines participatory FAHP with ExtGoalProg and used it to rank five forest management scenarios selected through a participatory process. We also compared three techniques for consolidating individual preferences from the "stakeholders' panel" into a collective preference.

1. Literature Review

A large number of research studies (Davis *et al.* 2001; Prell *et al.* 2009; Nordström *et al.* 1012; Maroto *et al.* 2013; Diaz-Balteiro *et al.* 2016; Focacci *et al.* 2017) have documented that managing forests sustainably means preserving and improving the numerous ecosystem services that woodlands provide, such as biodiversity, harvested wood products, recreation, and local livelihoods, while also addressing climate change, necessitating consideration of a wide range of evaluation criteria of highly different natures. Because of this, they all emphasize the necessity of using methods of multi-criteria decision analysis in order to handle decision-making challenges in forest management.

Furthermore, forest management frequently involves many stakeholders and/or interest groups, each with distinct interests, preferences, and points of view, which can enrich forest management planning. Nordström *et al.* (2010), Maroto *et al.* (2013), Borges *et al.* (2017), Nilsson *et al.* (2016) and Bruña-García and Marey-Pérez (2018) are among the studies that highlight the significance of considering and incorporating the interests and concerns of stakeholders in forest management processes. According to them, stakeholder participation in decision-making regarding forest planning and management is believed to have several advantages, such as making this process more open and transparent, giving a voice to underrepresented groups, bringing people together to understand other actors' viewpoints, finding agreement on issues and values, resolving disagreements in a timely and organized manner to prevent conflicts, and, finally, making a better and more legitimate decision. This study effectively addressed this problem. Additionally, Carmona *et al.* (2013), Sarvašová *et al.* (2014), and Balest *et al.* (2016) all stress the significance of participatory processes. They also demonstrate that forest managers and decision-makers can create tailored scenarios and policies that improve social acceptance and sustainability by learning about the interests and priorities of different actors.

Researchers have conducted several studies to explore the potential benefits of incorporating stakeholder participation into protected area management. For example, Valasiuk *et al.* (2018) evaluated the preferences of stakeholders in terms of public good planning for boreal forest ecosystems. In his article, Holder (2016) discusses the success of a forest governance structure in a transboundary reserve that is located in three different countries in Central America. He attributes this success to increased indigenous engagement. In addition, Clamote Rodrigues and Fischborn (2016) offer a plethora of examples of transboundary conservation initiatives, detailing the achievements of these reserves through better transboundary cooperation and more participatory processes involving local stakeholders.

On the other hand, the authors of Marques *et al.* (2020) and Brody (2016) say that forest management is often hard because different stakeholders have different needs and wants. They say that participatory approaches might help bring together the needs and wants of stakeholders, thereby solving this problem. Furthermore, even with a few disagreements, a large number of participants might make it hard to reach a consensus. In this study, we took these insights into account when we identified the "stakeholders' panel," where we included the most relevant stakeholders and then organized them into four "interest groups," as well as the establishment of a "study/professional group."

Based on the aforementioned information, we can conclude that the participatory framework necessitates the use of multi-criteria decision analysis tools to structure and quantify complex decisions during the decision-making process. This fits with a lot of research that has been done in the last few decades (Kangas *et al.* 2002; Laukkanen *et al.* 2004; Munda 2004; Mendoza and Martins 2006; Bolte *et al.* 2006; Rauschmayer and Wittmer 2006; Diaz-Balteiro and Asensoc 2006; Saarikoski *et al.* 2013; Grošelj *et al.* 2016; Grazhdani 2017; Gunduz and Alfar 2019) that says that MCDA and participatory process work well together to evaluate and/or rank the effects of different resource management strategies on the economic, environmental, social, and cultural long-term sustainability of forests. This research employed participatory multi-criteria decision-making analysis as its methodological framework.

Meanwhile, a wide range of other studies (Kangas 1994; Sheppard and Meitner 2005; Hiltunen *et al.* 2008; Ananda and Herath 2009; Nordström *et al.* 2010; Khadka 2013) have used a variety of mathematical modelling methods of various levels of complexity to solve participatory multi-criteria problems in the field of forest management planning. According to Gunduz and Alfar (2019), the AHP holds an important position in the mathematical description of the complex processes, including forest management, which arise during the decision-making process. Through pairwise comparisons, the AHP solicits expert input collected through surveys (Thirumalaivasan *et al.* 2003; Garfi *et al.* 2011). Two distinct scales, one based on crisp numbers (ranging from 1 to 9) and the other on fuzzy numbers, primarily categorize the extensive body of material on the AHP method for recording pairwise comparisons. Saaty (1980; 1990) developed the original method, which uses a crisp scale ranging from 1 to 9. Natural language labels, such as weak, normal, strong, etc., evaluate decision-maker preferences, representing them as a single crisp number on this scale and recording them in comparison matrices.

Moreover, the fuzzy method uses fuzzy integers to record expert preferences in fuzzy comparison matrices. Fuzzy integers more accurately represent human judgments and preferences than crisp numbers can because of the uncertainty and ambiguity of human behavior. Zadeh's fuzzy set theory has widely integrated the original AHP to address the issues of ambiguity and lack of clarity. This incorporation allows for the transformation of human judgments into ratio scales by utilizing a weighing scale consisting of fuzzy numbers. This is the rationale behind our use of the FAHP framework in this study, which allows us to derive weights from fuzzy comparison matrix data. It then uses these comparisons to generate ratio scales that reflect the decision-maker's preferences for different scenarios based on the criteria, as well as the relative weights of the criteria themselves. Calculating the normalized weighted sum across the criteria results in an overall score associated with each accessible alternative, aiding the decision-maker in choosing the scenario that will lead to the optimal decision. Pérez-Rodríguez and Rojo-Alboreca (2017) and Chan *et al.* (2019) demonstrate the conditions relating to differences between FAHP and classical AHP from both a quantitative and qualitative perspective.

We then use these weights to rank the various alternatives, taking into account the scores each option achieves for each criterion. An important part of the process is, thus, finding the weights in the comparison matrices.

To accomplish this, the standard AHP framework primarily uses the eigenvectors method. In addition to the eigenvector method, the literature offers a number of other alternative techniques. Most commonly used are the arithmetic and geometric mean techniques, as well as the extended goal programming technique. This study applies all three techniques in the FAHP framework used in this study.

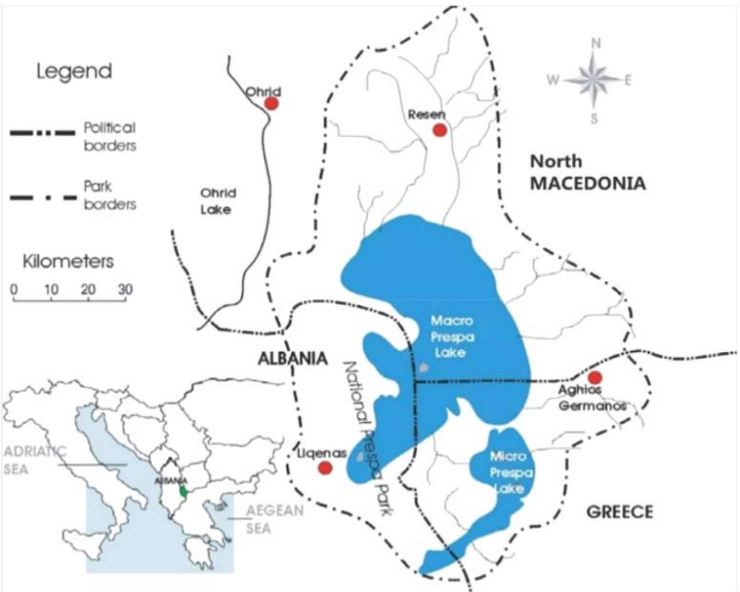
2. Material and Methods

2.1. Case Study Description

We conducted this study on the Prespa Park region, which serves as an excellent case study due to its status as a watershed area with rich biodiversity and a long human history (Grazhdani 2014). Prespa refers to a pair of freshwater lakes, namely Macro and Micro Prespa are two freshwater lakes located in southeast Europe (Grazhdani 2024a). Albania, Greece, and North Macedonia share these lakes (Figure 1). The prime ministers of three republics jointly formed it on February 2, 2000, making it the first trans-border protected area in the Balkans (Grazhdani 2023). At an altitude of 850 m above sea level (Grazhdani 2015), the park covers a combined drainage basin area of 2,519 km^2 and has a population of about 24,000 people (Grazhdani 2016), distributed among three municipalities: Pusteci-Albania, Resen-North Macedonia, and Prespa-Greece. According to the Ramsar Convention on Wetlands, there are two wetlands of international importance inside the Transboundary Prespa Park boundaries. WWF-International has designated the region as a Gift to the Earth, and the European Union has included Prespa Lakes in its water and biodiversity protection policy.

Prespa Park contains important freshwater and forest ecosystems, including pseudo-Alpine meadows located above the forest limit. Each of the three countries has designated lakes, shorelines, and the majority of forest regions as national protected areas. The entire Prespa region is home to a wide variety of remarkable habitats and species that are significant from a conservation perspective on both a European and a worldwide scale (Grazhdani 2024b).

Figure 1. Prespa Park Region



All of the forests in the Albanian part of the basin, which cover about 13,000 ha and 1,800 ha of pastures, are components of Prespa National Park (Grazhdani 2010). Eighty-six percent of all forests in Greece are included in the Prespa National Forest (Catsadorakis and Malakou 1997). According to Matevski *et al.* (2010), there are 356 km^2 of forests in the northern Macedonian part of the Prespa Park basin. Protected areas, including Pelister and Galicica National Parks, account for over 40% of these forests.

Although no habitat type can be considered uncommon on a worldwide scale, Prespa Park is home to many forests classified as habitat types of European interest. These forests include the following: *Quercetum trojanae macedonicum* thrives on stony, steep terrain at altitudes of up to 1,200 meters above sea level in Albania, Greece, and North Macedonia. The Grecian juniper woods *(Juniperus excelsa),* rare in Europe and only found in northern parts of Greece and North Macedonia, develop as another important forest habitat type in the oak forest zone (Matevski *et al.* 2010; Vrahnakis *et al.* 2011). North Macedonia should also recognize the well-preserved stands of beech woods (*Abieti-Fagetum macedonicum* and *Calamintho grandiflorae Fagetum*), which are among the forest habitat types of European interest (Matevski *et al.* 2010).

Prespa Park, which encompasses 465 km^2 of forests, is home to a number of well-liked recreation areas and is one of the region's most important economic drivers, along with tourism and agriculture. It is home to a number of well-liked recreation areas. In the winter, skiing is available, while in the summer, hiking and cycling are. Throughout history, humans have relied on forests, woodlands, and sporadic trees for food, fuel, shelter, building materials, and medicinal purposes. These days, they rely on forests for many ecosystem services, including the provision of materials and goods (food, fuel, fiber, and pharmaceuticals), a variety of regulatory services (protection of watersheds, control of climate change, preservation of biodiversity), and cultural services (entertainment, tranquility, inspiration, and aesthetic pleasure). The local population's demand for places for recreational, hunting, and fishing activities has been increasing, while the commercial use of the forest has been decreasing. Human interventions have affected all the forests within Prespa Park's perimeter. The recovery of forests is crucial for the restoration of essential forest functions. Only forests with intact ecosystems can provide the requested long-term services.

In an effort to tackle and resolve the intricate problems related to forest planning situations in Prespa Park, Grazhdani (2017) conducted a study. Based on this study's findings and taking into account its limitations, the present study used an improved methodological framework and normalization techniques to rank five forest management scenarios selected through a participatory process at Prespa Park.

2.2. Participatory Planning

Participatory planning is a series of interaction activities between institutions and individuals, as well as the many governance arrangements, forms, and methods that moderate these with the goal of defining and resolving a specific issue. Many scholars (Adger *et al.* 2005; Lemos and Agrawal 2006; Renn and Schweizer 2009; Rossi *et al.* 2011; Burton and Mustelin 2013; Focacci *et al.* 2017) have recognized the importance, equity, acceptability, and, in the end, sustainability of citizen participation in transdisciplinary governance processes.

Participation has a long history in different domains, including forest management and planning, and has played out differently across the world. Participatory forest planning is hard because it involves a lot of different local communities and new, cross-disciplinary methods like collaborative governance (Mermet and Farcy 2011; Kabisch *et al.* 2016; Nesshöver *et al.* 2017; Wamsler and Raggers 2018; Frantzeskaki 2019; Wamsler *et al.* 2020).

This study employed a participatory forest process for forest stakeholders, who are typically decision-makers, representatives from forestry and non-forestry businesses, municipal officials, nature conservation, tourism, outdoor sports and recreation, and nongovernmental organizations, to evaluate forest management scenarios that account for multiple stakeholder values.

2.3. Participatory MCDA Method

The MCDA method evaluates and compares different options based on multiple criteria. Different authors (Nordström *et al.* 2012; Grazhdani 2017) present the MCDA method for participatory decision-making in a variety of ways. These authors draw attention to the consequences of alternative solutions within the context of planning and policy-making. Interestingly, each author uses a different set of names and numbers to identify the steps of the process. Furthermore, MCDA serves as a tool for managing wicked situations by facilitating the study and structure of the decision problem and incorporating subjective preferences into the decision-making process.

On the other hand, forest management involves many stakeholders, increasing the dimensions of forest planning and forcing the use of participatory techniques. The participatory MCDA method incorporates stakeholder values and provides a structured way of working, ensuring that it is fair, transparent, and simple to understand—qualities that are essential for the process's legitimacy and acceptance by the stakeholders (Mendoza and Martins 2006; Rauschmayer and Wittmer 2006; Nordström *et al.* 2010; Adem Esmail and Geneletti 2018).

As de Castro and Urios (2017) highlight, protected area planning using participatory MCDA methods has been successful and has proven to be effective in certain complicated circumstances (Cortina and Boggia 2014; Sánchez-Lozano and Bernal-Conesa 2017). This consideration prompted this study to use MCDA in a transboundary Prespa Park protected area to evaluate stakeholder groups' involvement in forest management situations.

2.4. Fuzzy Analytic Hierarchy Process (FAHP)

According to Ezquerro *et al.* (2016), Cegan *et al.* (2017), and Diaz-Balteiro *et al.* (2017), structured methods have become among the most popular and widely used for organizing, analyzing, and resolving complex multicriteria decision-making. One of these is the AHP method. AHP assists decision-makers in determining the "answer" that best meets their purpose, rather than a "correct" selection, by setting a general objective with respect to a number of scenarios evaluated on multiple criteria.

AHP is also one of the most widely used MCDA methods in forestry applications, either alone or in combination with other MCDA approaches (Kangas *et al.* 2006; Ananda and Herath 2009). According to Kangas (1994), AHP is a tool that integrates public preferences for strategic planning decisions related to forest management, whereas Kangas *et al.* (2006) enhanced strategic forest planning's quantitative basis by employing the FAHP method. Additionally, according to Ortiz-Urbina *et al.* (2019), AHP has proven helpful in gathering stakeholder preferences during participatory planning processes in protected areas. Furthermore, Diaz-Balteiro *et al.* (2017) assert that AHP's attractiveness has increased over the preceding two decades. Today, the multi-criteria decision-making analysis process extensively uses the AHP analysis method, along with fuzzy set theory, known as the fuzzy AHP (FAHP) method. Kangas and Kangas (2005), Ananda and Herath (2009), and Ahmed and Kilic (2019) all say that researchers can combine FAHP with other MCDA methods, like goal programming, to make the results more accurate and to make the way humans make decisions more like real life. In this study, we used a hybrid approach, combining FAHP with extended goal programming.

We structured the procedure for using the FAHP in this study into four steps, as follows: In the first step, we construct a hierarchical structure that includes the main study goal, forest management scenarios, and criteria to evaluate the scenarios. In the second step, we compare the components (criteria, forest management scenarios) and derive weights for each level to establish their relative importance; then, in the third step, we calculate the weights of the criteria and scenarios using fuzzy arithmetic operations, and in the fourth step, we synthesize the weights to obtain normalized weights using extended goal programming. The ranking of the scenarios in descending order was based on the value of normalized weights (the greater the value of the normalized weights, the more highly ranked the forest scenario).

2.5. Extended Goal Programming

Goal programming (GP) addresses complex issues using the linear programming method. According to Ignizio and Romero (2003) and Nordström *et al.* (2012), GP develops compromise solutions that may not fully meet all the goals but do reach specific satisfaction levels defined by the decision-maker. This process involves the definition of an objective function and some defined constraints. Even in forestry environments, researchers regularly use GP as a method for measuring sustainability. In numerous studies (Cortina and Boggia 2014; Uhde *et al.* 2015; Diaz-Balteiro *et al.* 2016; de Castro and Urios 2017; Diaz-Balteiro *et al.* 2017; Sánchez-Lozano and Bernal-Conesa 2017), the researchers have successfully implemented GP to plan various forest resources and protected areas. In this study we used extended goal programming (*ExtGoalProg*) developed by González-Pachón and Romero (2007; 2010). For a detailed information of extended goal programming, consult the studies conducted by André and Romero (2008), Nordström *et al.* (2012), and Grazhdani (2017).

The operational procedure that we used for the *ExtGoalProg* technique to generate stakeholder preference data from the Prespa Park case study and five alternative forest scenarios for this study consisted of three steps: During the first step, we developed consensus matrices for each interest group and used these matrices to determine the criteria weights. During the second step, we established rankings for five different forest management scenarios for each interest group using the criterion weights. In the third step, we combined the forest management scenarios' rankings for each interest group to create their normalized ranking.

2.6. Data Collection

The study employed a number of methods to gather data and information during the course of 2019. For inclusive activities, we conducted three one-day participatory workshops and "Saaty-type" surveys.

People from the local community, forestry and non-forestry businesses, municipal officials, nature conservation, tourism, outdoor sports and recreation representatives, organizations that focus on natural resource management in the area, and those involved in forest management through policy were invited to participate in first one-day workshop. Prior to getting into the expectations and concerns of the forest stakeholders, we provided background information on the study, including its goals and objectives, to the participants upon their arrival at the workshop. During the remainder of the workshop, participants focused on two topics: identifying potential stakeholders and then establishing a stakeholders' panel; and forming a "study/professional group." The chosen stakeholders formed four "interest groups": the forest group, the nature-conservationists group, the tourism group, and the sports-outdoor life group. The number of representatives varied among the interest groups due to the nature of the circumstances. Nine people represented the forest group: six from forest companies or agencies and three from municipalities. Seven people represented the tourism operator group. The nature conservationists were represented by five representatives from nongovernmental organizations. Five people made up the group of representatives for sports and outdoor life. During the study, these 26 stakeholders formed a "stakeholders' panel" and individually stated their preferences through a "Saaty-type" survey. In addition, the workshop also formed a "study/professional group" consisting of individuals with diverse areas of expertise to contribute to the planning process. This panel included 15 members with experience in the forest sector, community development, recreation, nature conservation, outdoor activities, and ecosystem management who work together as a group to establish a collective preference directly through discussion.

Participants from a variety of fields, possessing extensive expertise in the subjects under investigation, attended the second one-day workshop that established criteria. The stakeholders' panel refined the preliminary list of 10 criteria, and the "study/professional group" asked the participants to rate them using a "Saaty-type" survey in the second one-day workshop. The entire workshop was filled with lively discussions among the attendees. At the conclusion of the workshop, we had reached an agreement on the following five crucial criteria: The first is the area of forest, measured in hectares (ha), that is not managed for social or recreational purposes; the second is the area of forest, measured in hectares (ha), that is not managed for the purpose of conserving nature; the third is the amount of forest, measured in hectares (ha), that is older than 100 years; the fourth is accessibility to the forest: information is given for both a) the area of forest, measured in hectares (ha), that is used for the collection of forest products and b) the area of forest, measured in hectares (ha), that is managed for social or recreational purposes. The fifth criteria is the aesthetic and cultural-historical value of the forest, defined as a low of 1 and a high of 10.

The objective of the third one-day workshop was to develop a series of scenarios related to forest planning. The "study/professional group" and the "stakeholders' panel" came together to achieve this. Through a series of short presentations and panel discussions, we briefed the participants on the key principles of the participatory multi-criteria decision analysis, the possible forest management scenarios, and their features in Prespa Park. At the end of the workshop, the participants developed five alternative forest management scenarios (referred to as S_1, S_2, S_3, S_4, and S_5) based on the specified criteria selected during second one-day workshop. They were as follows: Scenario S_1 involves the development of sustainable tourism and recreation opportunities, while scenario S_2 focuses on the protection of biodiversity and natural assets. Scenario S_3 involves utilizing the potential of cultural heritage. Scenario S_4 is a mixed-use scenario that makes use of the potential for cultural heritage, biodiversity conservation, and, to a certain extent, recreation; scenario S_5 is a mixed-use scenario that makes use of the potential for forest product collection, cultural heritage, recreation, and, to a certain extent, biodiversity conservation.

3. Results and Discussion

3.1. Ranking of Forest Management Scenarios Using FAHP–ExtGoalProg Approach in Prespa Park

Evaluating and ranking different forest planning plans increases the efficiency of decision-making in sustainable forest management. To address this problem, we used the FAHP method, coupled with the extended goal programming normalization method and a "Saaty-type" survey completed by "stakeholders' panel" members.

We established an FAHP procedure, structuring it into four steps as follows: During the first step, we established a hierarchical structure with three levels. This structure included the main study goal in the first level, which was to rank the forest management scenarios in support of sustainable management of the forestry in Prespa Park, forest management scenarios (second level), and criteria to evaluate the scenarios (third level).

In the second step, we determined the variables preferences (criteria, forest management scenarios) at each level by generating a set of pair-wise comparison matrices of all the variables in relation to each other. To do this, we produced an FAHP questionnaire and shared it via email with the "stakeholders' panel" members for assessment. Each member provided a possible value for each analyzed issue using Saaty's 1–9 scale, where 1 represents equal importance and 9 shows the extreme importance of one variable compared to another (Saaty 1980).

The next step was to carry out a consistency test. We mathematically calculated the consistency ratio (CR) to verify this. It is important to note that *CR* describes the degree of consistency or inconsistency, as Scholl *et al.* (2005) point out. We found the overall consistency of the hierarchical structure to be a consistency ratio (CR) of 0.084. We deemed the inter-level interactions within the hierarchical structure and the overall hierarchy's consistency satisfactory because this number is lower than 0.1 (Saaty 2008).

In the fourth step, we completed the weight determination. To rank the scenarios using the ExtGoalProg technique, we normalized individual preferences into a collective preference. We used Expert Choice Software (2002) to analyze the consistency test and calculate the weighting in this study. Table 1 summarizes the results of S_1–S_5 scenarios ranking within each interest group and their overall ranking obtained by the FAHP–ExtGoalProg approach.

Table 1. Ranking of scenarios S_1–S_5 within each interest group, and their overall ranking obtained by FAHP–ExtGoalProg approach

Variable	Interest group				Overall plans ranking
	Forest	Tourism	Nature - conservationists	Sports-outdoor life	
Scenario S_1	1	1	1	1	1
Scenario S_2	4	5	5	5	5
Scenario S_3	5	3	3	4	4
Scenario S_4	2	2	2	2	2
Scenario S_5	3	4	4	3	3
A higher rank is indicated by a lower numerical value.					

Source: The author's collected and elaborated survey data for 2019

The results (Table 1) revealed that the "Development of sustainable tourism and recreational opportunities scenario" (Scenario *S_1*) held the highest ranking, with the other scenarios following in descending order: Scenario *S_4*, a mixed-use scenario, utilizes the potential for cultural heritage, biodiversity conservation, and, to some extent, recreation. Similarly, scenario *S_5*, also a mixed-use scenario, utilizes the potential for forest product collection, cultural heritage, recreation, and, to some extent, biodiversity conservation. Finally, scenario *S_3*, which focuses on utilizing the potential of cultural heritage, and scenario *S_2*, which aims to protect biodiversity and natural assets, rank lower.

Overall, the process evaluation shows that using FAHP, participatory planning, and the *ExtGoalProg* technique together is a good way to handle complicated forest management situations involving several stakeholders and competing standards. The process evaluation demonstrates a good level of decision-making transparency by structurally integrating stakeholder values. Furthermore, the approach enhanced the quality of judgments by effectively balancing conflicting interests, resulting in broader acceptance among all stakeholders.

3.2. Results of Three Normalizing Methods in FAHP Participatory Forest Planning

Another goal of this study was to compare a trio of methods for normalizing stakeholders' individual preferences into a collective preference. The purpose of this comparison was to determine whether or not the choice of normalization method had an effect on the FAHP ranking of scenarios. To obtain preferences, we used the FAHP method, and to normalize individual preferences, we used the *WeighArithMeanTech*, *GeoMeanTech*, and *ExtGoalProg* techniques.

To address this goal, we first used the FAHP pairwise comparison approach to collect preferences from the "stakeholders' panel" about the criteria and the forest management scenarios. When the panel members had finished expressing their individual preferences, they next proceeded to make pairwise comparisons in order to figure out the relative importance of each stakeholder. After that, they normalized each individual's preferences into a group preference, and then they ranked the scenarios using three distinct techniques: *ExtGoalProg*, *WeighArithMeanTech*, and *GeoMeanTech*. Members of the "stakeholders' panel" were then engaged in a collective panel discussion where they together made comparisons between pairs of items.

Table 2. Scenario S_1–S_5 ranking using three normalized techniques

Variable		Forest management scenarios				
		S_1	S_2	S_3	S_4	S_5
Study/professional group preference approach		1	4	5	2	3
GeoMeanTech		1	2	5	3	4
WeighArithMeanTech	Variable weights	1	5	3	2	4
	Equal weights	1	3	5	2	3
ExtGoalProg	Variable weights					
	"majority principle"	1	5	2	4	3
	"minority principle"	2	5	4	3	1
	Equal weights					
	"majority principle"	1	5	4	3	2
	"minority principle"	2	4	4	2	1

A higher rank is indicated by a lower numerical value.

Source: The author's collected and elaborated survey data for 2019

The "study/professional group" that jointly performed the pairwise comparisons determined one ranking out of the eight in total. Additionally, the "stakeholders' panel," which performed the pairwise comparisons individually, established seven consensus rankings (Table 2).

The *GeoMeanTech* produced a single rating, while the *WeighArithMeanTech* produced two comparable rankings: one with equal weights for all stakeholders and another with variable weights determined by the stakeholders themselves. Meanwhile, the *ExtGoalProg* produced four distinct rankings.

The results (Table 2) show that using the study/professional group preference technique, scenario S_1 is ranked highest. The other scenarios are ranked in descending order as follows: scenario S_4, scenario S_5, scenario S_2, and finally, scenario S_3.

Second, all consensus rankings gave scenario S_1 the highest score, with two exceptions (Table 2) related to the *ExtGoalProg* technique. In this method, the distance metric parameter *r* from the ideal plan determined the ranking; a plan with a lower value ($r = 1$) ranks higher (place 1), while a plan with a higher value ($r = \infty$) ranks second (place 2).

Third, it is worth noting that the "mixed" scenario, specifically scenario S_4 and scenario S_5, gained the highest rank in *ExtGoalProg* when seen from the perspective of a minority ($\alpha = 0$, $\beta = 0$, and $r = \infty$). When it comes to finding solutions that are balanced and consensus-based, the minority perspective of *ExtGoalProg* appeared to be helpful.

Given that different normalization methods yield varying rankings, stakeholders should carefully consider the specific circumstances when selecting a normalization technique.

Conclusions

This study focused on incorporating stakeholder values and combining individual preferences to establish a common choice. We used the FAHP to elicit preferences, and we normalized individual preferences using the weighted arithmetic mean technique, geometric mean technique, and extended goal programming. The findings indicate that these methods can formalize public participation in decision-making while also increasing the process's transparency and legitimacy.

An assessment framework that combined FAHP and *ExtGoalProg* proved to be a useful tool for managing difficult real-world forest management situations in Prespa Park. The case study's findings show that the two most highly ranked alternatives were scenario *S1*, which focuses on the development of sustainable tourism and recreational opportunities, and scenario *S5*, which combines employing the potential of cultural heritage, recreation, the collection of forest products, and, to some extent, biodiversity conservation.

The study also compares the *ExtGoalProg* technique with the more established normalization techniques *GeoMeanTech* and *WeighArithMeanTech*, which are based on geometric and arithmetic means, respectively. Due to their different characteristics, the normalizing techniques investigated in the study produced varying ranks of five forest management scenarios. As a result, stakeholders should adapt the normalization technique to the situation at hand and provide an explanation for it.

The case study of the Prespa Park area demonstrates that, under specific circumstances, a forest management situation could benefit from integrating FAHP with participatory processes. On top of that, by weighing the competing interests of many stakeholders against one another, FAHP leads to solutions that result in increased overall satisfaction among the stakeholders. The suggested approach presents an interesting option for managing the points of view of several stakeholders, offers an operational foundation for sustainable forest management scenarios, and is suitable for handling analogous issues in environmental management.

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Declaration of Competing Interest

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The author declares that she has not used generative AI and AI-assisted technologies during the preparation of this work.

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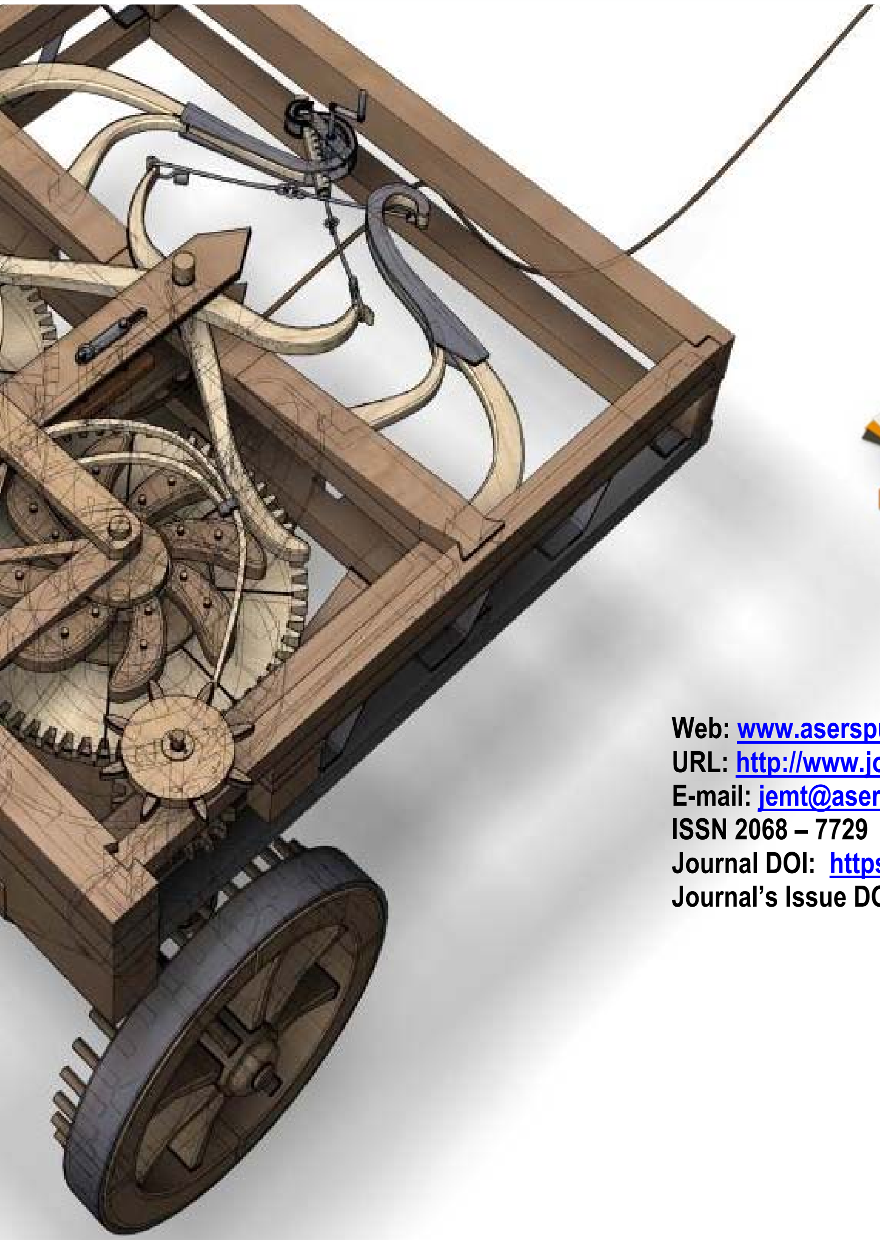

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