Sustainable Approaches in Forestry

Editors

Gökhan ŞEN - Ersin GÜNGÖR

DUVAR

SUSTAINABLE APPROACHES IN FORESTRY

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Chapter 1

Sustainable Management of Local Livelihoods and Ecological Functions: An Assessment on Boundaries of Natural Protected Areas

Mehmet KORKMAZ*

Abstract

In this chapter, assessments have been made of how protected area boundaries should be determined to ensure the sustainability of the livelihoods of local people living in or near the protected area and the ecological sustainability of natural resource values. The example of Kızıldağ National Park, whose boundaries were revised in 1993 and 2018, was used in these assessments. With the 1993 boundary expansion, five settlements were included within the boundaries of the national park. In addition, the agricultural areas of many settlements are located within this boundary. In 2018, the boundaries were revised again, and in addition to the increase in the size of the park, all settlements and a large part of the agricultural land were excluded from the national park boundaries. Of course, the first question that comes to mind at this point is "why were the settlements included in the boundaries of the national park in the first revision?" or vice versa. Because during the 25 years between the two boundary changes (from 1993 to 2018), no effective management could be achieved and no solutions to ecological, economic and social problems could be found. As a result, a three-step methodology is proposed for the delimitation of protected areas: (i) identification of resource values of national and/or international importance that need to be protected and drawing of a draft boundary to protect these values, (ii) detailed identification of the area in terms of ecological, economic and sociological analysis, definition of limiting factors and objectives, (iii) determination of the exact boundaries of the protected area together with planning decisions.

Key Words: National parks, Sustainability, Rural settlements, Socio-economic structure, Kızıldağ National Park

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The importance of nature conservation has increased from the past to the present. Concerns about climate change and the ecological, economic and social sustainability of natural resources are bringing conservation-oriented management approaches to the fore. Among the strategies for mitigating climate change and adapting natural resources to climate change, protecting old-growth natural forests and increasing the number and area of protected areas are among the priority strategies (Lutz et al., 2018; Moomaw et al., 2019; Mildrexler et al., 2020; Korkmaz and Adıgüzel, 2021).

The first studies on protected areas started with the protection of visually important, recreational areas. Today, the reasons why some areas are protected under various laws go far beyond recreation. Natural protected areas are characterised by the implementation of current strategies and policies such as sustainable development, sustainable environmental management, sustainable forest management and biodiversity. In other words, sustainable management of these areas can ensure economic and sociological sustainability as well as their ecological functions.

The concept of a national park was first introduced to the world by George Catlin, an American artist. Seeing the confluence of Yellowstone and the Missouri River, he thought that the natural environment in which humans and other creatures lived should be protected by government policy without losing its freshness. As a result, Catlin advocated the creation of a 'national park' to protect both the indigenous people and wildlife of the American plains. Catlin's idea was implemented, and Yellowstone National Park was created, marking the beginning of the protected area movement (Spence, 1999; Brockington, et al., 2008; Dearden and Langdon, 2009; Innes and Heintzman, 2012).

Protected areas have different statuses. While national parks and nature parks provide opportunities for nature-based tourism and recreational activities (eco-tourism, etc.) as well as protection, nature conservation areas are areas where only scientific activities are allowed. In Turkey, there are 48 national parks (911,204 ha), 261 nature parks (108,332 ha), 31 nature conservation areas (46,455 ha) and 113 natural monuments (8,357 ha) designated under the National Parks Law. In addition, there are special environmental protection areas and natural sites under the management of the Ministry of Environment and Urbanization (Table 1). Taking into account overlapping areas, the total protected area is 8,812,317 ha (URL-1, 2022).

For a protected area to deliver all the expected benefits, it must be managed effectively. This requires management plans. In many developing countries, planning and management of protected areas is dominated by a strict, protectionist approach that often excludes local people. This approach assumes that the resource can be protected by prohibiting or restricting the use of a natural resource through legislation (Rutagarama and Martin, 2006). This approach creates a conflict between decision-makers and resource beneficiaries in terms of the goals and objectives set for protected areas. While the goal of resource managers is to minimize or eliminate the use of these resources, the goal of beneficiaries is to increase their use of these resources, or at least to continue their current use. As a result, the failure to reduce the dependence of local people living in or near protected areas in developing countries on natural resources and the failure to provide alternative sources of income to these people facing socio-economic difficulties is the reason for this passive conservation approach (Arias et al., 2000; Thomas and Middleton, 2003; WWF, 2003; Alkan, 2009; Alkan and Korkmaz, 2009; Alkan et al., 2009).

Table 1. Protected Areas of Türkiye (URL-1, 2022)

Ministry of Agriculture and Forestry Protected Areas		Number	Area (ha)
National Parks		48	911.204
Nature Parks		261	108.332
Nature Monuments		113	8.357
Nature Reserve Areas		31	46.455
Wildlife Conservation Areas		85	1.165.448
Ramsar Areas		14	184.487
Nationally Important Wetlands		59	869.697
Wetland of Local Importance		32	92.236
Protection Forests		55	247.648
City Forests (Forest Parks)		134	9.728
Gene Conservation Forests (in-situ)		339	43.232
Seed Stands (in-situ)		311	40.338
Seed Orchard (ex-situ)		213	1.552
	Total	1.695	3.728.714
Ministry of Environment and Urb. Protected Areas		Number	Area (ha)
Special Environmental Protection Areas		19	3.834.213
Natural Sites		3.834	2.749.626
	Total	3.853	6.583.839

Another problem is the setting of protected area boundaries. Sometimes the boundary is set too narrow and the resource value to be protected cannot be adequately protected, while sometimes the boundary is set excessively wide without sufficient research and investigation. In this chapter, assessments have been made of how the boundaries of the protected area should be set to ensure the sustainability of the livelihoods of the local people living within or adjacent to the protected area and the ecological sustainability of the natural resource values. These assessments used the example of Kızıldağ National Park, whose boundaries were revised in 1993 and 2018.

Socio-economic issues and local people's perceptions of protected areas

There are significant problems with the way that protected areas have been managed in the past. Because the first point of departure for managers was the prohibition of use of the area. Many areas have been declared protected without adequate research into issues such as the status of the area, its size and boundaries. In fact, an area may have more than one protected status. For example, there are 1.5 million hectares of protected areas in Turkey that have been given more than one protection status (both national park and natural site, etc.). In this situation, more than one government institution is responsible, which can lead to confusion of authority over the area. In addition, many institutions may be working in these areas at the same time, but without coordination between them. Furthermore, it is possible to find studies carried out by the same institution, in the same area, at similar times, and related in terms of findings, but carried out by different groups without coordination. In addition, the sustainability of rural livelihoods is not sufficiently taken into account when determining the boundaries of protected areas.

Attempting to protect protected areas in a passive and rigid manner prevents conservation from achieving its purpose. It alienates people from the natural environment in which they live, from which they derive meaning and from which they have memories (Alkan and Korkmaz, 2009). Instead, there is a need to move away from the prohibitive and rigid protected area management model and implement practices that prioritise effective governance in which the public has a say (Kılıç and Kervankıran, 2019). Otherwise, negative perceptions may arise against the conservation objectives. In many protected areas, local people have suffered economic and social losses in many ways, and due to the inability to create alternative sources of income, local perceptions towards these areas have been negative. In addition, the negative perceptions of local people living in or near protected areas towards the conservation decision also have a negative impact on the sustainable management of the areas (Aagesen, 2000; Trakolis, 2001; Anderson and Barbour, 2003; Alkan, 2009; Alkan and Korkmaz, 2009; Mukherjee, 2009; Daim et al., 2011; Tokatlı and Gürbüz, 2014; Akbulut et al., 2015; Kervankıran and Eryılmaz, 2015; Koca et al., 2016; Alkan and Ersin, 2018; Akyol et al., 2018; Hidle, 2019). For example, some of the loss of livelihoods and the resulting changes in the perceptions of the villagers who have a relationship with Kovada Lake National Park in Turkey are shown in Table 2. The most important reasons for the formation of negative perceptions are related to the economic losses associated with the protected area decision. In this context, the fact that alternative sources of income have not been created also affects these perceptions.

Table 2. Livelihood issues faced by rural settlements and their impact on local perceptions (Alkan, 2009)

Livelihoods	The change that occurred with the declaration of a protected area	Reason for change or non-change	Reflection on perception and attitudes
Forestry	↓	Loss of income due to non-production in protected areas	↓
Agriculture	↓	- Prohibition of taking irrigation water from the lake - Agricultural land scarcity - Not allowing treasury lands to be rented by villagers	↓
Non wood forest products	↓	Not allowed to collect	↓
Fishery	↓	Prohibition of fishing in wetlands within the protected area	↓
Ecotourism	→	Although there was an expectation that ecotourism would develop with the declaration of a protected area, no development was achieved.	↓
Handicrafts	→	Macro-scale problems related to the sector and the failure to develop tourism	→
Direct employment	↓	There is an expectation of employment in protected areas.	↓

(↓ Negative, → No change)

It is important to implement long-term development plans for protected areas, including solving the problems mentioned above. It is known that in the past, plans prepared years after the proclamation of protected areas could not solve the current problems (Alkan and Korkmaz, 2009). One of the most important deficiencies in planning is that the principles, the planning method and the contents of the plans cannot be clearly stated. This situation leads to differences between plans and causes disagreements between the planner and the implementer. In this respect, it is important to make and implement plans that include the environmental, economic and social dimensions of sustainable resource management.

At the heart of the failures experienced in both the preparation and implementation of plans is the failure to ensure the participation of stakeholders, especially local people, in these studies. When an area is declared a protected area, the people living in the area are not consulted, and the solution to how to protect and benefit from the area is found without them. Especially when local participation in planning activities is not achieved, almost all local people who have an organic connection with the protected area tend to have a negative perception and attitude towards the area. As a result, conflicts between protected area management and local people are inevitable. These conflicts can be prevented through good planning and subsequent implementation processes. In order to plan natural resource management, it is necessary to establish criteria and indicators for planning by interdisciplinary teams, to propose planning models with scientific understanding, to produce an applicable planning guide and to ensure that this planning guide is used by resource managers. Moreover, the management of protected areas requires optimal strategies involving local communities and non-governmental organizations, which should be determined by evaluating multiple objectives simultaneously (Daşdemir and Güngör, 2008).

How should boundaries of protected areas be determined?

The first step in solving the problems outlined above is to define the boundaries of the protected area in such a way that the conservation objectives are met. This is essentially a multi-objective optimisation problem with ecological, economic and social constraints.

In this section, the process of boundary change in Kızıldağ National Park/Türkiye has been examined in detail and evaluations of the boundary setting have been made.

Kızıldağ National Park was proclaimed in 1969 with an area of 2316 hectares. In 1993, its area was expanded to 59400 hectares. In 2018, its boundaries were redrawn to include an area of 80203 hectares. The main resource values of the National Park are; pure cedar, larch and juniper forests, rich vegetation, wildlife, old coniferous forests, Dedegöl Mountain, Cayır Plateau, Kuzukulagi Plateau, Beysehir Lake, historical and archaeological values and the lifestyle-cultural values of the people living around the park.

As can be seen, Kızıldağ National Park is a good example of how to evaluate the boundaries of a protected area, as its boundaries have changed two times in its history (Figure 1). The area of the National Park has increased over time. This situation is important, as it indicates that awareness of the ecological resource values that need to be protected has increased over time (Table 3). With the latest amendment in 2018, the upper parts of the basin were included in the national park boundaries in order to protect Lake Beyşehir, which is the most important resource value of the national park. When examining the land use situation in Table 3, another situation that attracts attention is related to rural settlements. With the boundary change in 2018, there are no more residential areas inside the

National Park. In addition, most of the agricultural areas are outside the national park boundaries.

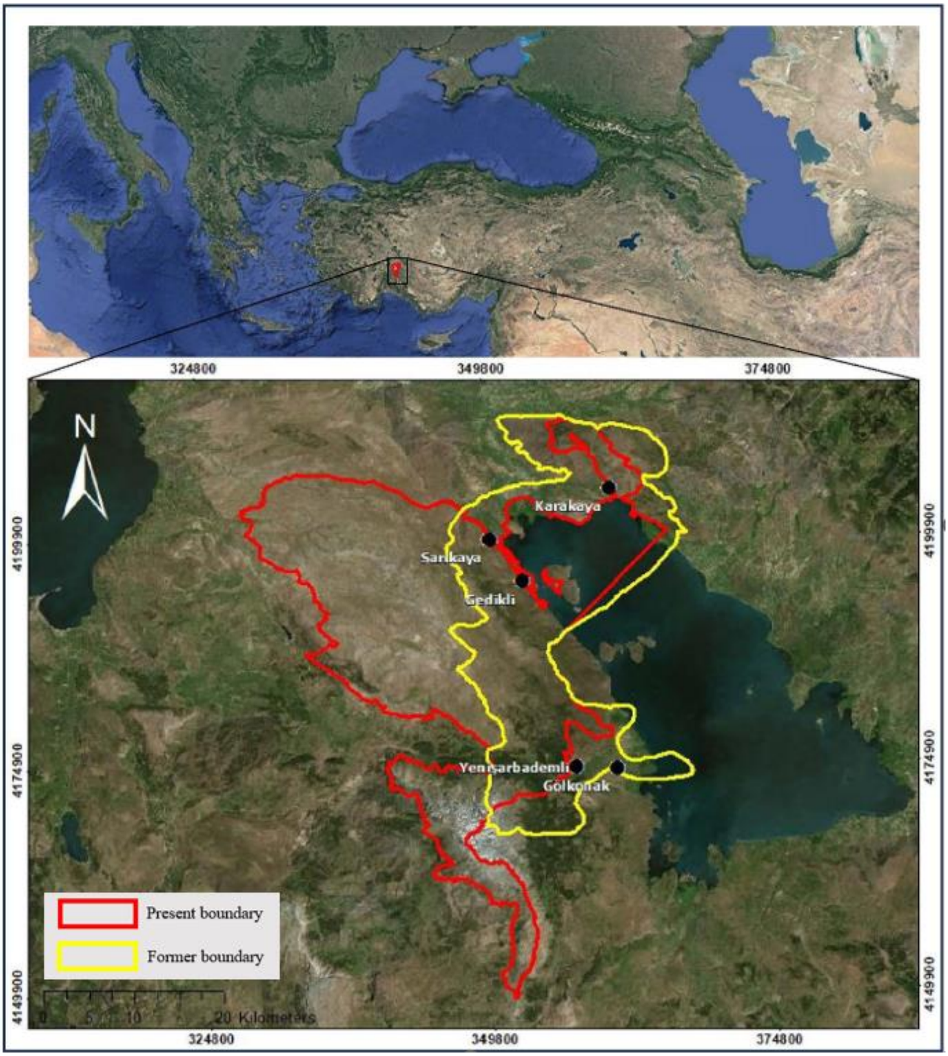

Figure 1. Former and present boundaries of Kızıldağ National Park

Table 3. Land use status in Kızıldag National Park

Land	Area -ha (1993)	%	Area -ha (2018)	%
Forest	29930	50.4	44999	56.1
Agriculture	6653	11.2	53	0.1
Bare land	3758	6.3	20845	26.0
Stony- Rocky land	2347	4.0	4126	5.1
Rural resident land	182	0.3	-	-
Lake	16530	27.8	10180	12.7
Total	59400	100.0	80203	100.0

Five settlements (Yenişarbademli, Gölkonak, Gedikli, Sarıkaya and Karayaka) were included in the boundaries of the national park with the 1993 boundary extension. In addition, the agricultural land of many settlements lies within this boundary. The first long-term development plan of the National Park was prepared and implemented in 2007. As a result, in the 14 years since the boundary change, the national park has only been managed with conservation prohibitions and use restrictions. The restrictions imposed on rural residents during this process resulted in income losses and negative perceptions of the national park. Alkan et al. (2010) found that more than 60% of local people living within or adjacent to the national park boundaries felt that the national park decision was not necessary.

From 2007 to 2018, the park's long-term development plan was implemented. As part of the plan, ecological protection zones were established, and several decisions were taken to support the economic and social development of the rural population. The framework for these decisions is outlined below (KMP-UDGP, 2007);

- To ensure that villagers engaged in agricultural activities are guided by product patterns and agricultural techniques that are appropriate to the region, thus achieving high yields without harming nature,
- Eliminate problems in the marketing and valuation of agricultural products,
- To make arrangements to ensure the continuity of traditional transhumance,
- Continue the livestock farming that forms the basis of traditional transhumance activities by taking measures to prevent damage to the resource values of the National Park,
- Informing and raising the awareness of people involved in transhumance activities,

- Develop tourism activities in a programmed manner and support the economic contribution of the local population by ensuring their active participation in these activities,
- Make the necessary arrangements for fishing activities to become an important economic activity for the local people,
- Create areas of daily use within the National Park for the benefit of visitors,
- Ensuring that field guides trained by the local people are used for tours within the National Park,
- Support and develop sales activities of traditional/local handicrafts and other natural products.

However, the negative perceptions formed in the pre-plan period (before 2007) have not changed. At the heart of the failures in both the preparation and implementation of this plan is the failure to ensure the participation of stakeholders, especially local people. While an area is declared as a protected area, the people living in this area are not consulted and the solution of how to protect this area and how to benefit from this area is tried to be found without these people. Akyol et al. (2018) found that during this process, income losses continued and there were negative changes in the traditional lifestyles of local people. Furthermore, the group most affected by these negative impacts are those involved in livestock farming. In short, the improvements in the economic and social structure of rural settlements that the planning decisions were intended to bring about have not been realised. As a result, the local population's support for the protection of the area has been low, and conflicts with the national park management have arisen. One of the factors contributing to these problems is that the settlements remain within the absolute protection zones in the plan.

In 2018, the boundaries were revised again, and in addition to the increase in park area, all settlements and the majority of agricultural land were excluded from the national park boundaries. Figure 2 shows the settlement area and agricultural land of Gedikli Forest Village. This decision was taken to solve the economic and social problems of the local population and to better protect the ecological, historical and cultural values of the area. Of course, the first question that comes to mind at this point is "why were the settlements included in the boundaries of the National Park in the first revision of the boundaries?" or vice versa. Because during the 25 years (from 1993 to 2018) between the two boundary changes, no effective management could be ensured, and no solutions were found to the ecological, economic and social problems.

Using the example above, a three-step methodology is proposed for drawing the boundaries of protected areas. In the first stage, the resource values of national and/or international importance that need to be protected should be identified and a draft boundary should be drawn to protect these values. This is also the stage at which the protected area is proclaimed. In the second stage, the area should be analysed in detail from an ecological, economic and sociological point of view, and limiting factors and objectives should be defined. This is the stage of the analytical study. In other words, the condition of the area should be revealed through a detailed survey. The next stage is to synthesis the data and then define the precise boundaries of the site. At the end of these stages, a long-term development plan will be drawn up. In the current planning approach, there are already three stages: analytical study, synthesis and planning. What is recommended here is to integrate the boundaries of the protected area into the planning phase. As this process could not be implemented in the revision of the boundaries of Kızıldağ National Park, the problems that have existed for years have not been resolved.

Figure 2. Settlement and agricultural areas of Gedikli Forest Village

Conclusions

All stakeholders must be involved in the process of protecting natural resources. This participation must be ensured in the management of the process from the very beginning, when the decision to protect is taken. One of the important issues in this process, which can be briefly summarised as information exchange, then data collection, analysis, synthesis, planning, implementation and monitoring and evaluation, is the most appropriate definition of protected area boundaries. This is because boundaries have positive or negative ecological, economic and social results. In this chapter, some assessments have been made in the context of these results.

It seems to be the most appropriate solution to finalise the boundaries of the protected area together with the planning process. Of course, at this point, after the declaration of the protected area, the studies for the long-term development plan have to start in a very short time. Otherwise it will not be possible to achieve the conservation objectives. Both ecological and socio-economic analyses are carried out during the planning process. The depth of these analyses will enable correct decisions to be made regarding the management of the area. In this context, the socio-economic dimension refers to several features related to the development of rural communities living in interaction with protected areas, without damaging the ecological, etc. values, among the planning objectives. In this context, the socio-economic dimension includes several assessments aimed at revealing the social, demographic, cultural and economic structure of the people living in the protected area. These are described below (Korkmaz et al., 2005):

- To identify sociological characteristics,
- To develop personal responsibility and regional awareness for nature conservation,
- To ensure public participation in planning activities,
- To determine the characteristics and importance of existing livelihoods,
- To decide on available livelihoods,
- To determine the nature and feasibility of alternative livelihoods,
- To develop cooperation for economically viable livelihoods.

The data obtained by determining the socio-economic structure will provide an important basis for studies to determine the development priorities and development models of rural communities, to regulate land use and to create protected zones at the planning stage. In order to improve the living standards of the rural population, rural development plans should be implemented in parallel with long-term development plans. The resulting positive socio-economic developments will improve the welfare of rural people, reduce human pressure on the protected area, and develop personal responsibility and regional awareness for nature conservation.

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Mehmet KORKMAZ

Chapter 2

The Impact of Ownership on the Sustainability of Forest Resources

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Abstract

The concept of sustainability, which has evolved since the 1972 Stockholm United Nations Human Environment Conference, involves the examination of intricate relationships between economic development, environmental quality, and social equality. Sustainable forestry, a fundamental principle of forest resource management and governance, aims to efficiently utilize limited resources to meet the needs of both current and future generations. Challenges in achieving sustainability in forests stem from uncertainties in property rights. This study explores the complex relationship between property rights and the sustainability of forest resources within legal systems that fundamentally embrace property rights as a form of legal protection. It argues that secure property rights are essential for sustainable forest management, providing evidence from various studies that demonstrate higher deforestation rates in areas with insecure property rights. The study also discusses different types of property rights regimes, including private ownership, state ownership, and common property. Emphasizing insights from global examples such as China, Thailand, and India, the research underscores the importance of well-defined and secure property rights in mitigating negative consequences and promoting sustainable forest management. The study is relevant to the ongoing debate about the role of governments in managing forests.

Keywords: Forest, sustainability, property rights, governance

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Relationships Between Property Rights and the Concept of Sustainability

In the Turkish legal system, the right to property holds the highest legal rank, enshrined in the Constitution. Article 35 of the Constitution asserts, "Everyone has the right to ownership and inherit it. These rights may only be restricted by law in the public interest." This provision serves to safeguard the right to ownership. Moreover, the article further stipulates, "The exercise of the right to ownership cannot be contrary to the public interest" implying that limitations can be imposed not on the right itself, but only on its use, for the betterment of society.

Both Article 683 titled[3] "Content of the Right to Ownership" in the Turkish Civil Code and the entirety of property law regulations establish that property is defined as the "real right that provides the broadest authority over a property" (Oğuzman and Seliçi, 2004). Inherently, humans have made establishing ownership rights over the chattels they use or benefit from a fundamental objective, prioritizing the protection of these rights. Moreover, the outer limits of property, known as the boundaries of property, refer to the extent to which the dominion arising from the right can be applied to the chattel that constitutes the subject of the right to property (Tahiroğlu, 2001). The acquisition, use, or loss of the right to property occurs through possession for movable property, while for immovable property, it is achieved by recording it in the land registry.

In order to accurately determine the legal status of rights on immovables, it is essential to first establish their boundaries. Subsequently, the legal status (ownership relationships) of immovable land parcels with defined boundaries needs to be identified (İpek, 2009). Due to the significance and natural characteristics of immovables, legislators have chosen to regulate property rights on immovables differently from those on movables. This distinction is particularly evident in the acquisition of immovables and in the content and scope of immovable property rights.[4] Initially protected by brute force, property rights on immovables began to be legally safeguarded in civilized societies through religious or legal rules, giving rise to the legal concept of "immovable property ownership" (Tüdeş and Bıyık, 2001).

The legal regulations that most effectively safeguard the right to property against violations and intrusions by third parties, bearing the characteristics of private law, are primarily enshrined in the Turkish Civil Code (TMK). Article 683 of the TMK underscores that an owner, within the constraints of the legal framework, possesses the authority to utilize, derive benefit from, and dispose of their property as they see fit. It is further emphasized that the owner has the

[3] Turkish Civil Code No. 4721 Art. Issue 683- The person who owns something has the authority to use, benefit and dispose of that thing as he wishes, within the boundaries of the legal order.
[4] For detailed information see, Akipek and Akıntürk, 2009. pp454

recourse to legal action to prevent any form of unjust enrichment by an individual wrongfully holding their property (TMK Article 683).

In addition to the aforementioned protections, it is observed that the right to property is also safeguarded in the field of criminal law through the provisions of Law No. 5237, the Turkish Penal Code, particularly in Articles 141 and following, which are under the heading “Crimes Against Property”.

In addition to the domestic legal framework, the right to ownership is also safeguarded by the provisions of the European Convention on Human Rights (ECHR). The 1st article of the “Additional Protocol to the Convention for the Protection of Human Rights and Fundamental Freedoms” (Paris, 20.3.1952) explicitly bears the title “Protection of the Right to Ownership”. The relevant article stipulates, “Everyone has the right to respect for his private and family life, his home and his correspondence.” It further asserts, “No one shall be deprived of his possessions except in the public interest and subject to the conditions provided for by law and by the general principles of international law.” The nature of the right to ownership as enshrined in the 1982 Constitution and the ECHR exhibits no significant divergence. Both texts emphasize the social dimension of the right to ownership and acknowledge that it can be subject to restrictions in instances deemed necessary for the public interest (Şimşek, 2011).

The concept of sustainability examines the relationships between economic development, environmental quality, and social equality. The concept has been evolving since the examination of the relationship between quality of life and environmental quality first took place at the 1972 Stockholm United Nations Conference on the Human Environment (Rogers et al., 2008). However, Goodland (1995) pointing to the existence of this concept even in earlier times, has suggested that the first traces of the concept of sustainability in resource use can be found in the writings of Malthus (1798) and Mill (1848).

In the literature, various definitions of the sustainability concept can be found, proposed by different individuals and organizations. Among these institutions, the Brundtland Commission, FAO, the Special Commission of the German National Agricultural Research Council (NRLO), and the German Development Agency (GZT) can be mentioned. Additionally, individuals such as Douglass, Gips, Conway, and Marten, Lockeretz, and Ruthenberg have made personal efforts in defining the concept. The definition provided by the Brundtland Commission is a broad one, mainly focusing on the political aspect of sustainability. In contrast, FAO, NRLO, Douglass, and Gips offer narrower definitions, concentrating on sustainable development and delineating the concept's boundaries with a focus on agriculture. Finally, Conway and Marten, Lockeretz, Ruthenberg, and GTZ focus on agricultural ecosystems and small-scale agricultural enterprises (Hulshof, 1992).

The concept of sustainable forestry is defined as meeting the needs of both current and future generations for forest products and services in an optimal and sustainable manner without jeopardizing the forest resources and their ecological, economic, and social functions (Daşdemir, 2018). Unsustainable forestry practices can have adverse long-term macroeconomic effects, such as the destruction of forest resources, degradation of water basins, and negative environmental impacts (Daşdemir, 2018). Moreover addressing the adverse impacts of climate change and establishing sustainability necessitate the development of comprehensive approaches for the planning, management, and preservation of forests (Güngör, 2021). Concurrently, it is imperative to create effective support structures for forest-community relations and mechanisms facilitating the judicious utilization of forest resources (Güngör & Şen, 2020). In light of this, the preservation and management of unique ecosystems such as forests are of paramount importance. Ensuring their value is maximized for the betterment of humanity while simultaneously safeguarding their sustainability is a critical imperative (Şen & Genç, 2017).

Forest Sustainability and Ownership: Understanding Their Interconnected Impacts

According to the records of the General Directorate of National Property, the Ministry of Treasury and Finance, 67% of our country is owned by the State. On the other hand, 45% of private property title holders are in a defendant position against the State. In such a situation, it is not possible to talk about the guarantee of property rights. The uncertainty of whether a person who has possessed a property for a long period, such as 40-50 years, can acquire ownership, and the consumption of their entire active life with this concern, is considered to violate the principle of legal security (Başpınar, 2009).

When there is no secure property structure, people may react excessively, be vulnerable to eviction from their lands, and be excluded from society. In places where access to resources is subject to inadequate control, the natural environment, and the biodiversity it harbors may be at risk of resource exploitation (FAO, 2009). When it comes to forest areas, the assurance of property rights is closely related to the challenge of governance. This challenge arises from having ownership of the resource, the right to manage the resource, or the use of values derived from the resource. Without securing property rights, sustainable forestry management and the impact of forestry on poverty alleviation cannot be discussed. Property rights play a foundational role in leading the way for poverty alleviation and sustainable forest management (FAO, 2007). In situations where well-defined and secure property rights are lacking, mutual benefit flows and value-enhancing investments can fail (Muthoo, 2004). Therefore, secure property rights become one of the crucial criteria to consider in forestry investments.

In a sample study involving 120 countries, including Türkiye, Deacon (1994) examined the relationships between deforestation, the reliability of property rights, population pressure, and income increase. He found that these variables interact with each other. According to his hypothesis, insecure property rights stem primarily from the inability to enforce property rights and a lack of governance.

Bohn and Deacon (1997), in their study, found that the relationship between deforestation and property rights security is statistically significant. Deacon (1999) also pointing to a study conducted by Southgate, Sierra, and Brown (1991) of by utilizing regional data, in the Equator region demonstrated that deforestation rates are lower in areas where land ownership is more secure (Deacon, 1999).

In China, the underlying cause of deforestation from the perspective of farmers has been identified as the changes in the property rights regime that were frequently and radically implemented in the past, leading to a decrease in trust in property rights. Tree planting has been more successful in family-owned land and farms where property security is the highest. Farmers, having full property rights, prefer to plant fruit and other non-forest tree species that do not require cutting quotas or permits, over planting forest tree species. Therefore, granting farmers full property rights has been considered important (Dachang, 2001).

In Thailand, despite declaring 50% of former royal lands as forest land in 1961, thereby placing them under protection and prohibiting agricultural activities, Feder et al. (1988) state that 20% of forested areas have been converted into agricultural land by settlers, alongside other activities being restricted in these areas (Rigg, 1993). Some areas designated as forests also include previously cleared and settled areas. In fact, the history of some settlements dates back more than 15 years (Feder and Onchan, 1987). This example alone is noteworthy in demonstrating the role of property rights security in the sustainability of forests.

Unsafe property rights hinder resource conservation. This situation, by reducing capital investments, also has a negative impact by increasing borrowing costs. This negative effect further reduces investment initiatives as it limits the right to obtain potential investment gains (Alessi, 2003).

The Possible Impact of Property Rights on Ensuring the Sustainability of Forests

In essence, the concept of sustainability involves meeting the current needs through effective utilization methods of existing limited resources, while also considering the needs of future generations. It would not be rational to assume that this pattern of utilization would spontaneously occur without a legal framework. Above all, property rights, which secure an individual's existence and life, are one of the most effective tools in this regard.

Property rights determine who can use a specific resource, how, where, and in what manner. Due to the role they play in the generation and distribution of income and welfare, these rights have been a subject of conflict and disputes in many static situations (Wiebe and Meinzen-Dick, 1998). Disputes over the acquisition of these rights can lead to loss or complete destruction of value in the resource, ineffective protection, and production methods. While long-term investment and resource utilization could contribute more, short-term resource use tends to take precedence (Libecap and NBER, 1999), thereby affecting sustainability.

Sustainable development is only possible in a legal system where property rights are well-defined, strengthened, and easily transferable. Property rights establish an order that promotes development, innovation, protection, and the exploration of new resources. In this regard, our approach to the protection and development of legal rules and property rights will not only determine how free and prosperous we will be in the future but will also influence our level of enjoyment of a high-quality environment (Anderson and Huggins, 2003).

Sustainable development establishes a conceptual balance between the absolute conservation and exploitation of forests in developing countries (Weiner, 2003). Furthermore, forestry is one of the areas where scientists first developed the concept of sustainable resource use (Köhn, 1999). Forestry in our country adheres to the standards set by the Ministerial Conference on the Protection of Forests in Europe in implementing Sustainable Forest Management and related international decisions. The six criteria for Sustainable Forest Management in Türkiye are determined as follows (OGM, 2006).

1-Forest resources

2-Biological diversity

3-Health and vitality of forests

4-Production function of forests

5-Protection function of forests

6-Socio-economic function of forests

Among these criteria, the first criterion, forest resources, is central to our topic, so it is necessary to examine the indicators of this relevant criterion. In the Sustainable Forest Management Criteria and Indicators Form[5] of the General Directorate of Forestry (OGM), five indicators are identified for Forests and Other Tree Areas: Planted Wealth, Biomass, and Carbon Stock; Increment; Forest with Management Plan; Forest Area with Cadastre.

The most significant criterion that brings sustainable forest management to the agenda is deforestation, as known (Siry et al., 2005). Among the indicators mentioned above, those related to the spatial changes of forests establish the connection between sustainability and the concept of property. Therefore, spatial change data in forests become the most reliable and controllable indicator between sustainability and the concept of property. However, a robust database showing the temporal changes in forest areas based on ownership types has not been established in our country. Hence, making definitive and clear judgments on this matter is currently not possible for our country.

When it comes to forest areas with bare ownership belonging to the Treasury and usufruct rights belonging[6] to the General Directorate of Forestry (OGM), and State Forest ownership, According to the OGM inventory results, there has been an increase of approximately 2.7 million hectares in forested area in the last 47 years [7]. However, there is insufficient data to track the temporal changes in forest areas owned by Private and Public Legal Entities. The main reasons for this situation include the total area of these two forest ownership types being less than 1%, and as of 2022, the forest cadastre has not been completed. Nevertheless, by leveraging comparative law and literature, it is possible to overcome the analysis difficulties caused by this data gap and reach specific conclusions. The positive or negative impact of property rights on the sustainability of forests has been demonstrated through numerous numerical studies and data analyses in foreign literature.

While most tropical forests are legally owned by the state, institutional deficiencies in enforcing administrative regulations and the distance from the center, unless there is a shared management approach in these areas, may lead to converting these forests into open access (Angelsen, 1999). Many researchers claim that property-related issues, especially the lack of well-defined property rights, are among the main causes of rapid deforestation in North America

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[5] http://www.ogm.gov.tr/yukle/soy_kg.zip Access date: 27.07.2011

[6]T.R. Constitutional Court, Case Number: 1987/31, Decision Number: 1988/13, Decision Day: 1.6.1988, Official Gazette Date: 20 August 1988 Official Gazette Number: 19905.

[7] 2020 Türkiye Orman Varlığı.pdf (ogm.gov.tr) Access date: 20.11 2023

(Jaramillo and Kelly, 1997). The same claim has been expressed by Namaalwa (2008) for South Africa.

Dorner and Thiesenhusen (1992), who are concerned with the relationship between deforestation and property rights, argued that deforestation in most regions of the world is due to concerns about the reliability of landowners' and settlers' property rights. As an example, they demonstrated that the expectation of land reform in Paraguay in 1980, coupled with the fear that forest areas owned by landowners would be declared as idle land, led to intense deforestation (Hotte, 2001).

Similarly, the Honduran government declared all national forests as state property in 1974 and also took significant management powers over private forests. With the regulation, control over all activities affecting forests, such as control over firewood and charcoal, clearing and burning for agricultural purposes, passed directly to the administration. Disregarding the local people's usage rights in this regard led to widespread disappointment and government opposition among the people. The local population opened forests, settled in areas declared state property, and illegally burned forests (Jones, 1982).

When India gained independence from the British, it changed the forest regime by restricting the local people's rights to use the forests and established a protective central system over forest areas. In fact, in 1980, it completely banned tree felling in areas above 1000 meters in the Himalayas. According to forest status reports in India (1996-98), during the period of implementing protective policies from 1967 to 1987, forest areas decreased from 783,962 km2 to 642,041 km2. With the policy change in 1988, transitioning from central forest management to regional forest management, the rights of local people regarding forests were once again recognized. Thus, deforestation during the period 1987-1995 decreased from an annual rate of 0.78 in the previous period to 0.05, reaching 639,600 km2 (Kant and Berry, 2004).

In China, the large-scale deforestation seen in the 1950s took its momentum from a radical change in the property regime in 1956. As a result of this change, forests were subjected to a common ownership regime, granting local administration decision-making authority in the resource utilization process. Due to competition with England in industrialization, numerous local foundries were established nationwide for steel production, and the firewood needed for these foundries was supplied from forests converted into common property. As a result, the forest area and volume in the Hubei region of central China fell by over[8] 30%

[8] Compiling Board of Hubei Provincial Annals of Forestry, HubeiP rovincial Annals of Forestry (Wuhan: Wuhan Publishing House, 1989).

(Dachang, 2001). This outcome is important in showing how the common ownership regime on forests, as a result of activities carried out to implement central government policies, can jeopardize sustainable forest management.

In Bolivia, a field study covering 18 villages and using a Tobit regression model, Godoy et al. (1998) found that natural resource property disputes between indigenous people and neighboring landowners arise from uncertain property rights related to land, leading to deforestation. Godoy et al. also argue that villagers may feel the need to cut down forests if they perceive a threat of foreigners taking over their lands, driven by the fear of being the first to enter the area.

Nelson et al. (2001), examining the effects of changes in property rights on land use in the Darien region of Panama using spatial econometric analysis methods, tested qualitative hypotheses suggesting that more effective property rights lead to more sustainable land use. The results, based on quantitative data, showed that property rights significantly influenced land use patterns and changes in forest areas. However, they also noted that the results may not be universal and regional variations could be observed. Furthermore, Deacon (1994), Bohn and Deacon (1997), and Ferreira (2004) found that legal regulations and indicators of the quality of property rights have statistical significance in explaining deforestation. Thus, experimental evidence suggests that property rights alone can be a determinant of the deforestation rate (Novoa, 2008).

Property rights, by creating new economic values for forests, can encourage resource owners to take better conservation measures, thus promoting sustainability. Property rights established on non-timber forest use, such as camping, fishing, and hunting, can serve as an example in this regard (Adamowicz and Veeman, 1998).

Economists often argue that insecure property rights accelerate deforestation. This claim stems from considering forest wealth as a form of capital and equating risks related to property to an increase in the interest rate applied to income from forests. The theory predicts that insecure property rights will encourage short harvest rotations or conversion to agricultural land. Additionally, the theory foresees that insecure property rights will play a deterrent role in reforestation. Conversely, this situation, when considered differently, could play a role in reducing pressure on natural forests (Deacon, 1999).

Ferreira (2004), asserting that ineffective property rights and limited legal rules are two common characteristics of developing countries, argues, based on the results obtained through spatial regression analysis, that trade freedom and indirectly insecure property rights and bureaucratic quality can directly impact deforestation.

Examining the impact of property rights on the sustainability of forests from the perspectives of private property, state ownership, common property, and open access, Bromley (1998) suggests that when the state, with the intention of protecting forests, takes them into its ownership but attempts to manage them as if they were its own property, it turns the resource into open access, becoming a significant cause of deforestation. Bromley argues that the common property regime, with conflicts arising among partners with legal management rights and a continuous increase in the number of partners, also contributes to deforestation. Addressing the issue from the perspective of private property, Bromley states that private property gives the owner the right to use the property as they wish and asserts that there is no legal basis to challenge an owner who transforms forest land into another use.

The common property regime reduces operating costs due to its sensitivity to society, consideration for the entire community, and drawing strength from its dynamics. With low violation rates and providing secure control over resources, it keeps resource waste at a low level, making the system economically efficient (Hussain, 1998).

Legal Solutions in Overcoming Bottlenecks in Sustainability Issues

Sustainability requires an adequate connection between social order and property rights regimes with the ecosystems in which they exist (Costanza and Folke, 1996). Undoubtedly, legal regulations, especially legal rules and property rights, are key in environmental development (Anderson 2003). While sustainability ensures the guarantee of the resource itself and its continuity, property rights also serve the same purpose by securing the resource and the individual who will use it.

Given that deforestation is the most crucial criterion that brings sustainable forest management to the agenda, when evaluating the question of Private or Public, considering the deforestation criterion, it is encountered that, for various reasons, the deforestation rate is higher in public forests. In the emergence of this result, incorrect public policies also have a secondary importance (Siry et al., 2005).

A resource owned by an individual or a specific person will likely provide better utilization opportunities for its owner compared to a resource owned and managed by the entire community. On a resource that everyone owns, a specific person cannot be held responsible; however, private ownership brings responsibility and accountability. Recognizing the importance of property rights in improving the environment and preventing potential environmental issues is crucial. Moving away from private ownership, as desired by some collectivists and environmentalists, hinders the authority from having full and personal responsibility in decision-making (Stroup and Baden, 1984).

Hardin (1968) questioned the ability of individuals to manage resources from the perspective of sustainable resource management. According to him, *"individual privileges obtained over a resource always lead to its overconsumption. Describing this situation as the tragedy of the commons, Hardin argues that a resource managed collectively by the community, due to the privileged usage rights owned by each individual in the community, makes each individual feel free to use the resource, thereby perpetuating the situation of overconsumption of the resource. Hardin suggests that the only way to overcome this problem is either privatization or centralization"* (Smajgl and Larson, 2007).

Hardin indicates that, when it comes to forests and lands, the traditional nature of property rights is defined by a simple distinction between open access and private property. However, this distinction fails in distinguishing between common property and open access (Hirsch, 1990). Bhattacharya and Lueck (2009), examining the effects of property rights on environmental quality and income, found that the transformation of forest property regimes from open access to common property positively influences the rehabilitation and yield of forests. They also observed an increase in tree density in degraded forests.

Hayes et al. (1997) state that within the traditional property system, there can be many incentive factors for investing in land. They argue that increasing individuality, especially in terms of selling and usage rights, directs individuals towards investing more in the resource.

In principle, public forests are managed in a productive and protective system for the public good, while private forests are managed for broader purposes according to the owner's desires compared to the public. To determine which of these two different regimes is more successful, one should look at the market value of forest products and services, both those with and without markets, and their supply by private or public entities (Siry et al., 2005). When determining the public or private ownership status of a resource, the following five criteria can be used as a guide: (1) intensity of use, (2) degree of comparative advantage of non-market values related to use, (3) need for resource conservation, (4) sufficient information about the type of property to be decided, and (5) the presence of a common public purpose with a widespread impact on resource use choices. These criteria, to be considered when deciding on private or public ownership of a resource, are steps towards refining resource use decisions (Harkin, 1972).

Ascher (1994), stating that local people play a key role in the sustainability of forests for four reasons, lists them as follows:

a) Limiting the number of people accessing the resource can reduce pressure on the resource.

b) Users living inside and on the edge of the forest are concerned with the sustainability of forests because resource continuity also means meeting their own continuous needs.

c) Granting the authority to protect the forest to local users can help facilitate more effective on-site protection activities.

d) Local users can develop more effective intervention methods for the long-term use of forests. To achieve these beneficial purposes, securing and strengthening the property rights of local communities may be helpful.

"Private ownership is highly decentralized and a secure harbor for the environment. Who, other than the owner, can be more willing and sincere for sustainable development? The owner protects, takes care of, and desires the well-being of what they own. This is also true for the environment" (Denman 1997). The conclusion that private ownership is more effective is a common consensus among property rights theorists based on the characteristic features of public and private ownership (Dura, 2006).

Considering empirical results, it can be assumed that, except for the open-access property regime, private, state, and common ownership regimes provide sustainable resource use under certain conditions. When sustainability is the focus, the success level of the four basic regimes can be measured by the criterion of addressing the two fundamental problems of common ownership: excluding other potential users and solving the resource-sharing problem due to common use (Berkes, 1996).

Forest Ownership and Sustainability of Forest Resources in Türkiye

While private ownership is generally considered more effective in terms of sustainability in property rights theory, it may not have the same impact on forests. In Türkiye, almost all forest ownership (99.9%) belongs to the state. According to existing constitutional regulations, forest ownership cannot be transferred, and the relationship with sustainable forestry continues through state forest ownership.

In the past, legal regulations aimed at the nationalization of all forests (Law No. 4785 on Nationalization dated 1945) were enacted, but significant public backlash was received. Looking at the statistics of the period, it is observed that the implementation of the nationalization law led to a significant increase in forest fires, from a low number of around 600 to levels of 1,169-1,023 in the years 1945-1946. It is claimed that the reaction to Law No. 4785 on nationalization caused this escalation (Özden et al., 2012).

Effective regulations are pivotal in the sustainable management of forests, complementing the legal frameworks that govern property rights. International mechanisms, such as certification programs, play a crucial role in enhancing the conservation and sustainable management of forests (Şen & Güngör, 2019). As a result of the evaluations, it can be concluded that forest ownership is highly related to sustainability, and private forest ownership would lead to better conservation and increased sustainability globally. However, this judgment may not be applicable to developing countries like ours.

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Chapter 3

Identification Of Sustainable Rural Development Strategies Focused On Ecotourism

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Ecotourism promotes nature conservation with low visitor impact while improving the socio-economic structure of local communities. Ecotourism is a tool that, if carried out in accordance with its purpose, can create resources for the protection of sensitive ecosystems and the socio-economic development of the population living in and around these areas. Protected areas are the most important areas where ecotourism activities can be carried out. The future of protected areas depends on the future of rural areas, the preservation of rural lifestyles and a healthy rural economy. The most important feature of the Kure Mountains National Park (KMNP), which is one of the important ecotourism centers of Turkey, is that its borders were determined by the joint decision of everyone by applying effective participatory methods for the first time in Turkey in the protection and planning process. There are many settlements for ecotourism activities in the national park buffer area.

In the study, ecotourism-oriented sustainable development strategies for KMNP were developed and the most appropriate one was determined. For this purpose, a SWOT analysis was initially conducted for KDMP ecotourism activities. Because of the SWOT, KMNP, which has virgin forests, karst structure, rich flora, fauna, folkloric structure and cultural values, is strong in terms of ecotourism. In the second stage, factors that emphasize the strengths were developed. These are *(1) Ecotourism Activities, (2) Ecotourism Income Perception, (3) Ecotourism Perception, (4) Ecotourism Profile*. In the study, alternative ecotourism strategies were developed by considering the four factors. Conjoint Analysis prioritized the strategies. The most ecotourism-oriented sustainable development strategy for KMNP is "*KMNP sustainable ecotourism activities such as trekking, bicycle tours, horseback trekking, etc. should be emphasized. For sustainable rural development in the national park,*

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the concepts of sustainable conservation and sustainable income should be considered together in ecotourism planning. In ecotourism activities, a conservation-oriented structure should be adopted instead of mass tourism perception. Conscious ecotourism activities should be carried out, travel time for ecotourists should be short, and spending per trip should be $100." In the ecotourism-oriented sustainable development strategy, KMNP emphasizes the principle of participation in ecotourism activities. In ecotourism planning, in addition to the state, more participation of local people and NGO representatives is recommended. Likewise, the idea of transferring a share of ecotourism revenues to local people should also find a place in ecotourism-oriented sustainable development strategies. In this way, conflicts in the KMNP will be prevented and active participation in management will be ensured. Thus, ecotourism-oriented sustainable development activities in protected areas will be better managed as resources will be transferred to sustainable rural development.

Keywords: Ecotourism, Sustainable Rural Development Strategies, Kure Mountains National Park, SWOT, Conjoint Analysis.

Rural Development and Ecotourism

Rural development is an integrated process wherein rural communities are transformed into advanced societal entities with economic and social objectives. During this transformation, efforts are made to standardize the economic, social, and cultural structures of rural communities and the relationships among these structures. In rural development initiatives, the problems of rural communities are identified and defined, and appropriate solution models are developed in response to these issues. Therefore, rural development programs not only address problems through agriculture-centric approaches but also evaluate different arguments that support rural development, such as ecotourism (Tolunay and Akyol, 2006; Meydan et al. 2020).

Tourism is not merely a sector driven by the triangle of sea, sun, and sand. The richness and diversity of archaeological, historical, and cultural assets are significant resources within the realm of tourism. However, the uneven distribution of settlements and unchecked industrial development lead to the loss of numerous tourist attractions. In many countries, industrialization has given rise to serious environmental issues. Protecting the environment not only enhances the quality of life but is also vital for the continuity and development of environment-dependent sectors such as tourism.

Tourism involves multifaceted relationships that both impact and are impacted by the environment. For tourism to be enduring and productive with such intricate interactions, the preservation, sustenance, and continuity of the natural and cultural environment are paramount. Therefore, the adoption of sustainability as a guiding principle in tourism is crucial for its ongoing success and for future generations to benefit from tourism activities (Ozturk et al. 2021).

In the concept of sustainable tourism, the aim is for the local community in the host region to derive greater economic benefits from tourism. Consequently, when the local community gains more economic benefits than tourism alone, their perspective on tourism becomes more positive, leading them to invest effort in developing tourism and preserving the environment. Additionally, the socio-cultural values and traditions of the local community are preserved. Sustainable tourism, as a form of economic development, seeks to enhance the quality of life for the local community, provide high-quality experiences for visitors, and ensure the sustainability of environmental quality for both the local community and visitors.

Sustainable tourism goes beyond conventional mass tourism, where participants engage in activities such as dining, entertainment, and relaxation. Sustainable tourism involves participants gaining knowledge about the region they visit, including its traditions, customs, lifestyle, and behaviors. Participants personally experience certain activities of the community and learn to live in nature, protect nature, and love the environment.

Within the scope of sustainable tourism, nature tourism promotes the efficient use of insufficient agricultural areas and encourages the preservation of areas covered with natural vegetation. Sustainable tourism aims to contribute economically to the local population through various tourism types such as agro tourism, farm tourism, and ecotourism, which utilize unused or economically less beneficial agricultural areas. It monitors, evaluates, and guides the impacts of tourism, develops environmentally responsible methods, and mitigates potential negative effects (Garda and Temizel, 2016; Ozturk and Isinkaralar, 2018).

Ecotourism involves trips to natural areas with the purpose of studying, observing, and experiencing the landscape, wildlife, and rural phenomena while leaving as little impact on the environment as possible. The active involvement of the local community is crucial for gaining socio-economic benefits (Pratiwi, 2000). Despite being a relatively new concept, ecotourism is still often misunderstood and misused. The term was first heard in 1980, and the International Ecotourism Society (TIES), established in 1990, provided the first valid definition. Ecotourism is responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education. Ecotourism comprises four fundamental elements: it involves nature-based activities, supports conservation, provides sustainable management, and offers environmental education. These are the root characteristics of the concept (Dowling and Fennell, 2003). The International Union for Conservation of Nature (IUCN) defines ecotourism as environmentally responsible travel to natural areas to conserve the environment, sustain the well-being of the local people, and involve interpretation and education. It aims to increase socio-economic benefits for local communities and enhance conservation through low visitor impact, alongside the appreciation of cultural features present and past, and evaluation and enjoyment of the natural surroundings (Hounsome and Ashton, 2001).

By generating income, providing sustainable livelihood alternatives, and contributing to conservation and rural development, ecotourism is a form of resource utilization that supports multiple objectives. Thus, ecotourism can be seen as a potential link between the preservation and economic development of protected areas. Therefore, ecotourism, within the concept of protected areas, can be defined as an ideal form of progress that meets current needs without jeopardizing the needs of future generations, ensuring the well-being of local communities and the preservation of sensitive ecosystems. When conducted appropriately, ecotourism often targets small groups, focusing on family-operated small facilities, traditional architecture, and the use of local resources. If aligned with its purpose, ecotourism can be a tool that creates resources for the preservation of delicate ecosystems and for the socio-economic development of the population living within and around these areas. Considering the poverty of the people living in villages in mountainous and forested regions with significant ecotourism potential, ecotourism is believed to be an activity that can reduce imbalances among social classes (Altıparmak, 2002).

Ecotourism Activities

Ecotourism activities are classified based on various criteria. These criteria include the modes of transportation used in tourism (bicycle, balloon, raft, horse), the nature of the destination (mountain, plateau, cave), the specific characteristics of the activities undertaken (river, science, trekking), the degree to which activities contribute to environmental conservation, and the number of participants. In light of all this information, when ecotourism activities are classified based on their primary purposes, three main categories are identified: education-based, recreation-based, and contemplation-based activities (Pratiwi, 2000; Rahemtulla and Wellstead, 2001; Weaver, 2001; McLaren, 2003; Barna et al., 2011; Naidoo, 2012; Barkauskiene and Snieska, 2013). The classification presented in Table 1 aligns with these three fundamental categories, incorporating various tourism activities found in the relevant literature.

Table 1. Ecotourism activities.

Learning Based Activities	Fun-Based Activities	Recreational Activities
Science Tourism	**Adventure Tourism**	**Health tourism**
- Botanical Tourism	- Balloon Tourism	- Climate Comfort Tourism
- Nature Photography	- Mountain-Rock Climbing	- Thermal Spring (Thermal) Tourism
- Monitoring Geomorphological Formations	- Nature Discovery (Safari)	
- Wildlife Observation	- Monitoring Extraordinary Events	**Camping-Caravan Tourism**
Culture Tourism	- Raft Race (Rafting)	
- Festival Tourism	**Sports Tourism**	
- Tradition and Custom Tourism	- Horseback Trekking	
- Road Tourism	- Bicycle Tourism	
- Steam Locomotive Tourism	- Trekking	
- Cultural Walks	- Canoeing	
- Agriculture-Farm Tourism	- Winter Tourism	
- Historical-Archaeological Site Tourism		

Protected areas are among the areas where ecotourism activities can be carried out. Protected areas are very important application areas for ecotourism activities due to their untouched nature and the diversity of their important resource values. Therefore, it is very important to protect these areas and ensure the continuity of their values. It can be said that the future of protected areas also depends on the future of rural areas, the preservation of rural lifestyles and a healthy rural economy. The small and dispersed population in rural areas and the insufficient income obtained by this population may cause it to be used for activities that will negatively affect areas that need to be protected and transferred to future generations (Akalın, 2007). It is very important to support agriculture and rural development in the efforts to eliminate this risk. This awareness has been emphasized in many reports and plans by many institutions over the years. For example, in the Turkey 2018 Progress Report prepared by the European Commission, it was mentioned that importance should be given to supporting agriculture and rural development (European Commission, 2018). In the 10th Development Plan covering the years 2014-2018, the main goal of the rural development policy was determined as improving the opportunities of the rural sector and the business and living conditions in the region where they are located (Ministry of Development, 2013). In addition, under the title of "Livable

Cities and Sustainable Environment" in the 11th Development Plan (2018-2023), targets and policies are aimed at protecting the environment, improving the quality of life in cities and rural areas, and reducing interregional development differences in parallel with increasing economic and social benefits. is included (Günşen and Atmiş, 2020). In these plans, many studies, especially ecotourism, are mentioned in order to protect the lifestyles in rural areas, and ecotourism is shown as an important part of rural development in the development plans. The necessity of transferring natural resources to future generations while being used in accordance with human needs is important in terms of the sustainability of natural resources. For this reason, many national and international legal rules and agreements are designed/drafted/signed to achieve a “protection-utilization balance” (Gençay ve Birben, 2018).

Protected areas are geographical areas determined, reserved and managed by law or other valid instruments for the long-term protection of nature, including the ecosystems and cultural values it contains (IUCN, 2011). While the areas in question were 2.4 million km^2 in 1962 (Emerton et al. 2006), according to 2010 data; Approximately 147,000 protected areas in the world cover more than 13% of the world, which is an area larger than the African continent (IUCN, 2011). There are a wide variety of management objectives, approaches and management styles in protected areas in different countries. In terms of management objectives, protected areas range from strict protection completely free of humans to cultural areas such as farms or managed forests (Dudley et al., 2005). IUCN (World Union for Conservation of Nature) defines protected areas, depending on management objectives, as absolute nature conservation reserves, wildlife areas, national parks, natural monuments or features, habitats/species management areas, protected landscapes/sea areas and areas managed for the sustainable use of natural resources. divides it into six categories: protected areas (Dudley, 2008).

In Turkey, the conservation objectives of protected areas regime are derived from and elaborated with reference to statutory guidance and policy statements, and in addition to that protected areas have been established in overwhelming proportion on state owned lands and managed by the state agencies (Birben et al, 2016). In Turkey, the National Parks Law No. 2873 divides protected areas into four categories. These are National Parks, Nature Reserves, Natural Parks and Natural Monuments. According to 2023 data, there are 48 national parks in Turkey and their total size is 911,200 hectares (URL-1). One of the national parks in question is the 37 thousand hectare Küre Mountains National Park (KMNP), which was declared in 2000. On the other hand, as of 2022, 46 national parks (907,520 ha), 250 nature parks (107,632 ha), 31 nature conservation areas (46,461 ha) and 115 natural monuments (9,393 ha) are under protection in Turkey (URL-1). Apart from these, other areas protected by national protection statuses in Turkey, apart from the protected areas included in the National Parks Law No. 2873; conservation forests, gene protection forests, seed stands, forest rest areas, seed gardens, wildlife development areas, wildlife protection areas, aquaculture production areas and protected areas. There are also international protection statuses determined within the agreements to which Turkey is a party, such as World Heritage Sites, Special Environmental Protection Areas, Emerald Network Areas, Wetlands, Ramsar Sites, Biosphere Reserves and Natura 2000 Areas (Güneş, 2011; Şen and Buğday, 2015).

The concept of national park, which first appeared in the USA in 1872, has found intensive application after the 1960s, and each country has developed its own national park system depending on the characteristics of its natural resources, community demands, social, economic and cultural structure. In Turkey, national park studies found a field of application with the 3rd and 25th Articles of the Forest Law No. 6831 dated 1956 and gained legal status with the National Parks Law No. 2873 enacted in 1983 (Daşdemir and Güngör, 2018).

Protected areas, especially national parks, need well-prepared management plans (long-term development plan or master plan) to protect, develop and ensure sustainability of natural, cultural and recreational resource values. For these plans to be successful, the current situation must be prepared taking into account environmental, social and economic variables. The opinions of all interest groups should be taken into account when determining goals, priorities and alternative management strategies (scenarios). In order to ensure effective management in protected areas, systematic evaluation studies based on participation and taking into account scientific principles should be carried out, the necessary administrative structure for sustainable management should be established, and the active participation of interest groups in decision-making, planning, implementation and supervision processes should be ensured. Considering the social benefit, participatory and sharing approaches and management models that take into account social and economic values as well as ecological values should be adopted. The bulk of policies in forestry are aimed for supporting sustainable forest management, wood production and ecological services of the forests rather than entrepreneurship as such. (Birben ve Gençay, 2018) On the other hand, multi-criteria decision making (MCDM) methods should be used in decision making, thus the best management strategies should be determined.

Küre Mountains National Park (KMNP)

The KMNP area is 37,753 ha in size. The 80 thousand ha area surrounding the national park is reserved as a buffer zone (URL-2). The national park and its location on Turkey are shown in Figure 1.

Şekil 1. Location of study area.

Data and Design of the Study

KMNP area is 37 thousand ha in size. The 80 thousand ha area surrounding the national park is reserved as a buffer zone. There are many settlements for eco-tourism activities in the national park buffer area (Figure 1). Within the scope of the research, literature on protected areas, planning in national parks and ecotourism (Kuvan, 1997; Menteş, 2001; DKMPGM, 1999; Demir, 2001; Zal, 2002; Daşdemir and Akça, 2002; WWF-Turkey, 2003; Karabıyık, 2004). ; Karabıyık and Çetinkaya, 2003; Daşdemir and Güngör, 2005; 2008; EUROPARK, 2005, UNDP, 2005; FAO, 2005) were examined and a basis for SWOT Analysis was created.

Küre Mountains National Park (KMNP), one of Turkey's important ecotourism centers and declared a protected area on 07.07.2000, is one of the 48 national parks in the country (DKMP, 2021). KMMP is one of the 100 forest hot spots that need to be protected in Europe, determined in 1999 with the contributions of WWF (Lise, 2011). The most important feature that distinguishes KMNP from other national parks is; for the first time in Turkey, effective participatory methods were applied in the conservation and planning process and its borders were determined by everyone's common decision, and it is the only national park that has a "buffer zone" as an official planning unit outside its borders (KMNP, 2021). There are many settlements for eco-tourism activities in the national park buffer area.

KMNP received the Platinum Wilderness Certificate award from the European Wilderness Society in 2019 (URL-3, 2019). KMNP is one of Turkey's 311 "Important Natural Areas" (UNDP, 2010) and has been designated as one of the 122 Important Plant Areas in Turkey by WWF. In addition, it is stated that KMNP is located within the Northern Anatolia and Caucasus Temperate Zone Forests, which is one of the 200 priority ecological regions at the global level in terms of nature conservation (KMNP, 2021).

The principle of participation was taken as basis in the declaration and determination of the boundaries of KDMP, which has important natural and cultural resource values. However, a management plan could not be prepared simultaneously with the declaration of the national park. During the preparation of the draft management plan, the principle of participation was not given as much importance as necessary. Therefore, for the sustainable management of KMMP, alternative management strategies that will ensure the effective participation of interest groups in decision-making, planning, implementation and supervision processes must be developed analytically, the best strategy must be determined by evaluating it with multi-dimensional decision-making techniques, and this strategy must be taken as basis in the management plan. Although there are many analytical and multidimensional studies conducted in the world on this subject (Teeter and Dyer, 1986; Hyberg, 1987; Stevens et al., 2000 etc.), some studies on the preparation of management plans of protected areas in Turkey (Kuvan, 1997; Menteş, 2001; Demir, 2001; Kalem, 2001), decision-making is based on subjective evaluations.

The aim of the study is to determine the optimum management strategy for KMNP sustainable ecotourism with a participatory approach. For this purpose, an attempt has been made to develop a management model that takes into account social and economic values as well as ecological values. In addition, the scenarios of "managing protected areas with the principle of participation" and "using revenues from protected areas for the development of local people" were also investigated in the study. Thus, alternative management strategies that took into account many factors were developed and the preferences of interest groups regarding the strategies were evaluated. As a result of the evaluation of the data obtained by the survey method with Conjoint (preference) analysis, the most important factors and their sub-levels (benefit, weight) affecting the preferences of each interest group were revealed, and then the factors and their sub-levels that are important and priority for all interest groups (general) and their sub-levels were revealed. Based on these, the optimum management strategy in terms of KMNP sustainable ecotourism has been put forward, based on the management strategy adopted by each interest group and the combination of interest groups (all participants), and its validity has been evaluated, interpreted and discussed from various angles.

Study Data and Evaluation Methods

There are many multidimensional decision making (MCDM) techniques, and Conjoint Analysis (CJA), which allows easier measurement of social preferences, is important in this regard. CJA in developed countries; comparison of forest planning and management strategies (Teeter and Dyer, 1986; Hyberg, 1987; Zinkhan and Zinkhan, 1994; Stevens et al., 2000), determination of versatile utilization principles (Zinkhan and Holmes., 1997; Sayadi et al., 2000).) is widely used in subjects such as value estimation of non-market forest products and services (Mackenzie, 1990, 1993; Gan and Luzar, 1993; Roe et al., 1996). In addition, CJA is used in determining the importance of nature tourism or ecotourism activities (Morimoto, 1999; Suh and Gartner, 2004), in the ranking of preferences for environmentally certified forest products (Bigsby and Ozanne, 2002), in determining the conservation value of natural resources (Matnews et al., 1995; Holmes et al., 1998; Kuriyama, 1998) is one of the frequently used MCDM methods. In this study, CJA was mainly used to determine the KDMP ecotourism strategy.

The principle of participation was taken as basis in the declaration of KMNP, which has natural and cultural characteristics, and in determining its boundaries. In the development of ecotourism strategies for sustainable rural development, the effective participation of interest groups in decision-making, planning, implementation and supervision processes is important. Strategies need to be developed analytically, evaluated with multi-dimensional decision-making techniques to determine the best strategy and be taken as a basis in ecotourism planning. In the research, based on the information obtained from numerous literature reviews and field studies, the current situation of KMNP was first revealed with the help of SWOT analysis. CJA was used to evaluate the data collected at the end of the survey and to determine the best among the nine alternative management strategies identified. The CJA model, which is generally used to understand consumers' reactions or preferences towards a product or service, is as in Equation 1 (Malhotra, 1996; Çemrek, 2001; Daşdemir, 2005):

$$U(X) = \sum_{i=1}^{m} \sum_{j=1}^{k_i} a_{ij} X_{ij} \quad (1)$$

Here;
U(X) : Total benefit of an alternative,
a_{ij} : i. factor j. benefit value at the level,
X_{ij} : i. factor j. dummy variable, which takes the value 1 for its level and 0 for other states,
k_i : i. number of levels of the factor (j=1,2,...., k_i),
m : Shows the number of factors (i=1,2,....,m).

In CJA, which includes statistical analyzes such as correlation, regression, and uses qualitative and quantitative data; the preference (utility) function is generally considered as the dependent variable. The effects of many independent variables on the dependent variable are investigated. In this way, the effects of variables on the consumer preference structure are determined. In this study, analyzes were made in the File-New-Syntax menu of the CJA, SPSS (Statistical Package for Social Science) 20.0 package program.

Within the scope of the study, a survey was conducted for CJA. The socio-economic characteristics of the 404 participants who were surveyed are shown in Table 2. According to this; 57% of the participants are men, the majority are middle age and married. While 70% of the local people are primary school graduates, 36% of the representatives of public institutions are college and university graduates. In terms of income level, 65% of the participants have an average monthly income below $800. On the other hand, 90% of local people have a monthly income of less than $600, while more than 74% of tourists and representatives of public institutions and NGOs have a monthly income of $600 or more. In terms of occupation, it is understood that 42% of the local people are farmers and retirees, while 47% of the tourists are public servants, self-employed and self-employed.

Table 2. Some socio-economic features of interviewees.

Feature	Level	Local Villagers		Public Institution Representatives		NGO		Potential Tourists		Total	
		Number	%	Number	%	Number	%	Number	%	Number	%
Sex	Male	65	65	55	55	60	58	54	52	234	57
	Female	35	35	45	45	44	42	50	48	174	43
	Total	100	100	100	100	104	100	104	100	408	100
Age	18-25	15	15	36	36	23	23	23	23	97	24
	26-45	15	15	40	40	27	26	47	46	129	32
	46-65	35	35	24	24	42	41	22	22	123	30
	66 +	35	35	0	0	10	10	10	10	55	14
	Total	100	100	100	100	102	100	102	100	404	100
Marital Statue	Married	71	71	62	62	59	58	55	54	247	61
	Single	29	29	38	38	43	42	47	46	157	39
	Total	100	100	100	100	102	100	102	100	404	100
Education Level	Illiterate	25	25	0	0	0	0	5	5	30	7
	Primary school	45	45	5	5	2	2	14	14	66	16
	Secondary school	20	20	12	12	20	20	29	28	81	20
	High school	10	10	22	22	23	23	21	21	76	19
	University	0	0	61	61	57	56	33	32	151	37
	Total	100	100	100	100	102	100	102	100	404	100
Monthly Income	≤ US$ 200	45	45	0	0	0	0	0	0	45	11
	US$ 201-400	30	30	4	4	8	8	4	4	46	11
	US$ 401-600	15	15	15	15	18	18	22	22	70	17
	US$ 601-800	6	6	25	25	37	36	33	32	101	25
	US$ 801-1.000	2	2	40	40	28	27	31	30	101	25
	≥ US$ 1.000	2	2	16	16	11	11	12	12	41	10
	Total	100	100	100	100	102	100	102	100	404	100
Occupation	Public institution	0	0	78	78	21	21	11	11	110	27
	Private sector	12	12	0	0	15	15	14	14	41	10
	Self-employed	13	13	0	0	20	20	22	22	55	14
	Retired	12	12	19	19	12	12	14	14	57	14
	Housewife	16	16	0	0	16	16	14	14	46	11
	Student	4	4	0	0	2	2	10	10	16	4
	Farmer	30	30	0	0	3	3	5	5	38	9
	Unemployed	12	12	0	0	11	11	7	7	30	7
	Other	1	1	3	3	2	2	5	5	11	3
	Total	100	100	100	100	102	100	102	100	404	100

In the study, SWOT analysis was used to develop sustainable rural development strategies focused on eco-tourism. In this way, the strengths and weaknesses of KMNP, the opportunities created by external environmental conditions and the threats it may cause were determined (Table 3).

Table 3. SWOT Findings.

SWOT	
STRENGTH	**WEAKNESS**
1. The existence of eco-tourism activities within the KMNP Management Plan, and the contribution of stakeholders in the planning and determination of eco-tourism activities.	1. Limitations in the expectations of the local community regarding ecotourism, inadequacies in the preparations for ecotourism.
2. The national park's possession of cultural and folkloric values, natural, old-growth virgin forests, canyons, valleys, caves, and waterfalls.	2. Insufficiency in ecotourism education activities directed towards the local community.
3. The presence of international eco-tourism projects directed towards the national park.	3. Scarcity of local entrepreneurs in investments, inadequacy in incentives for initiatives.
4. The opportunity for local villagers to offer handmade crafts, artisanal olive oil, soap, and similar products to tourists.	4. High migration rates approximately the national park.
5. The presence of eco-tourism activities in the KMNP, such as hiking, cycling, horseback riding, bird watching, photo safaris, river sports, agro tourism, and botanical tourism.	5. Non-charging of fees for entry into areas where ecotourism activities are conducted, with fees only applied at KMNP entrances, and these fees being low.
6. Information on transportation, proximity to cities, and awareness among conscious consumers.	6. Emergence of non-local entrepreneurs and the employment of local residents in unskilled jobs that do not require expertise.
7. KMNP buffer zone being a region where different cultures and beliefs coexist.	7. Visual pollution, wildlife adopting the habit of feeding on litter, an increase in pests, posing a threat to health.
8. Unlike mass tourism, there is no need for significant investments in the eco-tourism activities carried out in the region.	8. Destruction of natural and cultural values through mass tourism conducted under the umbrella of ecotourism.
OPPORTUNITY	**THREAT**
1. The nature-based essence of ecotourism, contributing to the preservation of biodiversity, supporting the well-being of local communities, and minimizing adverse environmental and socio-cultural impacts.	1. Inability to transfer a share of national park revenues to the local community due to legal barriers.
2. Increasing awareness and environmentally conscious ecotourism activities globally and in our country.	2. Insufficiency in the management budget of the KMNP and the finances allocated to ecotourism programs.
3. The presence of international organizations such as UNDP, FAO, WWF, GEF, JICA that could assist in the management and financing of the KMNP.	3. Ineffective conservation policies in Turkey, uncontrolled increase in KMNP visitor numbers.
4. The possibility of becoming a member of international certification organizations such as the European Wilderness Society and EUROPARK.	4. Inadequacy in planned and systematic ecotourism activities carried out in the region.
	5. High incidence of rural poverty in the region, inadequacy of poorly organized ecotourism activities in preventing migration.

5. Voluntary and willing participation for institutional collaboration.	6. Smuggling of artifacts, wildlife, and wild plants by malicious tourists.
6. The potential to generate employment opportunities for the local community through ecotourism activities.	7. Unresolved cadastral issues in the buffer zone.
7. The opportunity to establish strategic collaborations and partnerships with transportation companies, tour operators, tourism organizations, and local government bodies.	8. Elements in the region causing adverse effects on ecotourism (such as dam construction and urban solid waste disposal projects).
8. The advantage of ecotourism not requiring significant investments compared to mass tourism.	

In the study, based on the results of the SWOT analysis, factors were determined at three sub-levels each, namely (*1) Ecotourism Activities, (2) Ecotourism Revenue Concept, (3) Ecotourism Perception, and (4) Ecotourism Profile*, in order to develop sustainable rural development strategies with a focus on ecotourism (Table 4).

Table 4. CJA factors and sublevels.

Factor Name	**Level Code**	**Level Name**
(1) Ecotourism Activities	1–1	Learning-Based Activities (Botanical tourism, nature photography, etc.).
	1–2	Fun-Based Activities (Trekking, bicycle tour, horseback trekking, etc.).
	1–3	Recreational Activities (Health tourism, camping-caravan tourism, etc.).
(2) Ecotourism Income Concept	2–1	The priority in ecotourism is the sustainability of nature. Its income is in the second position.
	2–2	In ecotourism, sustainability of nature and income have equal priority.
	2–3	The priority in ecotourism is to generate income.
(3) Ecotourism Perception	3–1	Conservation: Ecotourism is perceived as conservation-oriented.
	3–2	Conservation + Use: Ecotourism is evaluated together with nature tourism. Sensitivity to nature is essential.
	3–3	Use: Eco-tourism is seen as a form of mass tourism. It is focused on generating income.
(4) Ecotourism Profile	4–1	Travel time 1 day. Spending $100 per trip.
	4–2	Travel time 2-5 days. Expense, $100-$1,000.
	4–3	Travel duration 5+ days. Spend over $1,000+.

Taking these factors and their sublevels into consideration, it is possible to develop 34 = 81 strategies based on full design (full profile) (Green and Sirinavasan, 1978; Malhotra, 1996). However, in this case, since it is difficult and time-consuming for the participants to prioritize or score the 81-ecotourism strategies, a special subset of these combinations, strategies in which each factor and its sub-levels are independent from each other, were determined. In this way, nine alternative ecotourism strategies based on the factors and their sublevels were developed (Table 4), according to the orthogonal design with no correlation between them (Hair et al., 1995; Smith, 1999).

Developed ecotourism strategies include combinations of factors and sub-levels. Accordingly, 9 cards, each with an ecotourism strategy, were prepared and presented to the participants along with a survey measuring some socio-economic characteristics of the participants. According to the personal interview technique, the participants were asked to rank their ecotourism strategies from best to worst. The survey was conducted in settlements located in the KMNP buffer area in 2021.

Since the target society in the research has a heterogeneous structure, it was first divided into 4 sub-layers (interest groups) and random subjects (participants) were selected from each interest group. Thus, the stratified simple random sampling method was adopted (Kalıpsız, 1987; 1994). It was aimed to conduct a survey with at least 100 people from each interest group in order to obtain reliable results and enable the application of statistical analysis. For this purpose, a survey was conducted with a total of 408 participants, 100 from local people, 100 from public institution representatives, 102 from NGO representatives and 102 from potential tourists. Alternative ecotourism strategies developed within the scope of CJA are given in Table 5.

Table 5. Ecotourism strategies created based on orthogonal design in CJA.

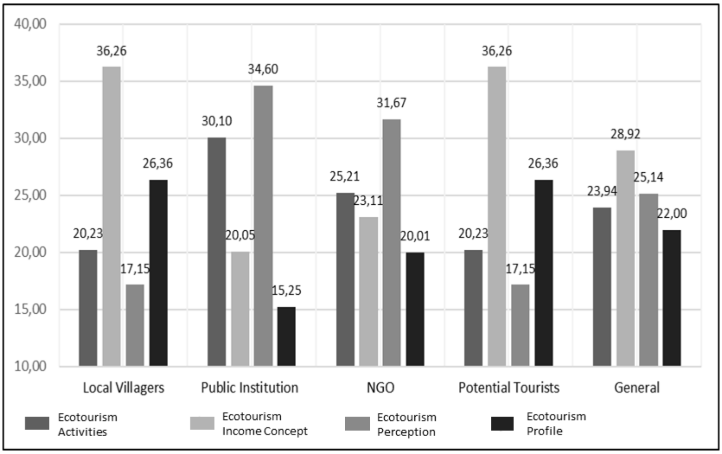
Strategy No.	Factors and Levels			
	Ecotourism Activities	**Ecotourism Income Concept**	**Ecotourism Perception**	**Ecotourism Profile**
1	Learning	The priority is to generate income.	Protection - Use	Travel: 5+ days. Spending: $1,000/person +
2	Learning	Sustainability of nature and income are equal priority	Use	Travel: 2-5 days. Expense: $100-1,000/person
3	Fun	Priority is the sustainability of nature	Protection - Use	Travel: 2-5 days. Expense: $100-1,000/person
4	Learning	Priority is the sustainability of nature	Protection	Travel: 1 day. Expense: $100/person
5	Rest	The priority is to generate income.	Protection	Travel: 2-5 days. Expense: $100-1,000/person
6	Rest	Sustainability of nature and income are equal priority	Protection - Use	Travel: 1 day. Expense: $100/person
7	Fun	Sustainability of nature and income are equal priority	Protection	Travel: 5+ days. Spending: $1,000/person +
8	Fun	The priority is to generate income.	Use	Travel: 1 day. Expense: $100/person
9	Rest	Priority is the sustainability of nature	Use	Travel: 5+ days. Spending: $1,000/person +

CJA Findings

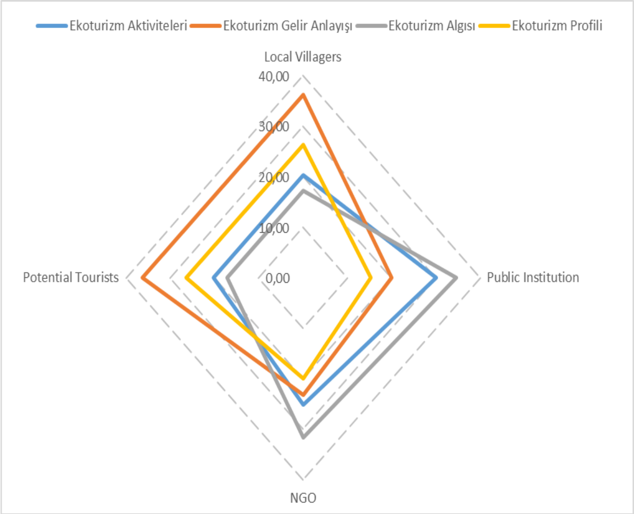
A linear regression model was established by considering the average of the priorities given by 108 participants to each ecotourism strategy in CJA as the dependent variable and the dummy variable levels of the factors as the independent variable. Because of CJA calculations, the findings shown in Table 6 and Figure 2 were obtained. Thus, based on the preferences of each interest group, the importance level of the factors and the benefit coefficients for their lower levels were determined.

Table 6. CJA Findings.

Factor Name	Factor Levels	Benefit Coefficient					Importance Level (%)				
		Local People	State Agency	NGO	Tourist	General	Local People	State Agency	NGO	Tourist	General
(1) Ecotourism Activities	1–1	-0,23	0,88	-0,44	-0,82	-0,61	20,23	30,10	25,21	20,23	23,94
	1–2	0,25	-0,84	0,88	1,24	**1,53**					
	1–3	-0,02	-0,04	-0,44	-0,42	-0,92					
(2) Ecotourism Income Concept	2–1	-0,40	1,02	0,99	-1,60	0,01	**36,26**	20,05	23,11	**36,26**	**28,92**
	2–2	-0,41	-0,68	-0,44	1,91	**0,38**					
	2–3	0,81	-0,34	-0,45	-0,31	-0,29					
(3) Ecotourism Perception	3–1	-0,20	1,24	0,91	-0,80	**1,15**	17,15	**34,6**	**31,67**	17,15	25,14
	3–2	0,55	-0,60	-0,50	-0,40	-0,95					
	3–3	-0,35	-0,64	-0,41	1,20	-0,20					
(4) Ecotourism Profile	4–1	-0,73	1,22	1,01	-0,40	**1,10**	26,36	15,25	20,01	**26,36**	22,00
	4–2	-0,25	-0,80	-0,51	0,84	-0,72					
	4–3	0,98	-0,44	-0,50	-0,44	-0,40					



(a)



(b)

Figure 2. Importance of factors in CJA (a), combination of interest groups (b).

Factors deemed important for sustainable ecotourism in KMNP for local people, one of the four interest groups; they are listed as *ecotourism income understanding, ecotourism profile, ecotourism activities and ecotourism perception*. Representatives of public institutions; *ecotourism perception, ecotourism activities, ecotourism profile*. The rankings of other interest groups are shown in Table 6 and Figure 2. These results show that local people primarily consider getting a share of the revenues in terms of sustainable ecotourism in KMNP. On the other hand, it can be stated that representatives of public institutions, NGOs and potential tourists do not have such an opinion and they rather support sustainable ecotourism activities for rural development. Some studies on this subject have found that ecotourism revenues are important for rural development in the region (Zinkhan et al., 1997; Holmes et al., 1998; Stevens et al., 2000).

When an evaluation is made for all participants, the factors considered important for sustainable ecotourism in KMNP are, in order of importance; *ecotourism income understanding, ecotourism perception, ecotourism activities and ecotourism profile*. When Figure 2 is examined, it is understood that the priority values given to the factors are close to each other. Accordingly, all participants adopted that ecotourism activities are a good rural development tool for forest villagers living in the KMNP buffer area. At the same time, participants think that ecotourism activities will contribute to sustainable development.

Because of CJA, the most preferred importance levels by the participants are stated below;

- Priority has been given to “Level 1.2” in the “Ecotourism Activities” factor. Accordingly, recreational activities (trekking, bicycle tour, horseback trekking, etc.) should be highlighted for ecotourism in KMNP.
- “Level 2.2” is important in the “Ecotourism Income Concept” factor. Accordingly, the sustainability of nature and the income to be generated in ecotourism should be considered together, and sustainable rural development should be highlighted in planning. In addition, ecotourism activities that will generate income in KMNP should be supported within the framework of sustainability principles.
- “Level 3.1” was deemed important in the “Ecotourism Perception” factor. According to these results, participants perceive ecotourism activities as conservation-oriented. Therefore, ecotourism activities to be carried out in KMNP should be carried out by excluding the perception of mass tourism.
- Priority has been given to “Level 4.1” in the “Ecotourism Profile” factor. In other words, the duration of stay and spending tendency of the eco-tourist are important in ecotourism activities. For a conscious ecotourism activity, travel time should be limited to 1 day, and expenditure per trip for an eco-tourist should be $100

Within the scope of the study, the most preferred (optimal) management strategy by the participants was determined as follows:

"*KMNP sustainable ecotourism activities include trekking; cycling tours; horseback trekking; etc. activities should be highlighted. The concepts of sustainable conservation and sustainable income should be considered together in ecotourism planning for sustainable rural development in the national park. On the other hand, ecotourism activities should adopt a conservation-oriented structure that excludes the perception of mass tourism. For this purpose, conscious ecotourism activities should be carried out, the travel time for the eco-tourist should be short and the expenditure per trip should be 100 $*."

In this study, which was undertaken to determine ecotourism strategies for sustainable rural development in KMNP, first, the current situation of KMNP was revealed with the help of SWOT analysis. Accordingly, KMNP's strengths include Europe's oldest and virgin forests, a rare karst structure in the world, canyons, valleys, caves, waterfalls, a rich flora, fauna, folkloric structure and cultural values for ecotourism. Research findings also support this situation. Likewise, when other studies examining ecotourism activities in protected areas (Zinkhan et al., 1997; Holmes et al., 1998; Stevens et al., 2000) are examined, it can be stated that the principles and strategies determined for ecotourism are similar to the findings of this study.

In the study, based on the SWOT findings, three sub-level factors were determined for KMNP: *(1) Ecotourism Activities, (2) Ecotourism Income Concept, (3) Ecotourism Perception, and (4) Ecotourism Profile*. From these factors, alternative ecotourism strategies have been developed based on orthogonal design. These strategies were presented to 108 participants, the obtained data were evaluated with CJA, and the most preferred ecotourism strategy for KMNP was determined.

This general or optimum strategy states that, contrary to today's understanding, the principle of participation should be highlighted in the ecotourism activities to be carried out in KMNP. Accordingly, in KMNP ecotourism planning, more participation of local people and NGO representatives, as well as the state, is recommended. Likewise, the idea of transferring a share from the ecotourism revenues to the local people should also be included in the planning. In this way, conflicts in KMNP will be prevented and active participation in management will be ensured. Thus, national park ecotourism activities will be better managed, as resources will be transferred to sustainable rural development.

With ecotourism planning, for example, in KMNP, the places and numbers of portable tents and cabins that do not harm the natural texture and allow visitors to stay can be determined. In fact, field carrying capacities can be determined effectively for each ecotourism activity. It is important to implement a fee policy for ecotourism activities to be held in the national park protection zone and even in the buffer zone. Nowadays, fees are charged only at the national park entrance gates. The entrance fee policy should be expanded to include all activities within the national park area. In this way, a balance of protection and use can be achieved in national park ecotourism activities. On the other hand, guidance services should be received from the local people for ecotourism activities, and an income policy should be created to ensure that the income for accommodation and even food and beverage activities remains with those living in the national park. In this way, employment opportunities in the region will increase and the rate of external migration will decrease or even reverse.

In conclusion, incorporating the ecotourism planning strategy determined for the KDMP into the preparation stage of rural development plans will contribute to the creation of dynamic and feasible plans, ensuring participation, and preventing conflicts. Furthermore, including nature-sensitive ecotourism activities in sustainable rural development plans will contribute to the preservation of the natural, geological, ecological, and cultural values of protected areas such as national parks, as well as generating income for the local community.

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Chapter 4

The Effect Of Climatic Parameters On The Sustainability Of Water Resources

Senem GÜNEŞ ŞEN[1]

ABSTRACT

Dams, lakes, and ponds are crucial structures that provide water for human needs. They have various applications in human societies, such as supplying drinking water, aquaculture, irrigating agricultural lands, recreation, energy production, wastewater treatment, flood and drought control. Additionally, they provide ecosystem services. However, climate change and human activities are causing temperatures to rise, leading to a reduction in ice cover and an increase in surface water temperatures in water resources during winter. This, in turn, is causing a rapid decrease in the surface area and water levels of these resources, making access to and supply of vital water a growing global concern. Climate change poses significant global risks, particularly to freshwater resources, by disrupting dynamic and variable water cycles across different time scales and geographical regions. During winter, as ice levels decrease and pond temperatures rise, evaporation rates increase, leading to lower water levels and surface areas if not balanced by changes in average precipitation or runoff. The effects of climate change in Turkey include increasing summer temperatures, decreasing winter precipitation, decreasing surface water, increasing drought frequency, land degradation, coastal erosion, and floods. These effects also pose a risk for ponds. Given Turkey's location in a region where both increasing temperatures and severe drought occur, it is crucial to protect lakes and ponds and ensure their sustainability. This study investigates the changes that have occurred in 14 ponds in Kastamonu province over the past 10-15 years and whether temperature and precipitation parameters have played a role in these changes. The results indicate that all 14 ponds have experienced a reduction in area and water levels. The study suggests that changes in the region's rainfall and temperature parameters have contributed to these changes.

KEY WORDS: Climate change, Global warming, Water resources, Temporal change, Pond, Kastamonu, Turkey

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Since the late 20th century, there has been rapid population growth, changes in consumption habits, and industrial developments which have contributed to severe water problems at the global, regional, and local levels. As the world population continues to grow, the demand for water increases, putting pressure on existing resources. This can lead to insufficient water resources to meet the needs of people. Access to healthy and reliable water resources can be ensured by having sufficient quantities of water available, maintaining its quality, and accepting the fact that it is a natural resource that can be depleted for various reasons (URL 1; Işıldar and Ercoşkun, 2021).

Dams, lakes, and ponds are crucial structures that enable people to meet their water needs from nature. These structures serve various purposes, such as providing drinking water, irrigation, industrial water, flood control, energy production, recreation, and wildlife conservation. To obtain the desired quality and sufficient amount of water from dams, appropriate management of soil and vegetation in the basin is necessary. Water is an essential resource for sustaining life, and it needs to be managed sustainably. Therefore, basin-based planning should be considered while allocating, using, and protecting water resources.

Satellite photos taken from space reveal that most of the Earth's surface is covered by oceans, giving the impression that water is an abundant resource that will never run out. But, in reality, only 2.5% of the world's total water resources can be used safely by humans for domestic, agricultural, and industrial purposes (Chin, 2000). The rest, which is about 96.5%, exists as saltwater in oceans and seas, which is unsuitable for human use. The average annual precipitation in Turkey is approximately 574 mm, which corresponds to an average of 450 billion cubic meters of water per year (WRMS, 2018). However, considering the current technological and economic conditions, the annual average total surface water potential for various purposes is around 94 billion m3. The determined groundwater potential is 18 billion cubic meters. The irrigation potential of our country is 112 billion m3, out of which 11% is used in industry, 15% in urban consumption, and 74% in irrigation (Muluk et al., 2013; FAO Aquastat, 2013). Unfortunately, the amount of water per person in our country has been decreasing over the years. It was in 2000, it was 1,652 m3, in 2009 it was 1,544 m3, and in 2020 it was 1,346 m3. This means that Turkey is one of the countries that suffer from water shortage when considering the usable water potential per capita (URL-2).

Since the flow rate of water transported in our country varies greatly from season to season depending on rainfall conditions, water is stored in dams and ponds and managed in a programmed manner to continuously meet the water demand (URL 3; Özalp et al., 2012). Dams, lakes, and ponds are important natural resources sensitive to climate change (Verpoorter et al., 2014). Ponds are also important indicators of regional watershed changes, making them suitable for detecting the earth's response to climate change. Since variables such as surface temperature, water level, ice cover, and color of lakes and ponds have a decisive influence on the characteristics of the Earth's climate, these water resources are classified as Essential Climate Variables (ECV) by the Global Climate Observing System (GCOS) (Woolway et al., 2020).

It has been found through research that lakes and ponds play a crucial role in mitigating climate change by serving as important organic carbon sinks (Cole et al., 2001; Sobek et al., 2003; Bastviken et al., 2004; Raymond et al., 2013). Due to their large water storage capacity, they also act as hydrological buffers that help in preventing extreme weather events such as floods, melting glaciers, and snow, which are expected to occur more frequently because of climate change (Schallenberg et al., 2013). However, climate change poses a significant risk to the sustainability of lakes and ponds (Arthington et al., 2016). Changes in precipitation patterns, reduced ice cover, increased surface water temperatures, and higher evaporation rates can all lead to decreased water levels and surface area of ponds (Güneş Şen and Aydın, 2017; Woolway et al., 2020).

Climate change poses global risks to freshwater resources by altering dynamic and variable water cycles at different time scales and geographical regions. This threatens the sustainability of our water resources, as confirmed by the National Climate Assessment reports of 2014 and 2018 (NCA, 2014; 2018). During winter, the amount of ice decreases and the surface temperature of ponds increases, leading to increased evaporation. Without changes in average precipitation or runoff, high evaporation rates can result in lower water levels and surface areas, as stated in a recent study by Woolway et al. (2020).

The effects of climate change in Turkey are concerning. Rising summer temperatures, decreasing winter precipitation, and surface water, increasing drought frequency, land degradation, coastal erosion, and floods pose significant risks to ponds. Turkey is located in a region that experiences both increasing temperatures and severe drought, which makes it essential to protect and ensure the sustainability of lakes and ponds.

In this context, this study was conducted to investigate how 14 ponds in Kastamonu province have changed over time, and whether temperature and precipitation parameters have affected this change. Kastamonu is located in the western part of the Black Sea region, between the Eastern longitudes of 33-46 and Northern latitudes of 41-42. It is bounded by the Black Sea to the north, Sinop to the east, Çankırı and Çorum to the south, and Zonguldak to the west (Öztürk and Özdemir 2013; Şen et. al., 2018). It is divided into 20 districts, including the center, and covers an area of 1,310,810 hectares (Şen et al., 2022; Anonymous, 2023). Kastamonu, which is quite mountainous and covered with forests, has a forest coverage ratio of

65%, which is above the average of 28.6% in Turkey. 26.2% of Kastamonu's forests are degraded (Şen and Güngör, 2018).

Kastamonu province is mostly rugged and mixed lands, with the Western Black Sea Mountains covering the northern part of the province. The Isfendiyar Mountains run parallel to the Black Sea coast. The province is bordered by the Ilgaz Mountains in the south, Gökırmak, and Arac Stream in the north, and Devrez Stream in the south. The valleys of the province are surrounded by plains, the most important of which is the Gökırmak Valley. A part of the Devrez Valley forms the Tosya Plain. The plains formed by small streams such as Araç and Daday streams are very small. Since the Kastamonu region is generally mountainous, there are no large flat areas (Anonymous, 2023).

Water drainage in Kastamonu province is provided by Gökırmak, Devrez Stream, Valay Stream, Araç Stream and their tributaries. The major tributaries of the Gökırmak River are Karaçomak, Karasu, Kumluca, Karadere, Akkaya, Daday Stream and Dona River. Valay stream originates from the Devrekani border and flows into the sea near Cide. Devrez Stream originates from the southern foothills of the Ilgaz Mountains, flows eastward around Tosya and joins Kızılırmak near Kargı. The Araç Stream originates from the Ilgaz Mountains, passes through the Araç district and joins the Soğanlı Stream, called Filyos, in Karabük (Anonymous, 2023).

Kastamonu province has two different climate types within its borders. The climate is temperate on the Black Sea coast, while the harsh continental climate is observed in the interior. According to the Thornthwaite climate classification, Kastamonu's climate class is C1, B'1, s, b'3. This means that the climate is semi-arid, and less humid, with a 1st degree mesothermal classification. There is excess water in winter at moderate levels, while the summer evaporation rate is 54.8%. The average temperature in Kastamonu over the years was 9.9 °C. Looking at long-term trends, temperatures tend to increase by 2.0°C per 100 years. According to long-term average precipitation, the average precipitation is 483.8 mm. When we look at annual precipitation trends over the years, we see a decrease of 60 mm in precipitation in 100 years (URL- 4). Unfortunately, anthropogenic activities are also endangering water resources, not only droughts caused by natural effects such as changing precipitation regimes due to climate change, decreasing precipitation, and increasing evaporation due to increasing temperatures.

Table 1: Climate conditions in Kastamonu province from 1930 to 2022 (URL-4)

Kastamonu	Measurement Period (1930 - 2022)												
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Average temperature (°C)	-1,00	0,80	4,30	9,60	14,10	17,50	20,10	20,00	15,80	10,90	5,30	0,90	9,90
Average max. temperature (°C)	3,20	6,20	10,90	16,60	21,30	24,70	27,80	28,10	23,90	18,20	11,10	4,90	16,40
Average min. temperature (°C)	-4,50	-3,50	-0,90	3,30	7,60	10,50	12,30	12,30	8,90	5,20	0,90	-2,40	4,10
Average Number of Rainy Days	12,43	11,38	12,11	12,91	14,55	12,08	6,39	5,73	6,65	9,01	9,48	11,99	124,70
Total Monthly Precipitation Amount Average (mm)	29,70	27,40	35,30	51,20	74,70	73,70	32,60	31,80	31,00	34,50	28,40	33,50	483,80
	Measurement Period (1930 - 2022)												
Max. temperature (°C)	19,2	21,1	27,8	31,4	35,1	37,5	42,2	40,2	39,3	32,5	24,7	21,1	42,2
Min. temperature (°C)	-26,9	-22,3	-19,7	-8,5	-3,6	0,2	3.Oca	0,9	-1,5	-7,5	-19,3	-23,7	-26,9

Water resources in the region are in danger of extinction due to anthropogenic activities, as well as droughts caused by natural effects such as changing precipitation regimes due to climate change, decreasing precipitation, and increasing evaporation due to increasing temperatures. Agricultural water diversion disrupts pond ecosystems and can cause regeneration to fail due to increased salinity and degradation of biological habitats due to improper land use, eutrophication, dam construction, agricultural irrigation, and unconscious use of groundwater. In this context, this study analyzed surface area changes of 14 ponds in Kastamonu province between 2011 and 2021 using past and present images from Google Earth.

1. Bezirgan Dam Pond

This pond is situated in the Daday district of the Kastamonu province, with a water accumulation volume of 16 million m3. The dam was constructed to irrigate 31,480 decares of land and is fed by water from Koldan Creek. As shown in Figure 1, the pond's current water capacity and surface area were 4.17 ha in 2012 when it was first put into service. Due to the pond's recent construction, the current water capacity is quite low, resulting in a small surface area. However, in 2019, the surface area increased to 55.83 ha (Anonymous, 2022; 2023).

The meteorological measurement station in the Daday district, where the Bezirgan Dam is located, began operating in 2014. According to the measurement results obtained from the Kastamonu Provincial Directorate of Meteorology Daday Station, the annual average total rainfall decreased to 355 mm after the pond began operating. The average annual total rainfall in Daday is 551.26 mm. Annual average temperature values also varied between 9 and 11 °C (Graph 1).

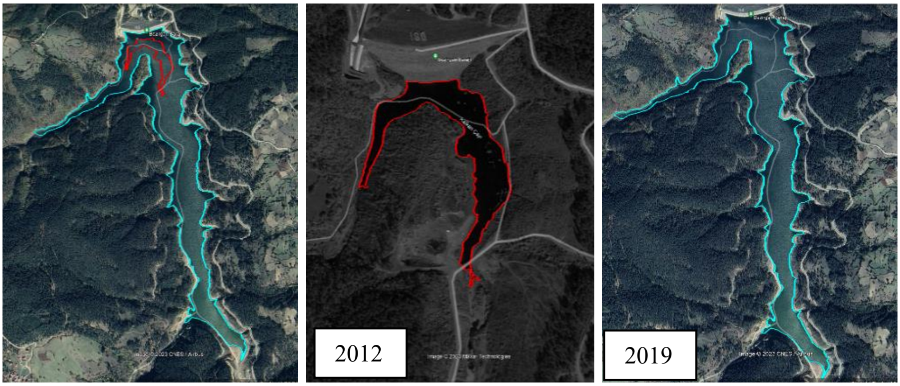
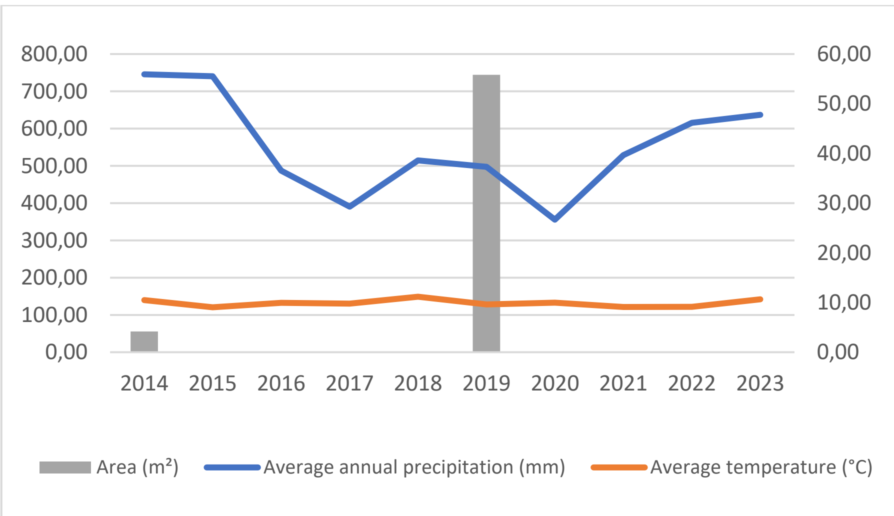


Figure 1. Surface area change of Bezirgan Dam Pond between 2012 and 2019



Gragh 1. Precipitation and temperature data of Daday district between 2014 and 2023

2. Beyler Dam Pond

This pond is located in the Devrekani district of Kastamonu province and is 9 km away from the district. It was established on the İncesu stream between the villages of Fakılar and Karayazıcılar in the northwest, for the irrigation of the lands of the Devrekani and Seydiler districts. It can irrigate a total of 5133 m2 of land, including 2458 m2 of Devrekani and 2675 m2 of Seydiler land (URL-5). When Figure 2 is examined, the surface area of the pond was 118.04 hectares in 2013, and with the increases in annual average precipitation in 2016, the surface area increased to 193.34 hectares. In 2019, as the average annual precipitation decreased and average temperatures increased, the surface area of the pond decreased to 149.91 hectares.

Generally speaking, it can be seen that there was a 22.5% reduction in the pond surface area from 2016 to 2019.

According to the measurement results taken from Kastamonu Provincial Directorate of Meteorology Devrekani Station, the annual average total precipitation amount is 578.38 mm, and the annual average temperature values varied between 7.04°C and 9.94°C (Graph 2).

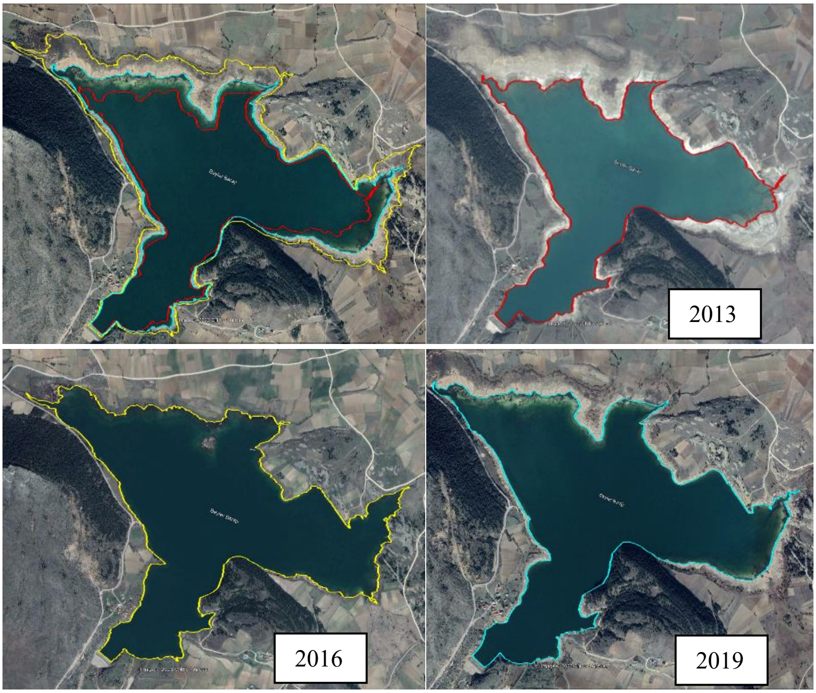
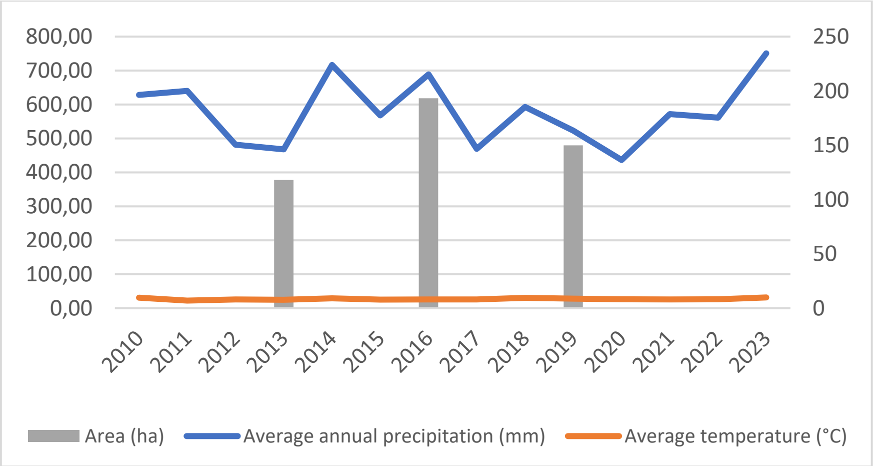


Figure 2. Surface area change of Beyler Dam Pond in 2013, 2016 and 2019



Graph 2. Precipitation and temperature data of Devrekani district between 2010-2023

3. Germeçtepe Dam Pond

This dam was built between 1977 and 1984 for irrigation purposes on the Şadibey Stream in Kastamonu Center. The body volume of the dam, which is a rock-fill type, is 309,000 m³, its height from the stream bed is 42 m., the lake volume at normal water level is 7.26 hm³, and the lake area at normal water level is 0.45 km². The dam provides irrigation services to an area of 968 hectares (Anonymous, 2022; 2023).

When Figure 3 is examined, the pond surface area, which was 30.4 hectares in 2013, increased to 44.4 hectares in 2016 and decreased again to 31.1 hectares in 2020. When we examine the change in the pond surface area from 2016 to 2020, we see that there is a 29.95% reduction in the surface area. According to the measurement results taken from the Kastamonu Provincial Directorate of Meteorology, the annual average total precipitation amount is 530.64 mm, and the annual average temperature values vary between 9.21°C and 11.48°C (Graph 3).

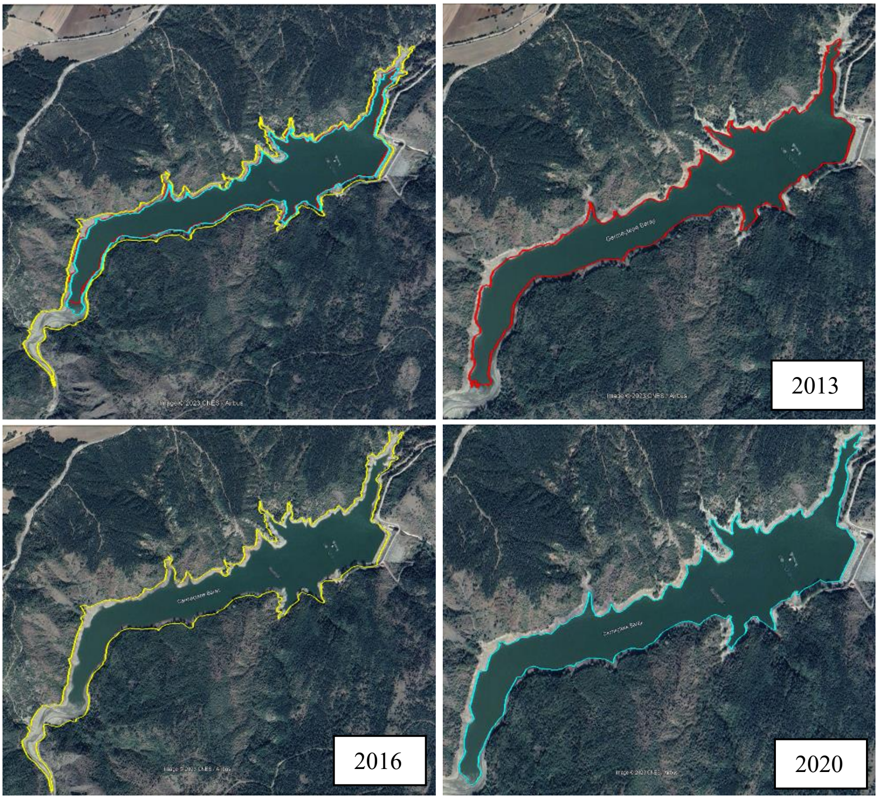
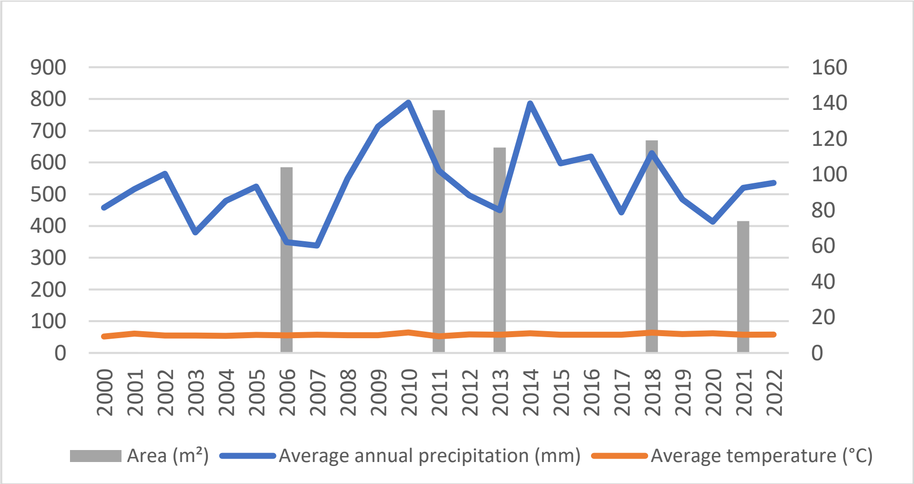


Figure 3. Surface area change of Germeçtepe Dam Pond in 2013-2016 and 2020



Graph 3. Precipitation and temperature data of Kastamonu district between 2000-2023

4. Karaçomak Dam Pond

Karaçomak Dam was built between 1968 and 1973 in Kastamonu. It was constructed for irrigation, flood control, and drinking water supply. The dam is a eart body fill type and has a body volume of 1,100,000 m³. Its height from the stream bed is 49 m. The lake volume at normal water level is 23.10 hm³, and the lake area at normal water level is 1.43 km². It provides irrigation services to an area of 2,596 hectares and supplies 3 hm³ of drinking water per year (Anonymous, 2022; 2023).

From 2013 to 2018, the surface area of Karaçomak Dam Pond increased from 115 hectares to 119 hectares. However, in 2021, the surface area of the pond decreased to 73.8 hectares (Figure 4). This represents a 35.8% reduction in the pond surface area from 2013 to 2021. The annual average total precipitation amount is 530.64 mm, and the annual average temperature values vary between 9.21°C and 11.48°C (Graph 4).

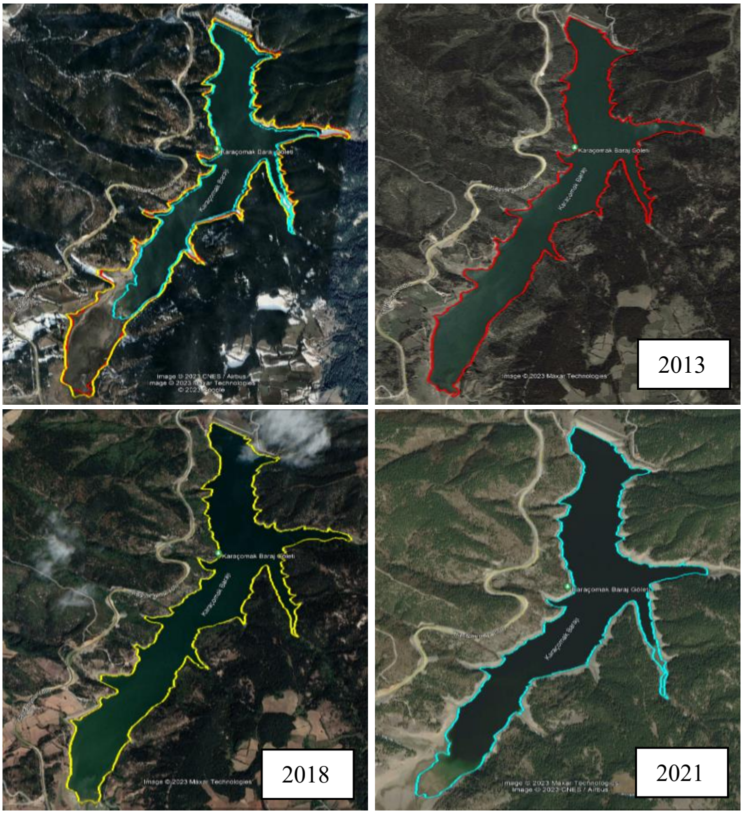
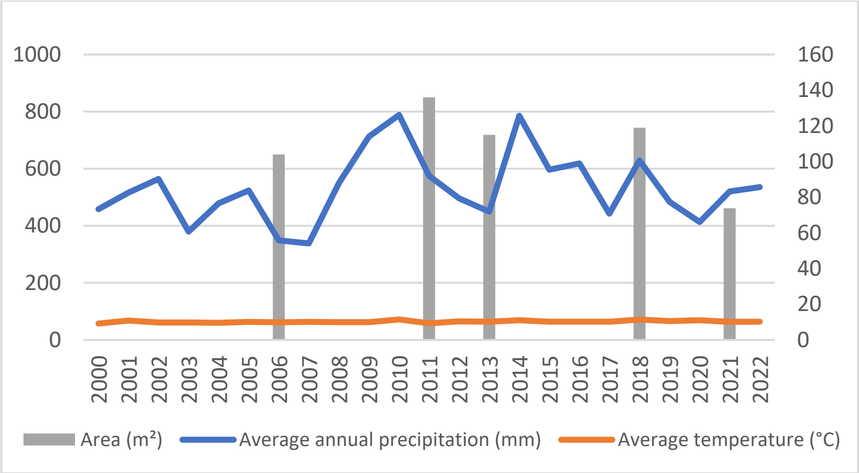


Figure 4. Surface area change of Karaçomak Dam Pond in 2013, 2018 and 2021



Graph 4. Precipitation and temperature data of Kastamonu district between 2000-2023

5. Asar Dam Pond

The Asar Dam was constructed on the Değirmendere River in the Taşköprü district of Kastamonu. It has a reservoir volume of 4.6 million cubic metres and stands 32 metres tall from the river bed. The dam is used to irrigate 1010 hectares of land and has a water accumulation volume of 4.56 million cubic metres (Anonymous, 2022; 2023).

Figure 5 shows that the pond's surface area increased from 28.1 hectares in 2014 to 31.9 hectares in 2017 and 2019. Based on the measurement results obtained from Kastamonu Meteorology Provincial Directorate Taşköprü Station, the annual average total precipitation amount is 486.53 mm. Additionally, the annual average temperature values range from 11.04°C to 13.01°C (Graph 5).

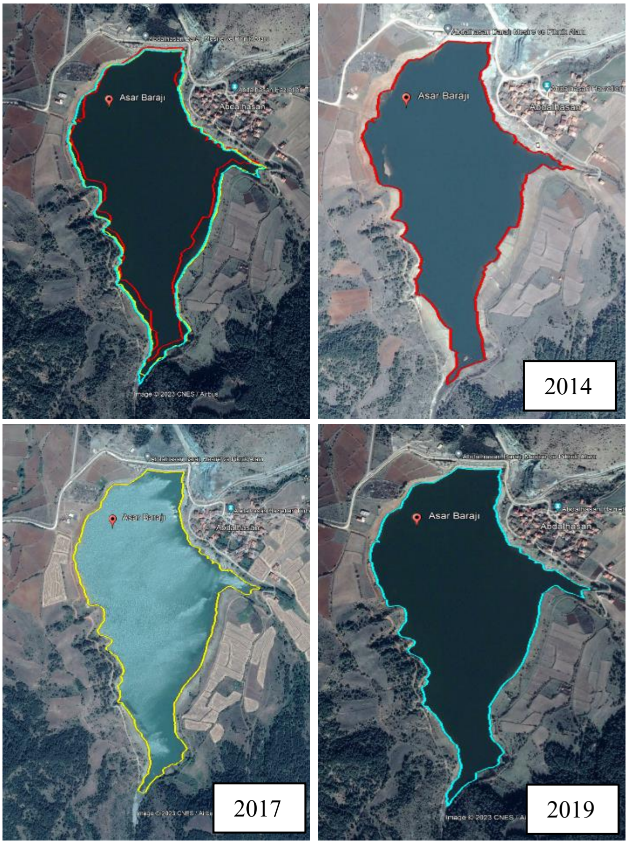
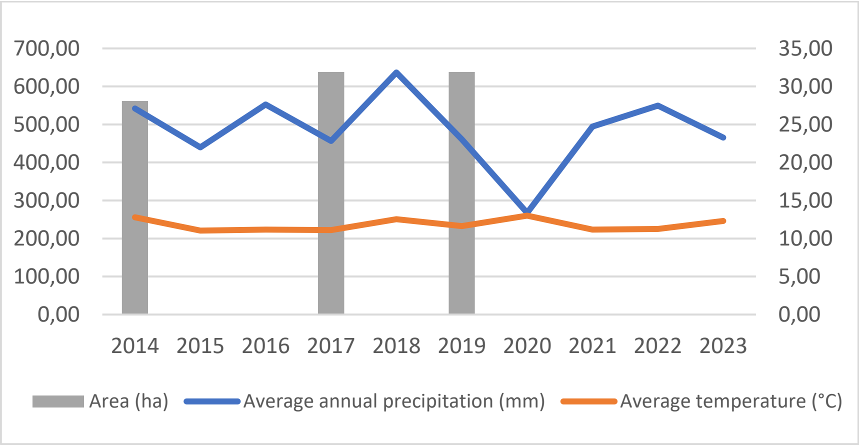


Figure 5. Surface area change of Asar Dam Pond in 2014, 2017 and 2019



Graph 5. Precipitation and temperature data of Taşköprü district between 2014-2023

6. Kulaksızlar Kınık Dam Pond

Also known as Kulaksızlar Dam, is an irrigation dam built on Bük Creek in Devrekani, Kastamonu. The dam is a rock-filled type with a body volume of 878,000 m³ and a height of 46 m above the riverbed. At normal water level, the lake volume is 18.72 hm³, and the lake area is 2.00 km². The dam provides irrigation services to an area of 5,128 hectares (Anonymous, 2022; 2023).

When figure 6 is analyzed, it can be observed that the pond's surface area decreased from 129 hectares in 2013 to 97.9 hectares in 2019 and 83.2 hectares in 2021. Although the annual average precipitation has increased, there are periods of decreased monthly precipitation, particularly in the spring and summer, with a decrease of up to 1.2mm. Even in the fall, precipitation remains at very low levels. Furthermore, the surface area of the pond has decreased by 35.5% due to high temperatures, particularly during periods of low rainfall, caused by evaporation. According to measurements from the Devrekani Station of Kastamonu Provincial Directorate of Meteorology, the average annual total precipitation is 578.38 mm, and the average annual temperature ranges from 7.04°C to 9.94°C (Graph 6).

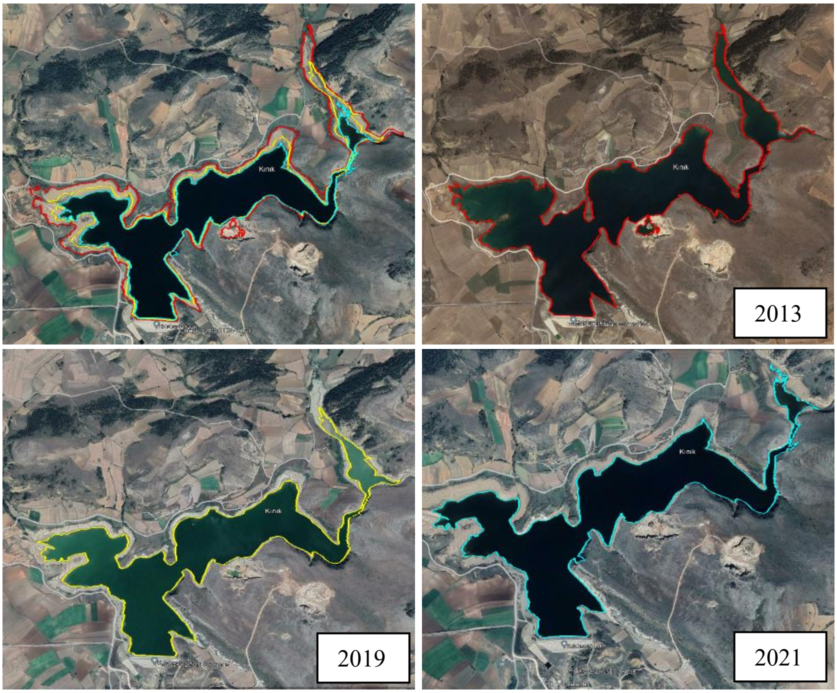
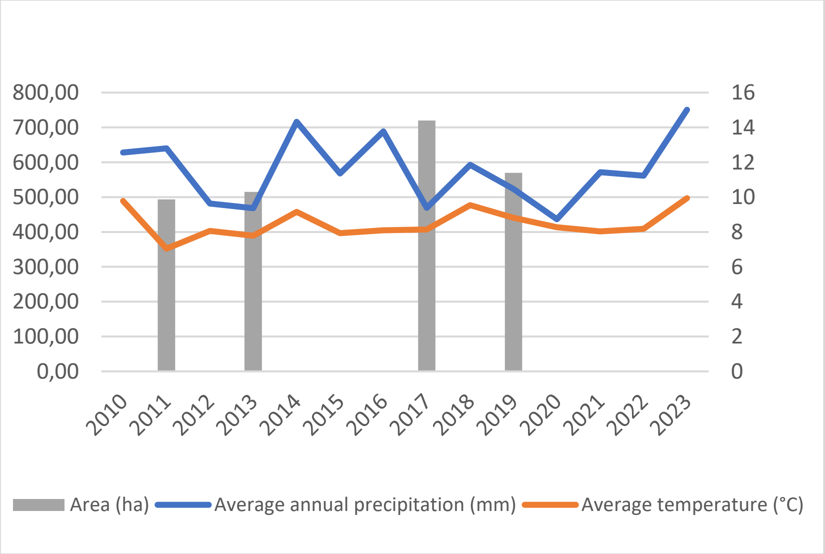


Figure 6. Surface area change of Kınık Dam Pond in 2013-2019 and 2021



Graph 6. Precipitation and temperature data of Devrekani district between 2010-2023

7. Karadere Dam Pond

Karadere Dam was built for irrigation purposes between Kastamonu and Taşköprü District. The dam is built in the earth body fill type with a body volume of 2,850,000 m^3, a dam body length of 309 m, and a height of 90 m from the stream bed. At normal water level, the lake volume is 32 hm^3 and the lake area is 1.10 km^2. The dam provides irrigation services to an area of 6,449 hectares (Anonymous, 2022; 2023).

When figure 7 is analyzed, the pond's surface area was 67.1 ha in 2014, increased to 102 ha by 2019, and then decreased to 68 ha by 2021. There has been a 33.3% reduction in the pond surface area since 2019. According to measurement results taken from Kastamonu Provincial Directorate of Meteorology Taşköprü Station, the annual average total precipitation amount is 486.53 mm, and the annual average temperature values range between 11.04-13.01°C (Graph 7).

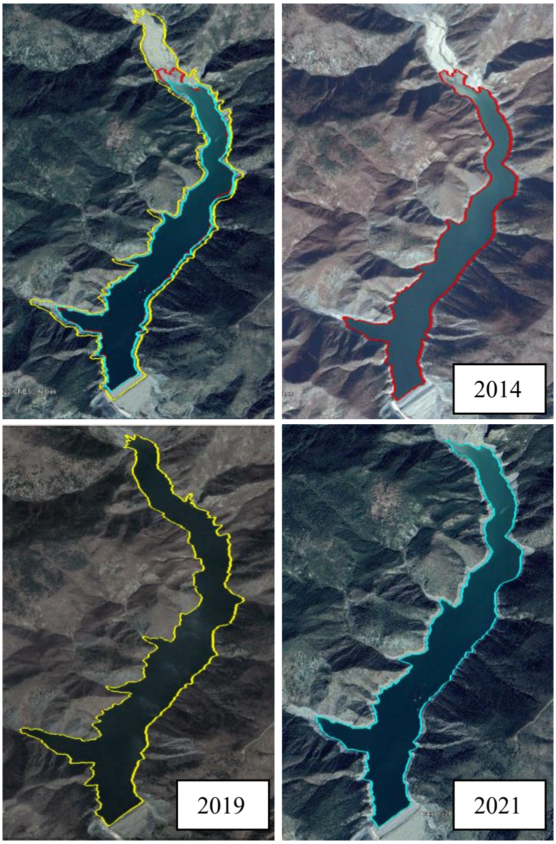
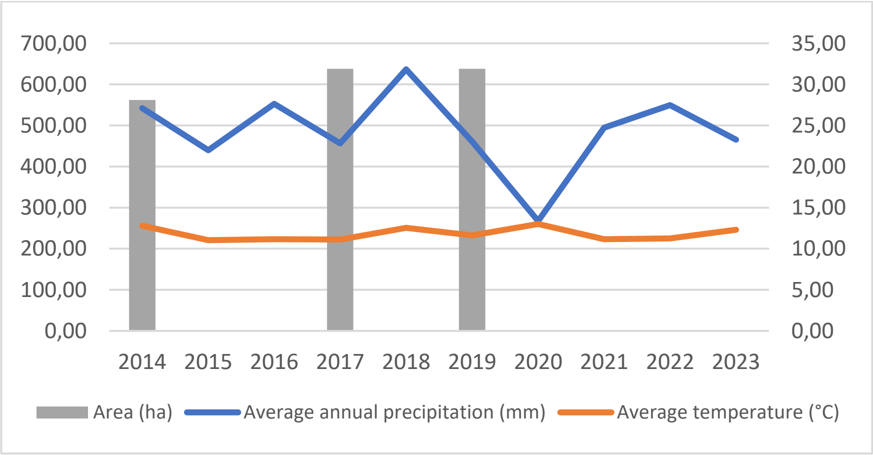


Figure 7. Surface area change of Karadere Dam Pond in 2014-2019 and 2021



Graph 7. Precipitation and temperature data of Taşköprü district between 2014-2023

8. Kabalar Pond

Kabalar Pond is situated in the Taşköprü district of Kastamonu province, on Değirmen Creek. It was constructed for irrigation purposes and has a storage volume of 0.56 hm3, with a maximum depth of 15 meters (Anonymous, 2022; 2023).

As shown in Figure 8, the pond's surface area was 9.58 hectares in 2014, increased to 12.2 hectares in 2017, and then decreased to 6.61 hectares in 2020, resulting in a 31% reduction in surface area after 2014. According to measurements taken from the Kastamonu Provincial Directorate of Meteorology Taşköprü Station, the annual average total precipitation amount is 486.53 mm, and the annual average temperature values vary between 11.04-13.01°C (Graph 8).

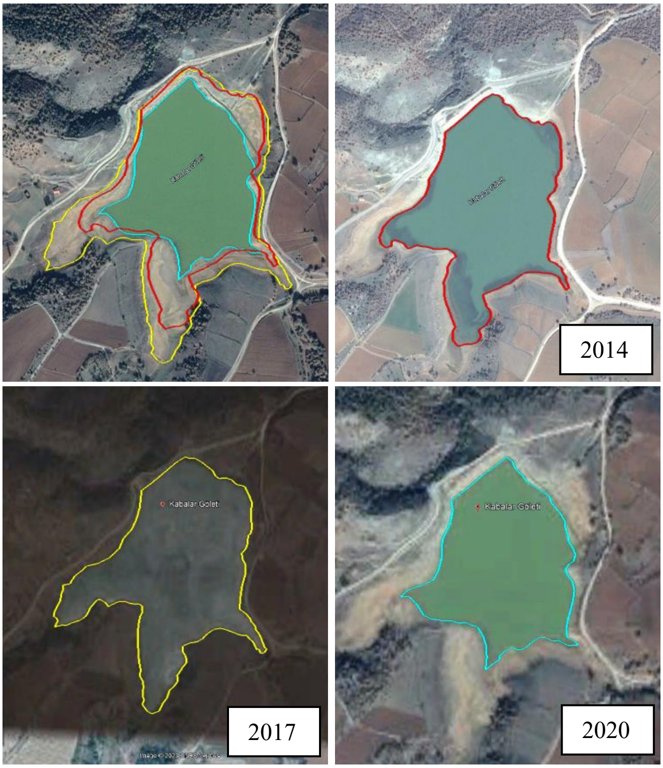
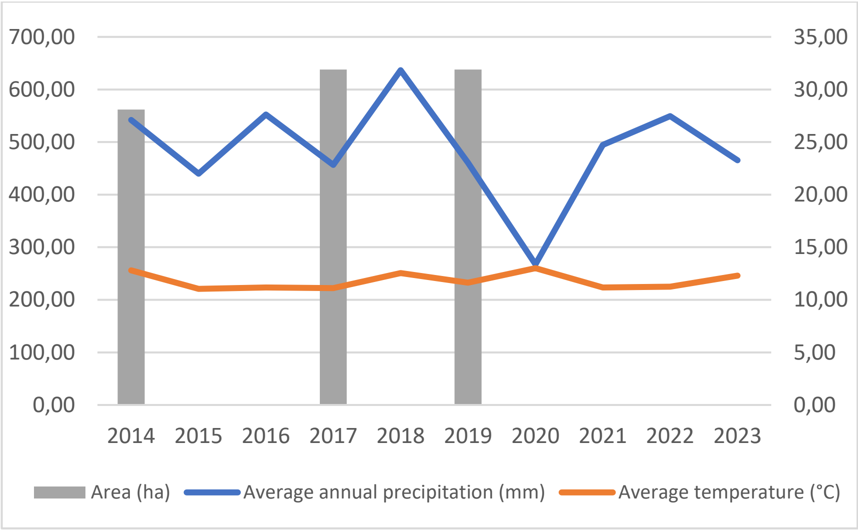


Figure 8. Surface area change of Kabalar Pond in 2014-2017 and 2020



Graph 8. Precipitation and temperature data of Taşköprü district between 2014-2023

9. Sakız Göleti

Sakız Pond is situated in the Taşköprü district of Kastamonu province, along the Kaya Stream. The pond was constructed as a land fill type for irrigation purposes, with a lake volume of 293,000 m3 and an irrigation area of 17 hectares (Anonymous, 2022; 2023).

Figure 9 shows that the pond's surface area was 3.16 hectares in 2014, increased to 4.92 hectares in 2017, and then decreased to 3.1 hectares in 2019. There was a 37% reduction in the pond surface area after 2017. According to measurements from the Kastamonu Provincial Directorate of Meteorology Taşköprü Station, the annual average total precipitation amount is 486.53 mm, and the annual average temperature values range from 11.04-13.01°C (Graph 9).

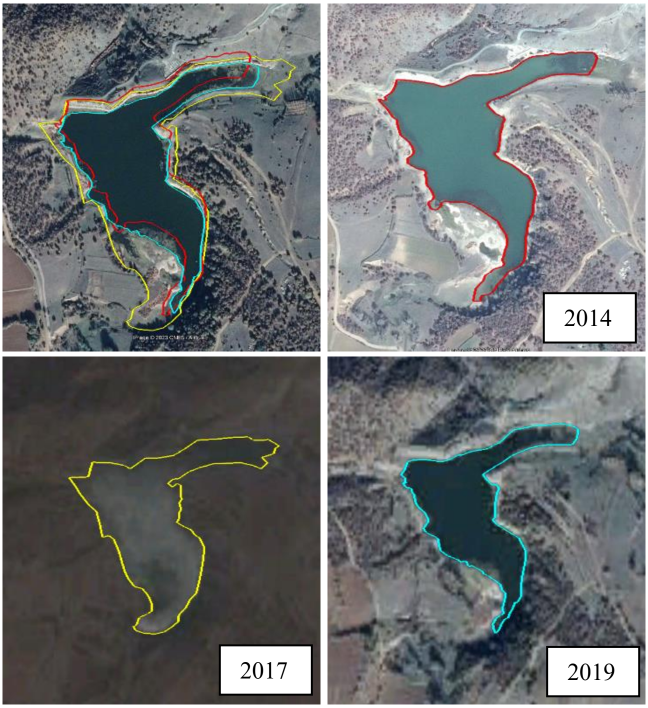
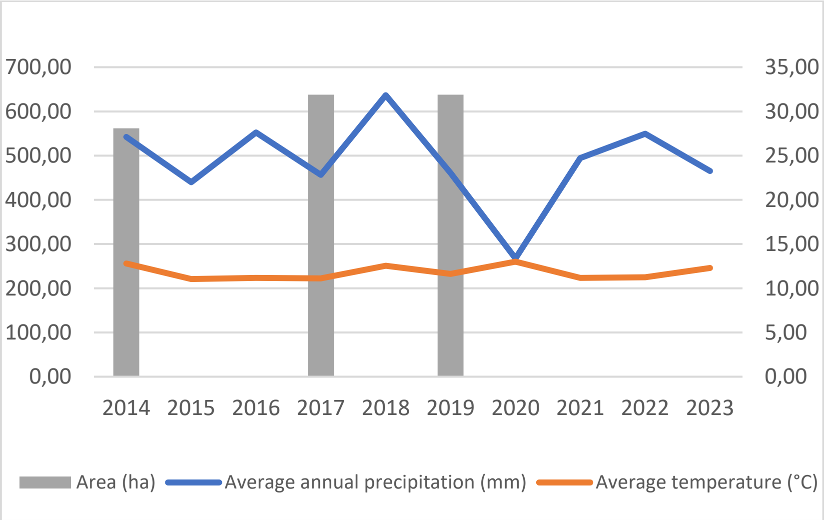


Figure 9. Surface area change of Sakız Pond in 2014-2017 and 2019



Grafik 9. Precipitation and temperature data of Taşköprü district between 2014-2023

10. Taşçılar Pond

Taşçılar Pond is located in the Daday district of Kastamonu province and was constructed for irrigation purposes. The pond has a volume of 1,020,000 cubic meters and serves an irrigation area of 126 hectares. The amount of water withdrawn is 280,000 cubic meters, and the pond is of the landfill type (Anonymous, 2014; Anonymous, 2022).

Figure 10 shows that the pond surface area was 4.93 hectares in 2001, increased to 8.10 hectares in 2014 and then decreased to 5.75 hectares in 2019. After 2011, there was a 29% reduction in the surface area of the pond. According to measurements taken from the Kastamonu Provincial Directorate of Meteorology Daday Station, the annual average total precipitation amount is 551.26 mm, and the annual average temperature values vary between 9.04-11.17°C (Graph 10).

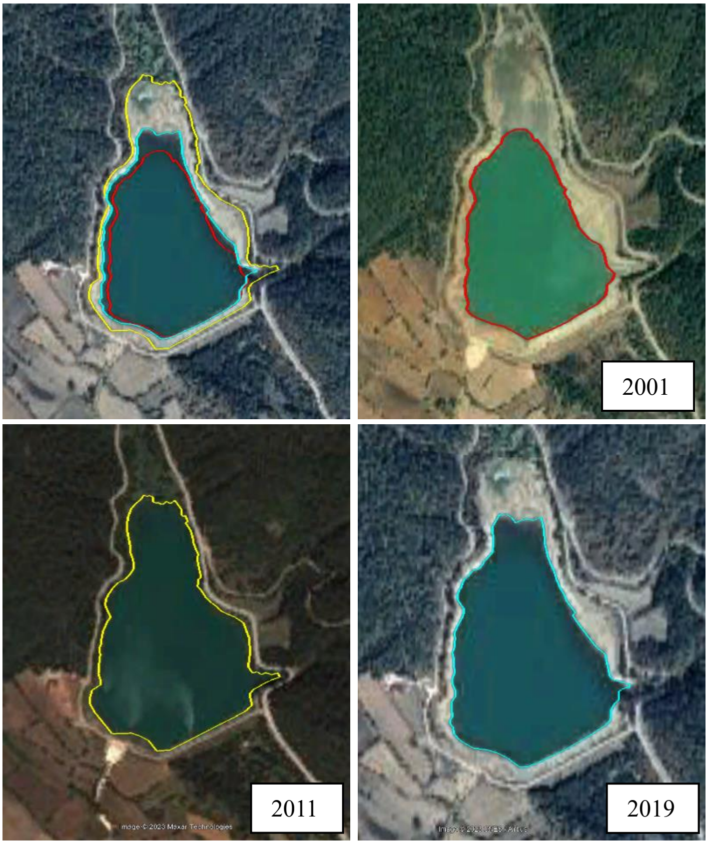
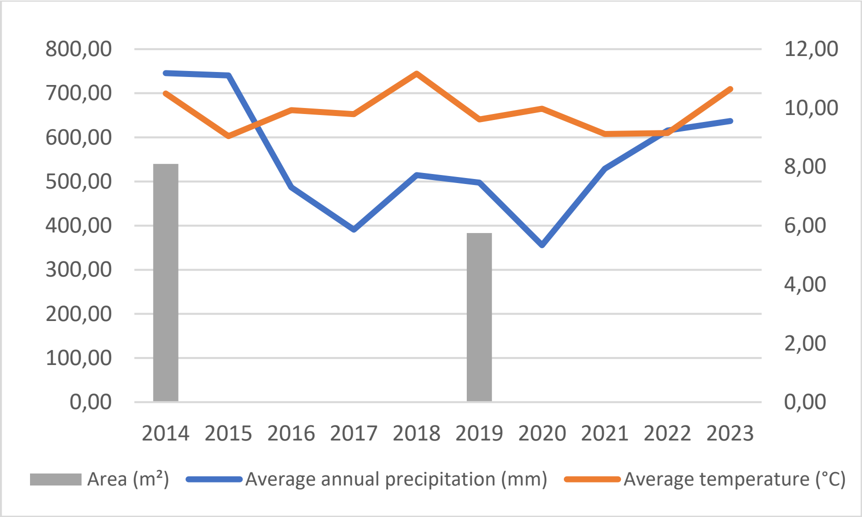


Figure 10. Surface area change of Taşçılar Pond in 2001-2011 and 2019



Graph 10. Precipitation and temperature data of Daday district between 2014-2023

11. Yumurtacılar Pond

Yumurtacılar Pond, located in the Daday district of Kastamonu province, was constructed for irrigation purposes. According to Anonymous (2014), the pond has a volume of 930,000 m3 and is of landfill type. The irrigation area covers 124 ha and 230,000 m3 of water is withdrawn.

Figure 11 shows that the pond's surface area was 14.6 hectares in 2011, increased to 15 hectares in 2013 and 2014, and decreased to 14.7 hectares in 2019. The pond's surface area has only decreased by 2% since 2013. The annual average total precipitation amount at Kastamonu Provincial Directorate of Meteorology Daday Station is 551.26 mm, with annual average temperature values ranging between 9.04-11.17°C, as shown in Graph 11.

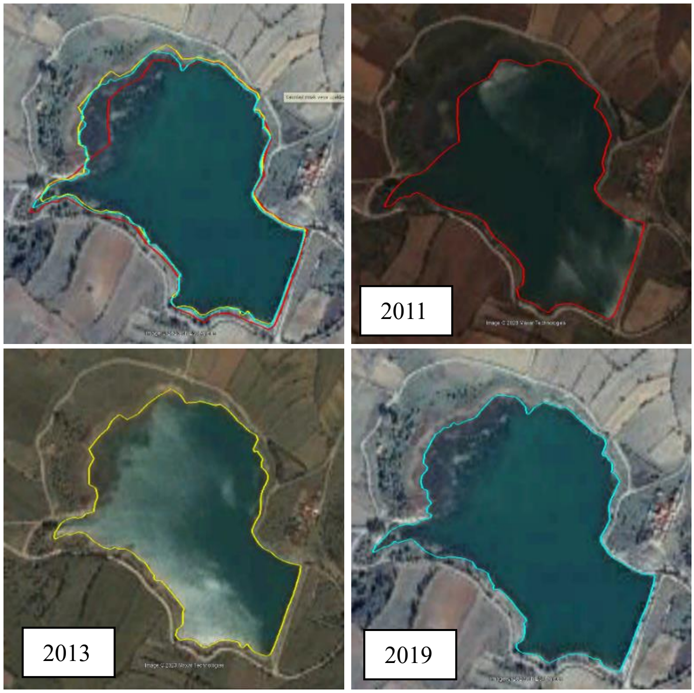
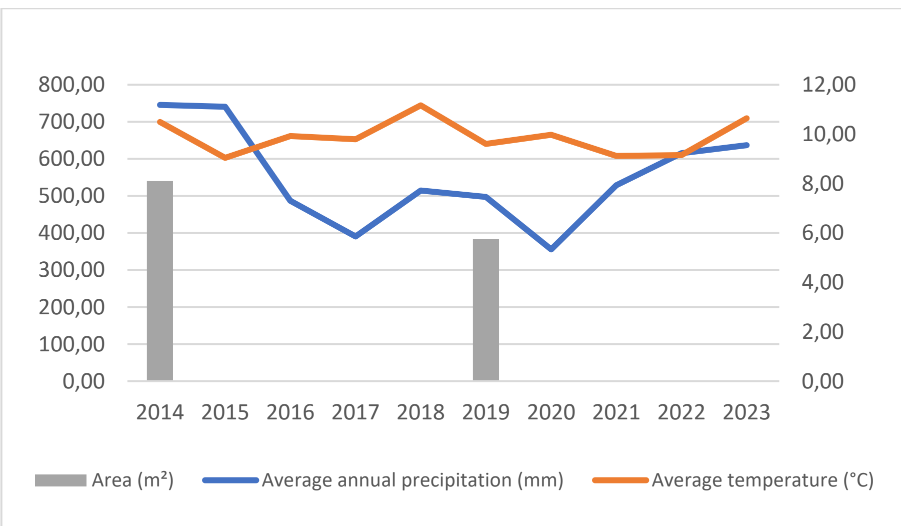


Figure 11. Surface area change of Yumurtacılar Pond in 2011-2013 and 2019



Graph 11. Precipitation and temperature data of Daday district between 2014-2023

12. Çiğdem Pond

Çiğdem Pond is an artificial irrigation pond located on Çatakboğazı Stream in the Devrekani district of Kastamonu province. The pond was constructed using the land fill method and has a volume of 1005,000 m3, providing irrigation for an area of 111 hectares (Anonymous, 2022; 2023).

Figure 12 shows that the surface area of the pond has changed over time, from 9.87 ha in 2011, to 10.3 ha in 2013, to 14.4 ha in 2017, and then to 11.4 ha in 2019. Since 2013, the pond's surface area has increased by 10%.

The data obtained from the Kastamonu Provincial Directorate of Meteorology Devrekani Station shows that the annual average precipitation in the area is 578.38 mm, and the average temperature ranges from 7.04°C to 9.94°C throughout the year (Graph 12).

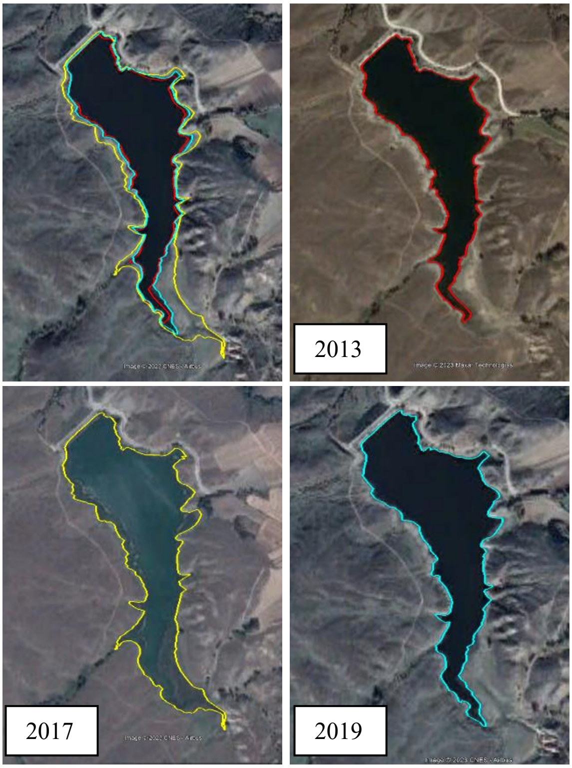
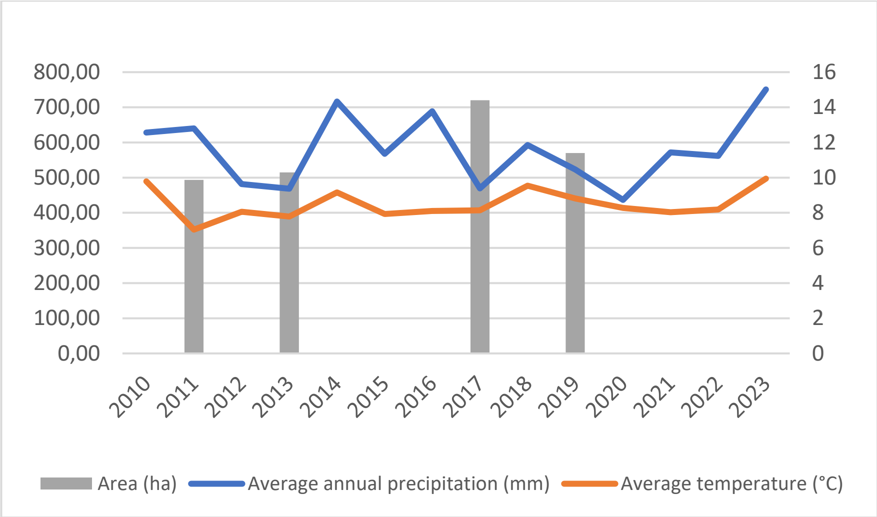


Figure 12. Surface area change of Çiğdem Pond in 2013-2017 and 2019



Graph 12. Precipitation and temperature data of Devrekani district between 2010-2023

13. Tuzaklı Pond

Tuzaklı Pond is situated in the Araç district of Kastamonu province. It was constructed on the Gavur Stream for irrigation purposes. The pond has a clay fill type and a lake volume of 1,100,000 m3, irrigating an area of 229 hectares (Anonymous, 2022; 2023).

Figure 13 shows that the pond's surface area decreased from 9.36 hectares in 2012 to 9.24 hectares in 2019, indicating a 1.3% change. Based on measurements taken from Kastamonu Provincial Directorate of Meteorology Araç Station, the annual average total precipitation amount is 544.46 mm, and the annual average temperature values range between 7.04°C and 9.94°C (Graph 13).

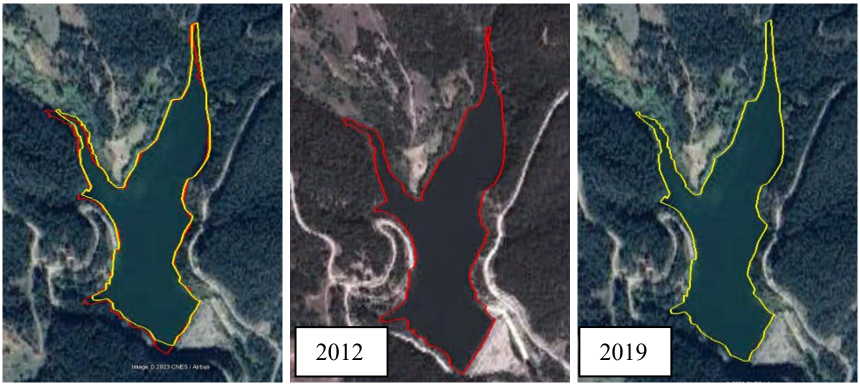
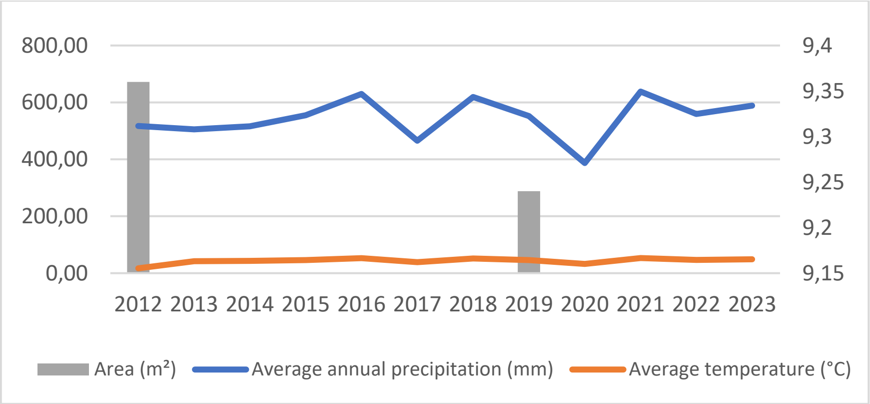


Figure 13. Surface area change of Tuzaklı Pond between 2012-2019



Graph 13. Precipitation and temperature data of Araç district between 2012-2023

14. Kösençayırı Pond

Kösençayırı Pond is situated in the Tosya district of Kastamonu province. It was constructed on Kavuncu Stream for irrigation purposes using a clay core - rock fill method. The pond has a volume of 1744,000 m3 and covers an irrigation area of 850 hectares (Anonymous, 2022; 2023).

Figure 14 shows that the surface area of the pond was 13.6 ha in 2013, but decreased to 11.4 ha in 2016 and further decreased to 10.4 ha in 2020. a 23.5% reduction in surface area since 2013. According to the measurement results obtained from the Kastamonu Provincial Directorate of Meteorology Tosya Station, the average annual total precipitation amount is 449.66 mm, and the annual average temperature values range from 7.04°C to 9.94°C (Graph 14).

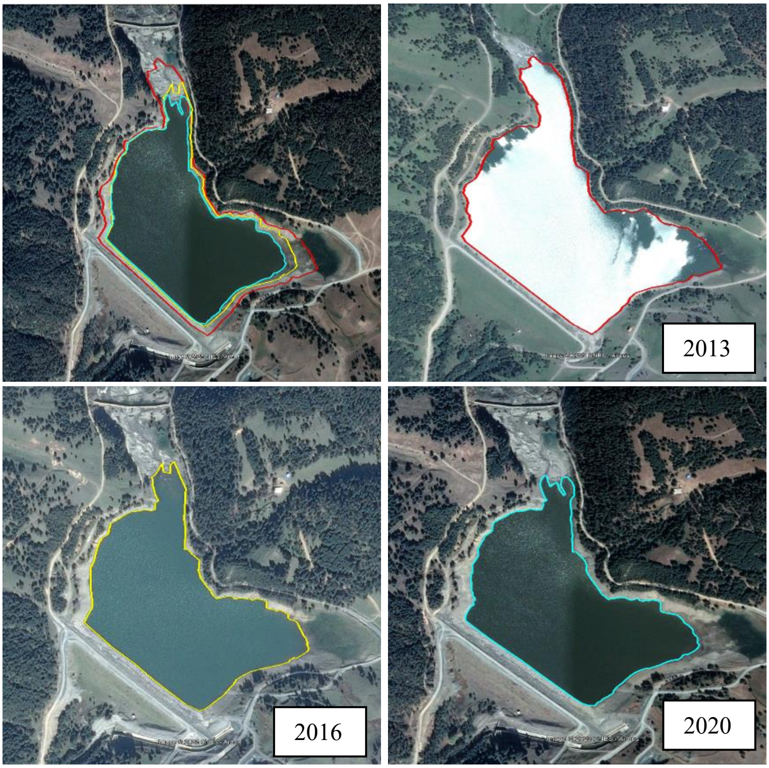
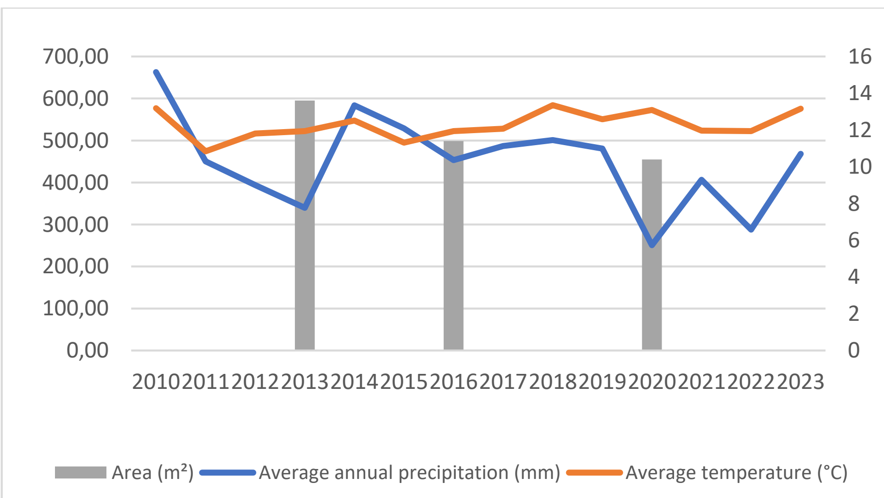


Figure 14. Surface area change of Kösençayırı Pond in 2013-2016 and 2020

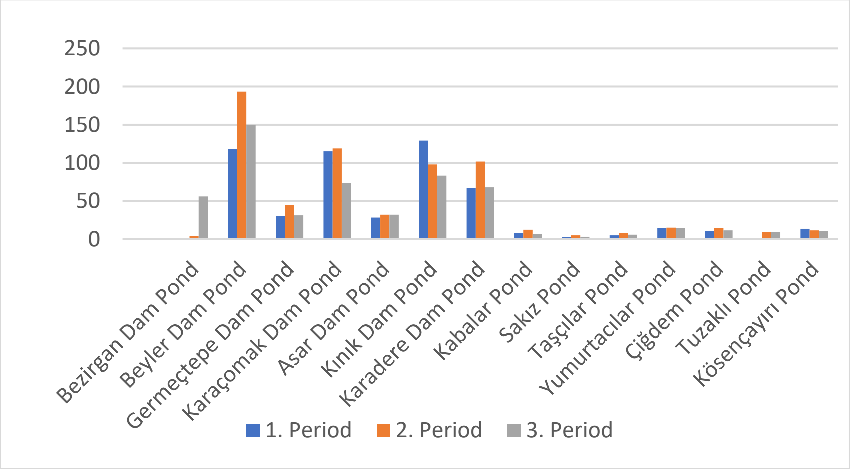


Graph 14. Precipitation and temperature data of Tosya district between 2010-2023

We evaluated spatial changes in 14 ponds over three different periods and found that the pond areas decreased over time. Table 2 and Graph 15 show the area changes of the ponds for each of the three different periods.

Table 2. Temporal change of surface areas of ponds

Pond Name	1. Period (ha)	2. Period (ha)	3. Period (ha)
Bezirgan Dam Pond	-	4,2	55,8
Beyler Dam Pond	118,0	193,3	149,9
Germeçtepe Dam Pond	30,4	44,4	31,1
Karaçomak Dam Pond	115,2	118,8	73,8
Asar Dam Pond	28,1	31,9	31,9
Kınık Dam Pond	129,0	97,9	83,1
Karadere Dam Pond	67,1	101,6	68,0
Kabalar Pond	7,9	12,2	6,6
Sakız Pond	2,8	4,9	3,1
Taşçılar Pond	4,9	8,1	5,8
Yumurtacılar Pond	14,6	15,1	14,7
Çiğdem Pond	10,3	14,4	11,4
Tuzaklı Pond	-	9,4	9,2
Kösençayırı Pond	13,6	11,4	10,4



Graph 15. Temporal change of surface areas of ponds

The size of ponds can be influenced by a range of factors, such as climate change, reduced precipitation, rising temperatures, increased evaporation due to temperature changes, and elevated salinity levels. Furthermore, human activities such as agricultural irrigation in stream beds, illegal boreholes, groundwater withdrawals, unplanned land use, and uncontrolled irrigation in agriculture, as well as the expansion of industrial facilities due to population growth and urbanization, all contribute to the depletion of water resources.

These factors increase the vulnerability of water bodies to the effects of climate change, which can result in a reduction in both water quality and quantity, as well as a decrease in the surface area of ponds. To prevent water wastage, it is important to raise awareness about water conservation in society. Specifically, measures should be implemented to prevent uncontrolled irrigation in agriculture, and methods that promote planned and conscious water usage should be encouraged. Furthermore, it is advisable to encourage local people to adopt water-efficient agricultural practices that are suitable for areas with low water availability.

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Chapter 5

The Possible Effects of Forest Roads in Terms of Sustainable Forestry

Mehmet EKER*

Abstract

For the continuity of forest resources and the sustainability of their benefits, all types of operations related to forest ecosystems are among the priority issues of public concern on a global scale. The effects of roads on ecosystem components are overshadowed by the effects of land degradation, such as land misuse and deforestation. Recently, however, the need to understand the functional sustainability of forest roads or roads through forests has emerged in the context of sustainable forest management. Indeed, roads have direct ecological impacts on aquatic and terrestrial habitats, disrupt soil integrity, and alter existing land cover, land use and vegetation cover. The large-scale interactive damage caused by roads and road networks on ecosystems and their occurrence are important for the ecological sustainability of forest roads. Policy makers, managers, planners, practitioners, and users need to be aware of the impacts of roads on forest ecosystems and act and behave accordingly in theory and practice. Based on this rationale, the potential impacts of forest roads were categorized with the support of the literature in this study. Then, some road indices were calculated using the presence of forest roads in Turkey and the characteristics of forest roads. The potential impacts of roads were evaluated together with the results obtained. It was found that the increase in the presence of forest roads, increase in road density, expansion of road occupation areas, major repairs, etc. will increase the severity of possible negative impacts of roads on the forest ecosystem. Measures should be taken to reduce the ecological impact of roads to ensure sustainable forestry in the process of road construction and use, starting from the planning and design to the maintenance and repair stage.

Keywords: Forest roads, Road Impacts, Ecological effects, Road density, Forest roads in Türkiye

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Highways constitute the basic infrastructure of the terrestrial transport system and provide physical contact between geographically disparate locations and the interaction of living and non-living things. Forest roads, which are a subset of the general road network, are an important system component that constitutes the access infrastructure within forests in terms of the continuity of forest resources and the sustainability of utilization of these resources. Forest roads have low geometric features (compared to other roads), do not have any rigid superstructure such as asphalt or concrete pavement and have a character where traffic is infrequent. However, they are single-lane (and generally) dirt roads that are suitable for the traffic of conventional vehicles all year round, especially for the protection, utilization, and development of forest resources. Forest roads are technically, economically, and ecologically different from other roads and must be functional, aesthetic, and safely. In this context, in parallel with the change in protection and utilization policies on forest resources, developments in the forestry sector and technological progress of humanity; the number of roads passing through forest ecosystems is increasing, and the functions and effects of forest roads are becoming more important by changing their shape and intensity.

In addition to the beneficial functions of forest roads, like other roads, there are also some negative effects. In general, roads form the transport system by weaving a spider's web through the land on which they are located, causing multiple changes to the geography. The road network affects ecosystem structure, the dynamics of ecosystem functions, and has a negative impact on ecosystem components, including species composition. The road network system formed by the combination of roads, with its direct (primary) and indirect (secondary) effects, causes the fragmentation and alteration of ecosystems and the destruction and re-forming of land integrity. In this context, the continuity of forest resources may suffer temporary or permanent damage due to the negative effects of roads.

Sustainable forestry is the maintenance and development of forest functions (such as timber production, protection of soil and water resources, conservation of biodiversity, carbon sequestration, etc.) for the benefit of society, now and in the future, in social, cultural, environmental and economic terms. The main criteria for sustainable forestry are the continuity of forest resources and their contribution to the global carbon cycle, the health and integrity of forests, the productive capacity of forests, biological diversity, the protective functions of forests and the socio-economic functions that must not be interrupted. In this context, forest roads, like other forestry practices, should be implemented with the lowest possible risks and hazards in order to achieve sustainable forest management. To ensure the functional sustainability of forest roads, knowledge

of the multiple impacts of forest roads plays an important role in determining the course of action and policies regarding planning, management, improvement and even decommissioning. For the sustainability of forest resources, facilities and activities that have temporary and permanent impacts on the forest ecosystem should be kept under control. To support this need, in this book chapter, in countries such as Turkey where the presence of forest roads is increasing, the effects of roads are first taxonomically classified and then the presence and effects of forest roads are evaluated in terms of functional sustainability.

Classification on Potential Impacts of Roads

In order to ensure functional sustainability, it is necessary to have a good understanding of the possible/potential positive and negative impacts of all roads. In this respect, the impacts of roads should be taxonomically categorized, and possible impacts described. In this way, it may be possible to understand the place of roads in the context of sustainable forestry, both technically and economically and ecologically, by taking a proactive approach to possible impacts.

Forest roads constitute the infrastructure of the forest products supply system and are indispensable essential facilities in terms of ensuring transport logistics. In this context, the duties of forest roads can be listed under the following general headings (Erdaş, 1997; Acar, 2005; GDF, 2008; Boston, 2016);

- Access to all types of goods and services in the forest,
- Economic transport of forest products,
- Carrying out operations to protect, manage and improve the forest,
- To provide the necessary equipment and personnel for the protection of the forest,
- Fighting forest fires and pests,
- Provide and maintain forest management and supervision services,
- Provide services for the construction and maintenance of facilities such as dams, drainage structures and infrastructure,
- Providing the transport network between the scattered forest villages,
- Providing recreational activities,
- Contribute to the defense of the country.

Forest roads provide access to the forest for all types of vehicles, enable the appropriate transport of people, tools, and equipment into the forest, and enable the technical and economic transport of forest products out of the forest.

Particularly in the wood raw material production process, forest roads perform not only a transport function, but also functions such as positioning, processing, handling and sometimes storage of the products. From this point of view, the functions of forest roads are as follows:

– Transportation (for the movement of personnel, products, and goods)
– Protection (fire prevention, anti-smuggling, etc.)
– Infrastructure and spatial organization (demarcation, storage, etc.)
– Strategic facility (defense logistics).

In addition to the technical, economic and social benefits of forest roads, the negative effects of forest roads, especially in terms of ecological aspects, have recently become more interesting in the context of sustainable forest management. In this respect, the terms related to the positive or negative impacts of forest roads are not used separately, but the impacts of roads and forest roads can be classified and listed together under the term "impacts". In this context, the potential impacts of roads are categorized below according to different perspectives, again using different sources (Spinelli and Marchi, 1998). The ecological impacts of road networks made up of roads and road segments are classified by Noss (1993) into direct and indirect impacts and listed as follows;

1.Direct impacts

- Road deaths
- Traffic avoidance and other behavioral changes
- Fragmentation and isolation of populations
- Environmental pollution
- Impacts on terrestrial habitats
- Impacts on hydrology and aquatic habitats

2. Indirect impacts

- Access to special areas
- Cumulative effects.

A general classification of the most significant ecological impacts of roads is as follows (Reed et al., 1996; Forman et al., 1997; Forman and Mellinger, 1998):

a) Habitat losses due to road construction,
b) Peak flows in modified watercourses and surface flows,
c) Soil erosion and sedimentation impact on rivers,
d) Changes in species pattern,

e) Human access into the forest and associated damages (smuggling, hunting, grazing, clearing, etc.)

Forman and Hersperger (1996) classified the ecological impacts of forest roads on settlements, cultivated land and forest land as impacts on habitat and species, impacts on water and soil, and impacts on atmosphere, depending on whether the source of impact is road and/or vehicle traffic. Accordingly, the negative impacts of roads are listed as follows;

1. Impacts on Habitat and Species (Road and traffic impacts)

– The road network divides/isolates rare natural habitats and fragments nature integrity
– Roads disrupt animal movement and behavior, especially in wildlife corridors
– Traffic noise levels reduce biodiversity
– New roads lead to rural development/development (sprawl of settlements) and consequent loss of key species and habitats and disruption of natural flows
– Exotic species; pest infestation of agricultural and pasture lands; natural ecosystems
– Providing access into the forest; reduction of wildlife, habitat quality and biodiversity

2. Impacts on Water and Soil

– Disintegration and dispersion of natural flows such as surface water runoff and groundwater
– Rise of peak flows in streams and rivers
– Increase of floods and inundations
– Change of water flow directions
– Acceleration of soil erosion
– Formation of sludge flows
– Increased sedimentation runoff

3. Atmospheric effects (Impacts of traffic)

– Increased nitrogen emissions and damage to natural ecosystems
– Damage to trees, natural systems and mountain ecosystems from emissions
– Harmful effects of greenhouse gases and particulate matter on climate, vegetation and wood production

From a different perspective, the ecological impacts of road networks have been classified by Forman and Alexander (1998) as follows:

1. Effects of roads on vegetation and animals

- Effects of roads on plants and vegetation
- Effects of roads on animals and movement behaviour

2.Effects of road and vehicle traffic on populations

- Animal deaths caused by roads
- Disturbances caused by vehicles and the effect of avoiding roads
- Barrier effect of roads and habitat fragmentation

3.Erosion and sedimentation effects of roads on soil, water resources and rivers

- Effects on soil
- Impacts on water flows
- Impact on sediment flow

4. Effects of roads on the atmosphere

- Chemical transport and pollution
- Emissions (greenhouse gases, nitrogen oxides, ozone)

5. Other impacts of the road network (impacts related to road density)

- Spatial effects on land pattern
- Edge effect of roads

6. Impact of roads on fires

- Contributing to increasing the causes of fires (human influx into forests, roadside clearings)
- Affecting the course of fire (roadside openings, safety lane/barrier
- Impact on fire response time and accessibility

The cumulative impacts of roads have been categorized by Gucinski et al. (2000) as follows (Eker et al., 2010):

1. Direct physical and ecological impacts of roads,

- Geomorphological effects
- Hydrological impacts,
- Impacts on growing environment productivity,
- Impacts on habitat fragmentation and spatial organisation,
- Impacts on habitats,
- Effects on biological invasions

2. Indirect impacts of roads at the scale of land integrity

- Impacts on aquatic habitats,
- Effects on terrestrial organisms,
- Impacts on road-related mortality,
- Effects on forest diseases,
- Impacts on biodiversity and nature conservation
- Impacts on water quality,

- Impacts on air quality

3. Direct socio-economic impacts of roads,

- Impacts on wood production programmes,
- Impacts on the production of non-wood forest products,
- Impacts on grazing,
- Impacts on energy and mineral resources,
- Impacts on eco-tourism and recreational activities

4. Indirect socio-economic impacts of roads

- Effects on fires,
- Impacts on forest inventory, monitoring and scientific research,
- Impacts on privately owned land,
- Impacts on the non-market and passive use value of land,
- Impacts on historical remains and cultural values and
- Economic effects.

Coffin (2007) classified the ecological impacts of roads as biotic and abiotic impacts on ecosystem components. These are detailed in the following list- abiotic impacts;

– Impacts on hydrology and water quality (erosion, sediment transport and chemical pollution),
– Noise and other atmospheric effects.
– Biotic effects
– The impact of roads as a source of mortality and a barrier to animal movement,
– Impact of roads as habitats, life corridors and conduits
– Roads are listed as disruption/alteration of land integrity, fragmentation and edge effect (road impact zone).

In the legislation on forest roads in Turkey (Communiqué No. 292), the following effects of forest roads are mentioned in order to make accurate decisions and implementations without ignoring the technical, economic, legal and social dimensions in the planning and construction of forest roads (GDF, 2008):

a) For 1 km of road, at least 4000 - 8000 m^2 of forest will be opened up, depending on the type of road, and 400 - 3500 trees will be destroyed, depending on the age of the stand,

b) As the excavated material flows down the slope, it causes damage by breaking, injuring and inviting harmful insects,

c) The supporting fabric of the slopes is broken and landslides are caused,

ç) The ecosystem is adversely affected by the inability to meet the water needs of natural stands by altering the flow direction of shallow groundwater,

d) The creation of wind corridors will increase breakage and overturning,

e) Triggering run-off and erosion,

f) Wildlife is disturbed and its right to live is restricted as a result of the artificial and intense pressure of traffic on natural wilderness areas,

g) Road construction and maintenance costs burden the national economy with debt.

In the set prepared by Gümüş and Acar (2005) for the environmental impact assessment criteria of forest roads, it is stated that forest roads have an impact on environmental components consisting of soil, water, vegetation, atmosphere, socio-economic conditions and cultural heritage (Gümüş, 2017).

In order to define and evaluate the ecological impacts of roads on forest ecosystems, Eker et al. (2010) made the following classification

a) Impacts on the physical environment (climate, topography and geomorphology, groundwater and surface water resources, atmosphere, noise, pollution),

b) Impacts on the biological environment (humans, plants and animals),

c) Impacts on socio-economic components (including land use),

d) Impacts on cultural/archaeological values.

If the above-mentioned ecological impacts of forest roads are classified according to their physical distance from the road axis, i.e., their distribution over the area, it can be said that the impacts occur first at the roadside, then at the catchment, watershed, and regional level. In other words, forest roads have local, regional, and national impacts. On the other hand, it may not be possible to say that all ecological impacts will occur throughout the road network, or that the possible impacts will occur with the same intensity. Some of the ecological impacts may occur along the entire road network and some may occur in different parts of the road network. Site-specific factors that differentiate ecological effects include construction technique, road slope, road position on the slope, climate, vegetation, catchment hydrology, soil properties and geological structure (Gucinski et al., 2000, Switalski et al., 2004).

Considering the time of occurrence of the ecological impacts of roads, it is possible to classify the impacts of roads as: a) those that occur during the construction process (on young and planted trees; on microflora and fauna; on soils and rivers), b) those that occur during the use process. If the ecological impacts are classified according to their source: a) road impacts (impacts due to the construction and use of the road network, e.g. flow of embankments and excavation slopes), b) vehicle impacts (impacts during the use of the road by vehicles; e.g. exhaust gases, noise, etc.).

Classifying the assets exposed to ecological impacts, it can be said that roads affect the biotic and abiotic components of the ecosystem. Roads affect the biotic components of plants and animals at the level of individuals, communities, populations, and ecosystems. If a classification is made by considering the time of origin of the ecological effects of roads and the assets exposed to the effect and the area of spread of the effect together, it is possible to make a classification into a) direct, b) indirect effects; as well as primary and secondary effects (Eker et al., 2010).

In order to understand the impacts, which can be categorized according to the different characteristics mentioned above, and most of which can be described as negative impacts, it is necessary to make an assessment of the current characteristics of the roads. To describe some of the ecological impacts of roads that mostly pass through forest ecosystems and have the characteristics of forest roads, forest roads in Turkey have been evaluated using various statistical data and some analytical criteria.

Analyzing Forest Road Impacts

To understand the cumulative impacts of forest roads and road network, some road metrics (Kolkos et al., 2023) should be utilized. To analyze and evaluate the positive and negative impacts of roads, some road metrics are explained below through the example of Turkish forestry.

Geometric Properties of Forest Roads

The cumulative impact of roads can vary depending on the geometric standards of the road and the width of the excavation and filling area it occupies (Eker and Ada, 2011). In this respect, it is important to know the characteristics of forest roads in Turkey to assess possible ecological impacts. This is because, according to the latest statistics at the end of 2022, the total forest area in Turkey is 23,245,000 ha, of which 13,707,843 ha is defined as productive forest.

Forest roads are the roads built to fulfill all the necessary functions of the forest, from production to maintenance, and are distributed in a planned manner in all areas of the forest. Forest roads are classified into three main classes according to their functional forestry purpose, considering the amount of product to be transported per year, the purpose of construction, the number of vehicles used, and the size and weight of the vehicles used on these roads (Table 1) (GDF, 2008).

1. Main forest roads; these are primary roads that follow the main streams and have a platform width of 7 m suitable for traffic. The amount of wood products transported on them in a year must be more than 50,000 m³.

2. Type-A secondary forest roads; these are mainstream roads with a platform width of 6 m suitable for traffic. To build a road of this width, the amount of wood products to be transported on the road in a year must be between 25,000 - 50,000m³.

3. Type-B secondary forest roads; are stream and slope roads with a platform width of 3-5 m suitable for traffic. The amount of wood products transported on these roads in a year is less than 25,000 m³. Considering factors such as the production and transport season, the type of products to be transported and the structure of the land, all or part of these types of roads are covered with 3-4 m wide superstructure material. If there is solid and hard rock at a distance on the slope of the land over 75%, the road platform in such parts will be 3 m, the ditch 0.50 m, and the B-type secondary forest road will be 3.5 m wide.

Table1. The geometrical properties of forest roads in Türkiye

<table>
<tr><td rowspan="4" colspan="2">Technical features</td><td colspan="6">Road Types</td></tr>
<tr><td rowspan="3">Main Forest Road</td><td colspan="4">Secondary Forest Roads</td><td rowspan="3">Tractor road</td></tr>
<tr><td rowspan="2">Type A</td><td colspan="3">Type B</td></tr>
<tr><td>S</td><td>N</td><td>E</td></tr>
<tr><td>Platform width</td><td>m</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>3.5</td></tr>
<tr><td>Number of strip</td><td>pcs</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Maximum slope</td><td>%</td><td>8</td><td>10</td><td>9</td><td>12</td><td>12</td><td>20</td></tr>
<tr><td>Minimum curve radius</td><td>m</td><td>50</td><td>35</td><td>20</td><td>12</td><td>8</td><td>8</td></tr>
<tr><td>Strip width</td><td>m</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td>Shoulder width</td><td>m</td><td>0.5</td><td>0.5</td><td>0.5</td><td>0.5</td><td>0.5</td><td rowspan="3"></td></tr>
<tr><td>Ditch width</td><td>m</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0.5</td></tr>
<tr><td>Superstructure width</td><td>m</td><td>6</td><td>5</td><td>4</td><td>3</td><td>3</td></tr>
</table>

S: B-Type secondary forest road with improved standards; N: Normal B-Type Secondary Forest Road; E: Extreme B-Type Secondary Forest Road

Type B secondary forest roads, which are generally described above and provide access to a large part of the forest, are divided into three sub-groups, considering factors such as the topographical structure of the land, the intensity and priority of forestry activities, economic centers and traffic density.

a) Type-B secondary forest road with increased standards (SBT):These roads are the roads that reach the center of the forests of the Chief Forestry Office or provide access to the group villages together with the forests, where trailers can carry heavy construction equipment without maneuvering, with a platform width of 5 m, a ditch width of 1m, a maximum slope of 9 %, a minimum curve radius of 20 m and suitable for lasers, a minimum visibility of 20-30 m, art structure and superstructure construction priority.

b) Normal type-B secondary forest road (NBT): These are roads with a carriageway width of 4m, a ditch width of 1m, a maximum gradient of generally 9 %, rarely 12 %, a minimum radius of 12 m for bends and curves, and generally provide access to forests. These roads are used under normal topographic structure and terrain conditions.

c) Extreme type-B secondary forest road (EBT): These are roads that can be used for short distances in areas with very difficult terrain conditions or in areas with very steep slopes and solid rock with blind roads when approaching the mountain zone from the forest zone. The width of the platform is 3 m, the width of the ditch is 0.50 m, the maximum gradient can be 12% for short distances, there are meeting points and turning points at the end of the road, and traffic signs are placed in appropriate places.

Intensive production areas not accessible by mechanization or forest roads with normal gradient Low-standard roads with a length not exceeding 1 km used for short-distance transport of forest products accumulated in areas with very difficult terrain up to the road or ramp suitable for full capacity transport are considered as tractor roads.

Forest Roads Length

The beginning of regular forest road construction in Turkey dates to 1937. After 1957, the construction of forest roads, especially for transport and production purposes within the forest, began to be carried out by machine. In 1966, a road department was established within the GDF organization and in 1979, the road network planning studies of Turkey were completed and the planned length of forest roads required was determined to be 201.810 km (road density was calculated to be 9.99 m/ha). By the end of 1994, approximately 120.000 km of forest roads had been constructed (Erdaş, 1997). With the changing paradigms of forestry in the world and in Turkey, forestry policies and practices have also become dynamic in line with the principles of sustainable forest management. In this context, according to the forestry statistics, activity reports and performance data of the strategic planning targets for 2022, the amount of functional forest roads planned for the realization of all types of forestry activities has been revised to 365.215 km. Accordingly, 222.206 km of forest roads have already been completed. Together with 78.463 km of village roads, highways and other roads (mining roads, plateau roads, etc.) passing through the forest, the total length of roads that can be used for forestry services and related to the forest ecosystem has reached 300.669 km (GDF, 2023).

According to official forestry statistics, new road construction and other road components between 1998 and 2022 are summarized in Table 2.

Road Density

Road density is a useful indicator for describing the potential ecological effects of roads on a landscape (Forman, 1995; Forman and Alexander, 1998). Ecological effects for which road density can be used as an indicator include animal movement, population fragmentation, human traffic, hydrology, aquatic ecosystems and fire relationships. Indeed, many studies have found a negative relationship between animal and plant species density and road density, and a positive relationship with distance from the road (Mech et al, 1988; Canaday, 1996; Develey and Stouffer, 2001; Strittholt and DellaSala, 2001; Crist and Wilmer, 2002).

Table 2. Some statistical realizations about forest roads in Türkiye

Years	Bridge	Project and application	New road	Surface structure	Hydraulic structures	Tractor road	Repair and maintenance
	m	km					
1998	143	2 995	1524	333	779	154	97 740
1999	111	2 404	1027	266	870	122	101 409
2000	116	2 759	1115	455	1 406	178	108 146
2001	40	2 187	758	432	1 404	104	113 952
2002	152	2 617	950	674	1 881	206	123 327
2003	159	2 590	956	676	1 518	242	121 914
2004	123	3 108	1000	970	2 237	289	125 689
2005	43	3 200	1000	1 080	2 200	350	132 836
2006	90	3 200	1000	1 153	1 747	439	131 092
2007	56	3 579	1400	1 137	1 777	448	131 040
2008	122	3 800	1600	1 184	1 801	500	130 106
2009	26	3 600	1316	819	1 482	447	131 606
2010	69	3 600	1400	1 179	1 832	431	138 267
2011	123	3 644	1468	1 162	1 817	422	136 197
2012	202	4 618	1518	1 860	1 959	448	138 186
2013	142	4 728	1479	1 532	1 881	404	140 662
2014	209	5 394	1542	2 094	2 387	443	130 630
2015	256	5 717	1624	2 261	2 823	511	136 216
2016	323	6 188	1852	2 142	3 131	751	154 260
2017	190	7 721	2542	2 520	3 210	684	157 891
2018	111	8 826	2902	2 843	3 696	969	169 293
2019	12	109	1324	515	873	1 025	168 590

2020	55	-	2675	710	2 071	1 538	171 251
2021	-	1 307	3822	942	1 251	2 538	175 803
2022	-	8 292	6865	1 132	1 948	2 740	187 221

When determining the density of forest roads, general density values are calculated by considering the standard forest roads that pass through the forest for production purposes as well as the roads inside the forest for other purposes (Erdaş, 1997; Eker and Çoban, 2010). Road density is a value obtained by dividing the road length by the area. Accordingly, the density of forest roads in Turkey was calculated using the following general road density formula.

$$\text{Forest Road Density(m/ha)} = \frac{\text{Total Forest Road Length (m)}}{\text{Forest Area (ha)}} \quad (1)$$

The following results were obtained in the calculations made by considering the forest roads and roads passing through the forest, general forest area and productive forest areas. According to this:

a) Considering only standard forest roads (222,206,000 m) and total forest area (23,245,000 ha), road density is 9.56 m/ha.

b) Considering only standard forest roads (222,206,000 m) and productive forest area (13,707,843 ha), road density is 16.21 m/ha.

c) Considering the total road length passing through the forest (300,669,000 m) and total forest area (23,245,000 ha), the road density is 12.93 m/ha.

d) Considering the total road length passing through the forest (300.669.000 m) and productive forest area (13.707.843 ha), the road density is 21.93 m/ha.

Road Spacing and Opening-up

Road spacing is the average horizontal distance between two roads measured perpendicular to the road axis and is a more accurate measure of road density. Theoretically, road spacing calculations can be used to calculate areas open to road traffic. The boundary that is assumed to pass through the center of the road intervals is defined as the traffic boundary. The operational area of a road segment is half the road spacing value. On the other hand, the following equation (2) is theoretically used for the relationship between road density and road spacing per unit area (1 ha) (Erdaş, 1997). In this equation, the factor 10000 represents a square area (100mx100m) with the smallest side dimension value for a unit area of 1 ha. Accordingly, the road distance can be calculated for different road density values above.

$$\text{Forest Road Spacing (m)} = \frac{10.000}{\text{Forest Road Density}} \quad (2)$$

According to the road density value (12.93 m/ha), which is obtained by relating the total length of roads through forests in Turkey that can be used for forestry activities to the total forest area, the road distance is about 770 m. In other words, the theoretical horizontal distance between two forest roads is about 770 m.

On the other hand, the area that forest roads affect in the direction of the forest to fulfil forestry purposes is defined as the opening-up area. Thus, the theoretical opening-up area of a forest road is 770 m on both sides of the road. Therefore, the total operational area of standard forest roads (222,206 km) (the width of the road's zone of influence) is approximately 17,110,000 ha. Accordingly, the opening-up ratio, i.e. the proportion of the total forest area accessible by standard forest roads, is about 74%.

Width of Road Construction Area (Clearing With)

In order to construct secondary forest roads on a stable platform and to avoid the negative environmental impacts of filling and excavation slopes, an average of 20 m is theoretically worked within the construction area (GDF, 2008; Eker et al., 2010; Eker and Ada, 2011). This value can vary depending on the topography of the land, the width of the road, the slope of the road, the construction machine and even the operator. For example, the average width of the construction area of forest roads in the Ağlasun Forest District in Burdur Province of Turkiye, was found to be 13 m (Eker and Ada, 2011). In terms of environmental impact, the area covered by the cross-section of the road at each location is important both in terms of forest loss and slope stabilization.

Accordingly, the total construction/occupation area within the forest ecosystem resulting from the construction of standard forest roads (222.206 km) with a theoretical construction width of 20 m is 44.441 ha. This means that only 1,9 percent of Türkiye’s forest area is occupied by standard forest roads. Considering the total number of roads crossing forests (300.669 km), the percentage of area lost or occupied by roads is 2,6 %.

Discussion on Ecological Impacts of Forest Roads

It is essential to ensure the functional sustainability of forest roads in terms of the continuity of forest resources and the sustainability of utilization of these resources. The technical, economic, and social sustainability of roads or road network is an issue that should be well understood by both decision makers (policy makers related to forests), managers (forest administrators) and other stakeholders (forestry sector, forest villagers, recreationists, hunters, etc.).

The building (construction, maintenance, and repair) and use (provision of transport) of forest roads should be technically and economically sustainable in order to maintain all the functions and benefits. In the last 24 years in Turkey, with an annual average of 1.860 km of new road construction, approximately 1.300 km of major repairs and an annual average of 138.000 km of repair and maintenance works (Table 2) (GDF, 2023), it can be said that the economic sustainability of forest management through forest roads has been ensured without interruption. The current geometric characteristics of forest roads are also technically capable of ensuring functional sustainability. Restrictions such as increasing the carriageway width of forest roads to 5 m with improved standards and reducing the longitudinal gradient of the road by increasing the curve radius allow vehicles with long chassis and wide axles to operate in the forest. This indicates that the continuity of transport logistics can be ensured.

In addition, it can be said that socio-economic sustainability is ensured by the function of forest roads in connecting forest villages, plateaus, winter pastures, grazing and recreational areas (Hasdemir and Demir, 2005). However, one of the clearest indicators of forest roads in human-forest interactions is the (positive and negative) effect of the road network on forest fires. This is because human access to the forest interior and the effect of being a source of disturbance tend to increase with high road density (Lyon, 1983). High road density leads to an increase in human-caused fires on the one hand, and an increase in fire intervention and extinguishing efficiency and a decrease in average fire size on the other (Saunders and Hobs, 1991). It is known that humans are responsible for 90% of forest fires. However, more than half of human-caused forest fires start on roadsides. It is known that 78% of human-caused fires start within about 80 m of the roadside. Although roads mediate the occurrence of human-caused fires, their importance in terms of controlling and extinguishing fires and creating barriers cannot be denied (Noss, 2002).

Ecological impacts of forest roads have not yet received the same attention as economic and social impacts. However, in the context of sustainable forest management, the continuity of the ecological functions of forest roads depends on an understanding of the cumulative impacts of roads, and on acting to reduce the damage of these impacts in the planning, design, construction, use, maintenance, and repair processes. For example, although measures to reduce the ecological impacts of forest roads have been developed at the legislative level in Turkey (Communiqué No. 292, (GDF, 2008)), it can be said that the multiple ecological impacts of forest roads are not sufficiently understood (Eker and Çoban, 2010).

The opening of roads in forest ecosystems, construction works, superstructure and infrastructure works, vehicle traffic, the use of roads and roadsides for various purposes, and maintenance and repair activities are the main factors that reveal the ecological impacts of roads (Eker et al., 2010). Roads that open into the forest facilitate the entry of vehicles, weapons, chainsaws, construction machinery and barbecues into the forest. As the road network opens up natural forest areas for exploitation and increases human access to the forest, poaching, deforestation and conversion of forest land to agricultural land are effective (Noss, 2002). The road network fragments the larger holistic landscape, leading to habitat fragmentation, shrinkage, and degradation. The forest road network creates a spatial pattern that is different from other roads because it leads to the formation of meandering and winding distorted forest fragments, the reduction of forest area in the overall core structure, and the formation of more border impact areas (border habitats) than areas opened to timber production (Miller et al., 1996; Eker and Çoban, 2010). As a result, the ecological impacts of the road network can cause ecological pressure, biodiversity loss and changes in land use classes. The fact that the length of roads passing through forests in Türkiye has reached 300.669 km (GDF, 2023) can be seen as a sign of possible risks and hazards related to these impacts. In fact, it is possible to access about ¾ of the forests in Türkiye and carry out forestry activities with standard forest roads. This situation shows that the potential impacts of forest roads can theoretically spread to ¾ of the forests.

Effects of Roads on Vegetation

The impact of roads on terrestrial ecosystems is manifested in direct habitat loss, weeds, alien species, pest infestations and diseases as a function of roadside effects. The light and moisture potential of roadsides allows some exotic invasive plant species and their dependent animal species to use roads as dispersal corridors (Forman and Alexander, 1998; Watkins et al., 2003; Gelbard and Belnap, 2003; With, 2003). On roadsides, the long-term productivity of the growing habitat is reduced during road construction due to the accumulation of low nutrients in the soil, reduced water holding capacity and compaction of the soil surface (Noss, 2002). There is also the transport of plant seeds by construction machinery or excavation (into and out of the construction area), which alters the growing environment (Willard et al., 1990). Considering that approximately 2.000 km of forest roads are constructed, and 138.000 km of forest roads are repaired and maintained annually in Türkiye, it can be said that these impacts on roadsides are unavoidable. To avoid invasive species, roadsides should be repaired with natural species of the region using an ecological approach. In this way, the possibility of invasion of exotic species can be reduced, attractive or repellent environments for animals can be created, and drainage of the road can be increased (Forman and Alexander, 1998). In Türkiye, it can be said that these recommendations have the potential to be realized with the recent practice of creating fire-resistant roadside zones (Yılmaz, 2016).

On the other hand, biodiversity increases with the arrival or introduction of exotic, albeit rare, species to roadsides, and both plant and animal diversity can be increased by creating different habitats for animals and allowing new animal species to colonize these environments. Roadsides can provide habitat diversity for the conservation of natural species and ecosystems, and the vegetation structure in this environment can act as a 'biodiversity reservoir' (Forman and Alexander, 1998).

Knowing the average width of the road impact zone is an indicator for estimating the areas ecologically affected by roads (Forman et al., 1997). To emphasize the importance of the road impact zone along roadsides, there is a direct positive relationship between road building and forest fragmentation, deforestation, regional climate change, increased fire and drought (Laurance et al., 2008).Roads and roadsides cover 0.9 % of the total area in the UK and 1 % in the USA. In the Netherlands, for example, 10-20 % of the total area of the country has been set aside as roadside zones to protect the habitats of birds sensitive to traffic noise (Forman and Alexander, 1998). It is known that the road edge effect is concentrated in a 50 m wide zone up and down the slope (Eker et al., 2010). Considering the total length of the road through the forest (300.669), the road impact zone covers 1,29 % of the total forest area. This situation strengthens the possibility of ecological impacts on road edge impact zones in Türkiye.

Effects of Roads on Animal Habitats

Roads and roadsides provide habitats for small mammals and insects (Brock and Kelt, 2004) and are good feeding grounds for some animals (Bennett, 1988). In roadside habitats, animals are mobile to find food, to move between disjunct populations, to migrate long distances, and to increase and spread their populations (Bennett, 1991). Birds may follow the openings provided by major roads as migration routes. The number of insect species found along roadsides can be higher than in other areas (Vermeulen and Opdam, 1995; Keller and Pfister, 1997).

The natural and exotic vegetation structure along roadsides can also provide high species richness and population density for animals (Roach and Kirckpartick, 1985). Considering the length and edge effects of roads through forests in Turkey, it is possible that the potential effects of roads on animal habitats can also be seen in Turkey. The clearest indicator is the effect of road mortality (traffic accidents) on wildlife populations. Road mortality is a classic cause of animal mortality. The main reasons for wildlife deaths due to road traffic accidents are the disruption of animal migration routes and habitats by roads, the entanglement of animals with traffic as they move along open roadsides, and the fact that roadsides are an ecological trap for some animals as they try to feed on carrion and leftover food along roadsides.

One of the negative effects of roads is the barrier (isolation) effect, which disrupts animal movements and feeding patterns of populations. The barrier effect of roads can be defined by the behavior and characteristics of the species, the physical quality of the road infrastructure, the characteristics of the vehicle traffic, the spatial configuration of the land adjacent to the road, and the land use pattern. Roads can divide animal populations by fragmenting small mammals (Oxley et al., 1974), large mammals (Nellemann et al, 2001), birds (Develey and Stouffer, 2001), insects (Bhattacharya et al., 2003) and reptiles (Smith et al., 2005) into small groups, and these localized groups are vulnerable to genetic change and extinction (Mader, 1984; Merriam et al., 1989; Fahrig et al., 1995; Johnson and Collinge, 2004).

Although road density and traffic density through the forest is low, hunting pressure, illegal settlement, clearing and grazing increase as access to the forest becomes easier. These have negative impacts on animal populations (Bennett, 1991). In areas where roads and vehicle traffic are dense, wild animals change their behavior or avoid roads (Mumme et al., 2000). Traffic noise, lack of hiding places along roadsides, pollution and the effect of becoming prey to predators along the road are among the most important reasons for road avoidance (Slabbekoom and Peet, 2003). The fact that the total road density in forested areas in Türkiye has reached approximately 13 m/ha and that this ratio is expected to exceed 20 m/ha for optimal forest management (Erdaş, 1997) indicates the potential for these ecological impacts. Considering that the current standard forest roads open 70% of the forests to management, it can be better understood that negative impacts can penetrate into the forest.

The impact of roads on wildlife populations is related to road density. In areas of natural integrity where large predator populations are found, it is recommended that road density should not exceed 6 m/ha (Mech, 1989, Forman et al, 1995). As road density increases, the numbers of some animal populations decrease. These species tend to avoid the road due to the increase in road density and human impact. However, species that move along the road without crossing it benefit from high road density (Bennet, 1991). The fact that the density of roads passing through forest areas in Turkey is 9-13 m/ha, and that this ratio will increase with the new roads to be constructed, increases the possibility of being affected by the potential ecological impacts of the road network.

Effects of Roads on Hydrology and Erosion Formation

Road construction alters the hydrology of the catchment by changing the morphology of the river bed and the groundwater level. Roads on sloping upper slopes collect surface water flows at one point and alter water flow by forming channels (Montgomery, 1994). Although roads can act as barriers to prevent or reduce downslope water flow, they can often accelerate water flow (Jones et al., 2000).

Surface water is transported by roadside ditches. The rapid flow of water from roadside ditches and road surfaces into stream channels can increase the energy of the stream system (Dunne and Leopold, 1978). Slow-moving groundwater in humid, hilly and mountainous terrain can be converted to fast-moving surface flows in roadside ditches (Jones and Grant, 1996; Wemple et al., 1996). Increased surface flows can increase the rate and magnitude of erosion, reduce infiltration and alter channel morphology (Bilby et al., 1989). The majorities of forest roads in Türkiye are of secondary forest road standard and are constructed with a theoretical ditch width of 1 m (Table 1). Together with the width of the road platform (5 m), the area suitable for surface runoff generated by forest roads is approximately 133.324 ha, which represents a significant potential for hydrological disturbance and erosion risk.

However, on average 40% of Turkish forests have slopes above 40%. Therefore, an occupied area of 13-14 m (for a 4 m secondary forest road) on a standard road profile on land with a slope of 40% and an occupied/constructed area of approximately 19 m on land with a slope of 50% will result in land loss. In addition, the natural slope of the land in such areas can be up to 70% due to excavation and fill slopes (Eker et al., 2010). Therefore, it can be said that excavation and fill slopes accelerate surface runoff due to the increase in slope (Akay et al., 2007).

Forest roads cause loss of fertile topsoil, increased erosion, changes in soil properties and microclimate, and thus reduce the productivity of the growing environment. The loss of cropland for road construction alone can range from 1 to 30 % of forest area (Megahan, 1988). In Türkiye, it is stated that the rate of land loss due to forest road construction (the sum of ditch and platform width multiplied by the road length) should not exceed 1% of the forest area (GDF, 2008). Accordingly, the length of B-type secondary forest roads in Türkiye (222.206 km) means that 0.57% of the forest area is occupied. If the areas occupied by excavation and filling slopes and defined as construction area (theoretically 20 m) are added, it can be said that 1,9 % of the forest area is destroyed by forest road construction. This ratio is similar to the values encountered in the literature (Kleinschroth and Healey, 2017). However, considering that the width of the construction area varies according to many factors, it should be noted that this rate may be lower. Therefore, forest roads should be designed by forest engineers and road crossings and constructions should be carried out under the supervision of forest engineers. By matching forest roads with forest ecology engineering knowledge, the negative effects of roads on the ecosystem can be eliminated or reduced from the outset.

Effects of Roads on Sediment Generation

Sediment generation from roads depends on road geometry, slope, road length, road width, road surface, road maintenance and repair, soil properties, and vegetation cover (Grayson et al., 1993). Road surfaces, ditch slopes, embankment slopes, bridge/culvert/ditch locations and ditches are sources of road-related sediment generation (Reid and Dunne, 1984). Some of the sediment generated by road construction material flows accumulates in places where the slope is reduced, limiting subsequent erosion. The remainder reaches streams where it alters riparian ecosystems, channel morphology and aquatic habitats. Runoff from roadside ditches deposits fine-grained sediment, and landslides deposit coarse-grained material in streams. Sediment deposition in streambeds can change the temperature, turbidity, depth, quality, flow, etc. of the water. Fine-grained sediment increases turbidity, which can inhibit the growth of aquatic plants, macro-invertebrates and some fish, and can cause habitat alteration. Coarse material and stones cause habitat heterogeneity in deep pools and streams (Brown, 1994). Unpaved forest roads continue to produce sediment throughout their lifetime unless they are re-vegetated (Forman and Alexander, 1998; Rice and Lewis, 1991).

Pollution from Roads

The source of roadside pollution is from vehicles using the road and from superstructure materials such as embankments, bridges and culverts (Grant et al, 2003). While pollutants are generally effective close to the road, they can also be transported to distant areas by wind and rain (Forman et al, 2003). Pollutant runoff can alter soil chemistry, be absorbed by plants, affect stream ecosystems and be transported long distances by streams in dispersed and diluted form (Yousef et al, 1985; Brown, 1994; Gilson et al, 1994).

In addition, sodium chloride (NaCl) sprayed from the air or from the ground by de-icing and snow removal vehicles on highways adjacent to forests can cause various types of damage to trees (Forman and Alexander, 1998). Herbicides can be carried into forests by winds from vehicle traffic or by adhering to tyres and can cause the death of non-target species (Wust et al., 1994). Nutrient fertilisers also affect roadside vegetation (Cale and Hobs, 1991). Nitrogen from NOX emissions from vehicles can also affect vegetation within 100-200 meters of the road (Angold, 1997). Road runoff also alters water quality, as heavy metals, salinity, turbidity, opacity and dissolved oxygen levels in rivers are altered by road runoff (Cramer and Hopkins, 1982).

Road pollution starts with road construction. The most obvious effect of roads during construction is noise pollution, which continues during traffic flow and alters animal behavior. Lead compounds used in vehicle fuels or lubricants and in tyre coatings cause pollution of roads and roadsides (Noss, 2002). In Turkey, an average of 125 m of bridges, 1.317 km of major repairs, 1.203 km of superstructures and 1.920 km of art structures are built each year, which means that pollutants from road construction are transported into the forest and potential impacts can occur.

Atmospheric Effects of Roads

There are also atmospheric effects resulting from the physical structure of roads. Roads affect wind direction and speed, relative humidity, temperature and solar radiation patterns. In general, roadsides are windy and stormy, hot, dry and sunny (Forman et al, 2003). However, the air near roads is dustier, especially on unpaved roads. Road dust covers the vegetation surface and affects photosynthesis, respiration and transpiration patterns, causing damage or reduced productivity (Farmer, 1993). This microclimate can lead to changes in the composition of flora and fauna (Forman and Deblinger, 2000).

Conclusions

Sustainable forestry is about ensuring the continuity of forest resources and the sustainable use of the products, services, and values they provide. All types of facilities and practices that can damage the forest ecosystem can lead to disruption of the ecological functions of the forest. For example, roads affect the living and non-living components of the ecosystem by altering the dynamics of animal and plant populations, the direction of flow within the soil integrity, the dispersal of exotic species, and the level of resource availability. Research has shown that roads threaten biodiversity, increase habitat degradation and fragmentation, and cause impacts such as edge effects, invasions of exotic species, pollution and overfishing on terrestrial and aquatic ecosystems. It is therefore concluded that the cumulative ecological impacts of linear structures that constitute the main infrastructure facilities of forestry, such as forest roads, should be known, awareness should be raised at all levels, and timely and appropriate action should be taken. However, it may not be possible to identify the cumulative effects of roads through forests for each road segment or road network (at local and regional scales), which is not desirable. Therefore, in order to ensure the functional sustainability of forest roads, it would be appropriate to draw conclusions based on the possible/potential impacts of the roads.

However, in order to ensure the functional sustainability of roads, the negative aspects affecting forest continuity should be eliminated or reduced. To this end, ecological principles should be applied to the organization of the road network - transport system at the national level in order to reduce environmental damage and protect biodiversity. The majority of forest roads were planned and built before the ecological approach gained importance. It is therefore difficult to say that these roads are ecologically oriented. It can be an ecological approach to close the technically obsolete or rarely used roads to traffic and rehabilitate the forest area. The closure or removal of roads can provide an opportunity for the formation of large islands of land (patches) within the integrity of the forest area. Many negative impacts on natural populations and ecosystems can be reduced by preventing motorized vehicles from entering the forest.

An environmentally sensitive road network can be created by leaving a very wide zone of influence (200 m inwards from the road) on the roadside. Natural processes (animal and water movements) interrupted by the barrier effect of roads can be corrected by the construction of ecological overpasses, tunnels, drains and culverts. Bare roadsides and slopes can be vegetated or stabilized with geotextiles to reduce erosion, landslides and sedimentation. Buffer strips can be left between roads and streams to prevent sediment from reaching water sources. It should be remembered that the negative effects of roads passing through and adjacent to forests can spread throughout the land structure and over time, even to areas with low road density.

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Chapter 6

Financial Analysis of Public Forestry Activities in Türkiye: The Case Study on Ayancık Forestry Management Directorate *

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Abstract

The development of the global economy gradually increases the need for natural resources. One of these resources is forest assets. Ayancık district is an important production and supply center for the Turkish economy with its rich vegetation. The purpose of this study is to examine the general and financial situation of public forestry in Sinop-Ayancık district between 2018-2021. For this purpose, Ayancık's forest products production, cost, sales, export and supply chain structure were examined comparatively over the years, in line with the statistical and financial data received from TSI, Ayancık Management Forestry Directorate, Sinop Chamber of Commerce and other relevant institutions, and its financial situation was analyzed using financial analysis techniques.

As a result, it was observed that the raw material production amount, supply costs and total sales amount of Ayancık district public forestry tended to increase throughout the relevant years. In addition, although the number of species sold is the same, the number of provinces and companies selling raw materials has also increased. However, although the number of manufacturing companies in the district is partially good, it has been determined that the number of exporting companies is insufficient. According to the vertical analysis of the balance sheets and income statements, it can be said that current assets tend to increase, fixed assets and long-term foreign resources tend to decrease, and equities first increases and then decreases. In addition, it has been determined that costs tend to decrease and profitability tends to increase compared to net sales. According to the horizontal

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analysis, it can be stated that there is a decreasing trend in fixed assets and short-term foreign resources and an increasing trend in equities. It can be said that there is a general increasing trend in profit for the period. According to the ratio analysis results, it can be said that the liquidity ratios are above the ideal ratios, the assets are largely financed with equities, the turnover rates follow a variable course with ups and downs, and the profitability ratios are on the rise, and the pandemic has an impact on the analysis results of financial tables.
Keywords: Public forestry, comparative analysis, financial tables, production, Sinop

Forests cover 31 percent of the world's land area (FAO, 2022). As of 2020, 29.4% of Türkiye's land is forest areas (OGM, 2020). Forests; It offers ecological, economic and sociocultural benefits to humanity in many different aspects such as fuel, shelter, food, oxygen source, water, employment, medicine, source of income, recreation area, landscaping and erosion prevention (OGM, 2020). However, the rapidly increasing population and growing industrialization also cause a serious increase in the use of natural resources (Xu and Zhao, 2023). Forest resources are also significantly affected by this change and are under serious pressure, especially from an industrial perspective. For this reason, the current situation of forest existence and economy on a global / regional scale needs to be analyzed accurately. In addition, good financial management of forestry activities is also important for sustainability.

State forests, which were previously generally managed according to tax farming (iltizam), began to be operated by state forest enterprises established in accordance with the "state management of state forests" provision of the Forest Law (Law No. 3116) enacted in 1937. However, due to old agreements, the operation of some forest areas by private entrepreneurs continued until the 1945s. One of these is the operation of Sinop-Ayancık forests by the Belgian Zingal Company between 1928 and 1945. Seeing profitability as the primary goal in this operating process has led to the destruction and damage of forest resources. In the Forest Law No. 6831, enacted in 1956, it is stated that "state forests will be operated by the state and all kinds of works related to state forests will be carried out by the General Directorate of Forestry". In addition, the provision that "state forests will be managed and operated by the state" was also taken as basis in the 1961 and 1982 Constitutions (Daşdemir, 2011). As a result, almost all of Türkiye's forests are state forests, and their management and operation activities are carried out according to the principle of sustainability by the central and provincial organizations of the General Directorate of Forestry, which is under the Ministry of Agriculture and Forestry (Özen and Alkan, 2023).

Ayancık district of Sinop province also contains some of Türkiye's important forest assets. Forests are the natural vegetation of the Ayancık region. The vegetation of the district is dense and very rich and varies according to altitude zones (Ayancık Kaymakamlığı, 2022).

In this study, the general and financial situation of public forestry in Sinop-Ayancık district between 2018-2021 is examined. For this purpose, statistical and financial data obtained from TSI, Ayancık Forestry Directorate, Sinop Chamber of Commerce and other relevant institutions were used. The production, cost, sales, export and supply chain structure of Ayancık public forestry was evaluated in general and its financial situation was analyzed using financial analysis techniques.

Analysis of Forest Existence in the World and Türkiye

Forests are considered a critical component of the world ecosystem in terms of the biodiversity they contain. Humanity is in constant interaction with this biodiversity. This interaction takes place for different purposes such as health, food, social activities and economic activities. 31 percent of the total global land area consists of forests. Approximately half of these areas are far from human activities and are ecologically intact. Although forests are not evenly distributed around the world, the total global forest area is 4.06 billion hectares, or approximately 5,000 m^2 per person. As seen in Figure 1, more than half of the world's forests are located in just five countries and two-thirds are located in ten countries (FAO, 2022).

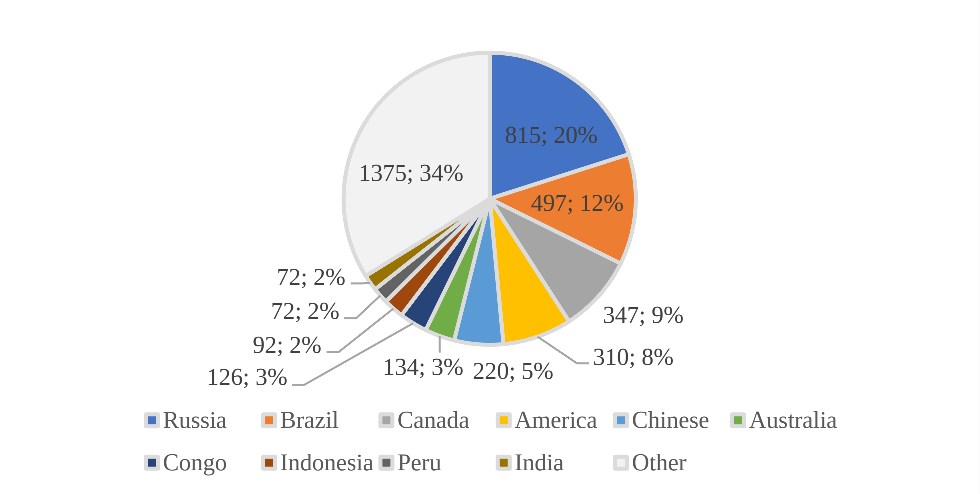

Figure 1: Global Distribution of Forests, 2020 (million hectares and percentage) (FAO,2022)

The global size of the wood, forest and paper products sector, which grew by approximately 1% between 2014 and 2019, is expected to exceed 3.5 trillion dollars by 2030. While China realizes 29% of the current production, it is followed by the USA with 16% and Japan with 5% (kolayihracat, 2022).

In Türkiye, which has a rich ecological diversity, approximately 23 million hectares of the 78 million hectare area are forested as of 2020. In other words, forest areas cover 29.4% of the country's area, and treeless forest areas are not included in this rate. The change in forest areas over the years is shown in Figure 2. 367,096 hectares of the total forest areas in 2020 are within the borders of Sinop province (OGM, 2022)

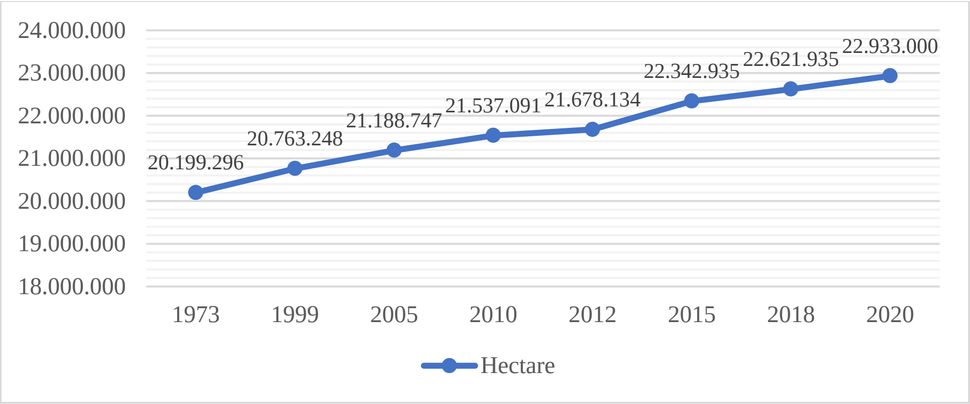

Figure 2: Change of Türkiye's Forest Areas by Years (hectare) (OGM,2022)

As of 2020, 9,668,571 (42%) hectares of the 22,933,000 hectares of Türkiye's forests are closed forest areas with gaps and are unproductive. The remaining 13,264,429 (58%) hectares are normal closed forest area. The distribution of forest wealth according to forest form over the years is shown in Figure 3. 53,323,959 m^3 of the forest wealth in 2020 belongs to Sinop province (OGM, 2022).

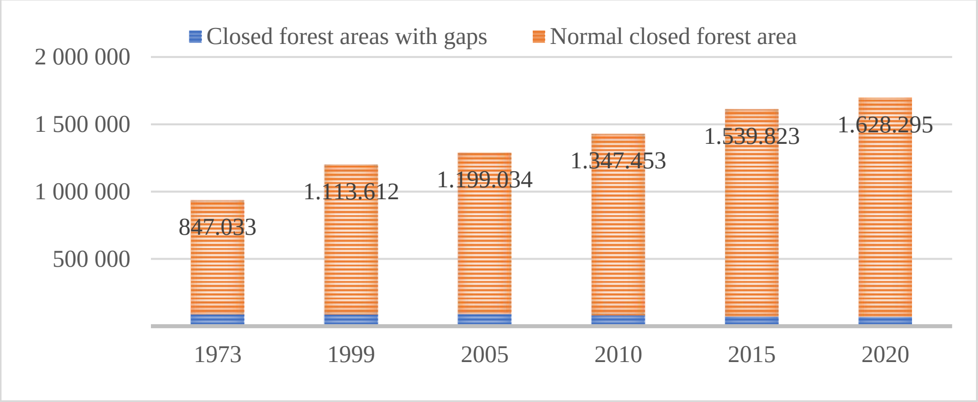

Figure 3: Distribution of Türkiye's Forest Wealth by Forest Form and Years (thousand m^3) (OGM, 2022)

Normal Closed Forest Areas: These are forests where the tree tops cover the area at a rate of 11-100%.
Closed Forest Areas With Gaps: These are forests where tree tops cover less than 10% of the area.

Table 1: Türkiye Forest Products Production Amounts (OGM, 2022)

Years			2015	2016	2017	2018	2019	2020
	Product Type	Unit						
Industrial Wood (m³)	Log	m^3	5 904 015	5 786 106	5 474 260	7 152 776	8 514 026	9 790 637
	Wire pole	m^3	54 257	57 574	60 610	71 147	58 333	68 298
	Mine pole	m^3	663 689	632 168	561 967	731 604	929 259	1 070 533
	İndustrial wood	m^3	764 010	835 157	752 253	875 403	1 008 952	1 092 798
	Wood for paper	m^3	2 375 172	2 486 595	2 169 059	2 874 882	3 175 505	3 609 978
	Fibre-chip wood	m^3	6 866 356	7 201 462	6 494 372	7 361 714	8 417 096	9 105 038
	Pole	m^3	10 098	10 935	9 102	12 611	10 078	13 784
	TOTAL		16 637	17 009	15 521	19 080	22 113	24 751
Firewood		(Ster)	5 022 986	4 877 067	4 359 646	4 890 455	5 589 798	5 396 680
		(m³)	3 767 240	3 657 801	3 269 734	3 667 841	4 192 349	4 047 510
Other (kg)	Rosin	kg	3 000	21 000	42 552	175 000	290 000	420 000
	Pitch pine root	kg	3 056 000	105 019	1 899 000	6 156 120	50 411 220	39 107 000
	Boxwood	kg	2 000	18 000	224 000	13 600	1 000	51 085
	Leave of daphne	kg	21 634 930	21 788 140	27 678 879	28 582 884	32 537 003	44 350 000
	Oregano	kg	2 159 141	1 256 423	1 511 058	1 977 674	1 834 828	2 195 005
	Sage	kg	578 027	279 636	229 020	281 052	261 400	342 532
	Linden	kg	48 700	65 000	208 000	35 265	76 490	30 593
	Mushroom	kg	146 997	803 166	87 864	242 822	73 454	50 077
	Flower bulbs	kg	118 968	35 172	98 495	341 424	327 121	221 568
	TOTAL		27 747 763	24 371 556	31 978 868	37 805 841	85 812 516	86 767 860

The changes in industrial, firewood and other non-wood products produced from forests in Türkiye over the years are given in Table 1. The table shows that there has been an increase in industrial wood production amounts over the years, except for 2017. It is observed that there was a significant increase in non-wood production amounts in 2019 and 2020.

Table 2: Annual Average Prices of Türkiye Forest Products (TL) (OGM, 2022)

Years			2015	2016	2017	2018	2019	2020
Product Type		Unit						
Industrial Wood (m³)	Log	m^3	273	249	327	393	422	464
	Wire pole	m^3	316	340	357	416	483	576
	Mine pole	m^3	216	185	255	324	332	341
	İndustrial wood	m^3	199	173	224	272	280	301
	Wood for paper	m^3	162	151	178	225	233	262
	Fibre-chip wood	m^3	94	103	106	121	149	172
	Pole	m^3	97	141	145	147	162	180
Firewood	(Stere)		58	60	74	87	97	90
	(m³)	(Ster)	81	72	99	117	130	120
Other	Rosin	(m³)	0,08	0,10	0,11	0,10	0,12	0,13
	Pitch pine root	kg	1,37	1,45	1,71	0,02	0,02	0,02
	Boxwood	kg	1,30	1,47	0,08	0,10	0,15	0,17
	Leave of daphne	kg	0,07	0,07	0,08	0,10	0,12	0,13
	Oregano	kg	0,06	0,07	0,08	0,10	0,15	0,17
	Sage	kg	0,07	0,08	0,09	0,10	0,15	0,17
	Linden	kg	0,30	0,31	0,33	0,35	0,35	0,50
	Mushroom	kg	0,61	0,64	0,68	0,72	0,72	1,01
	Flower bulbs	kg	0,26	0,21	0,30	0,31	0,40	0,45

Table 2 shows the changes in prices of Türkiye's forest products over the years. According to the table, it can be seen that the prices of industrial wood, firewood and other products are in a constant upward trend.

Analysis of Sinop Forest Products Asset and Sector

Sinop province is an important forest city of Türkiye today, as it was in the past. More than 90% of the Sinop's villages are forest villages and a significant amount of forest products are produced. Despite this, Sinop Regional Directorate of Forestry was closed in 2011 and its forestry management directorates, including Ayancık, were transferred to Kastamonu Regional Directorate of Forestry. However, in 2021, Sinop Regional Directorate of Forestry was re-established. There are six forestry management directorates under it, including Ayancık. Some information about the forest existence of Sinop province over the years, in comparison with Türkiye in general, is given in Tables 3, 4 and 5.

Table 3: Sinop Forest Area (Hectare) (OGM, 2022)

	2019			2020		
	Normal	Closed with gap	Total	Normal	Closed with gap	Total
Türkiye	13 083 510	9 656 787	22 740 297	13 264 429	9 668 571	22933 000
Sinop	296 698	70 398	367 096	296 698	70 398	367 096
Ratio	2,27	0,73	1,61	2,24	0,73	1,60

Note: The total area of Sinop province is 572,565 hectares, approximately 64% of which is forest area.

Table 4: Sinop Forest Wealth (m^3) (OGM, 2022)

	2019			2020		
	Normal	Closed with gap	Total	Normal	Closed with gap	Total
Türkiye	1 588 247 192	69 872 808	1 658 120 000	1 628 295 394	68 759 606	1 697 055 000
Sinop	52 667 052	656 907	53 323 959	52 667 052	656 907	53 323 959
Ratio	3,32	0,94	3,22	3,23	0,96	3,14

Table 5: Sinop Industrial Unprocessed Wood Production Amounts (OGM, 2022)

Years		2015	2016	2017	2018	2019	2020
Türkiye		16 637 598	17 009 998	15 521 622	19 080 137	22 113 248	24 751 066
Sinop							
Industrial Wood (m^3)	Log	212 560	206 908	242 823	267 925	307 439	326 945
	Wire pole	3 646	2 173	3 270	4 300	2 180	2 764
	Mine pole	8 191	4 182	6 666	7 678	7 604	11 098
	İndustrial wood	14 698	13 324	14 660	15 639	14 776	17 125
	Wood for paper	184 220	162 842	107 035	120 630	161 903	138 176
	Fibre-chip wood	233 513	204 840	265 003	262 328	289 456	358 914
	Pole	22	93	295	187	106	243
	TOTAL	656 850	594 362	639 751	678 687	783 464	855 265
Firewood	(Ster)	130 980	147 319	107 275	132 375	153 248	152 230

A comparison of the export performance of the Sinop province by years and other provinces is given in Table 6. As seen in the table, the 2021 export amount of the

Sinop province in the sector increased by 9.4% compared to the previous year. Despite this, while the Sinop's export amount in the sector was 8 per hundred thousand compared to Türkiye's total in 2020, it decreased to 7 per thousand in 2021.

Table 6: Sinop Furniture, Paper and Forest Products Sector Export Performance ($1000) (TİM, 2022)

	Province	2020	2021	Change
1	İSTANBUL	2.227.859,64	2.775.298,14	24,6%
2	BURSA	626.250,32	820.589,74	31,0%
3	İZMIR	592.704,16	663.298,96	11,9%
4	KAYSERI	414.767,02	529.526,32	27,7%
5	GAZIANTEP	372.387,23	409.124,15	9,9%
6	ANTALYA	166.560,55	279.524,24	67,8%
7	ANKARA	168.191,64	203.427,95	21,0%
8	KOCAELI	144.092,58	197.809,95	37,3%
9	ADANA	112.132,89	130.336,37	16,2%
10	ORDU	46.320,93	90.048,06	94,4%
…				
63	SINOP	458,14	501,14	9,4%
	TOTAL	5.563.973,77	6.993.833,11	25,6%

Export amounts of the Sinop province in the "furniture, paper and forest products" sector over the years are shown in Figure 4. No data could be found for the Ayancık district.

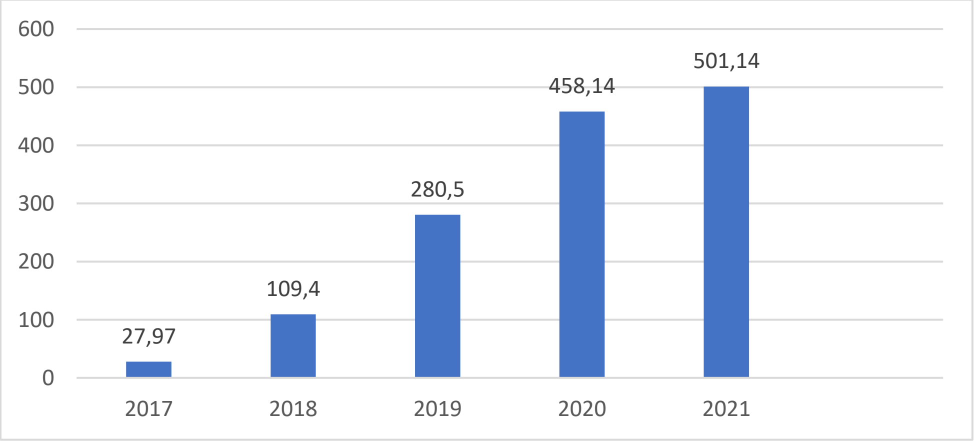

Figure 4: Furniture, Paper and Forest Products Sector Total Export Amounts in Sinop ($1000) (TİM, 2022)

As seen in Figure 4, total export amounts tend to constantly increase. According to the Sinop Chamber of Commerce 2022 data, the countries with the most exports are Iran, Iraq, UAE, Egypt and Azerbaijan. The exported items are as follows.

• 440711: Pine Timber

• 440712: Timber from fir (Abies spp.) and spruce (Picea spp.) trees; thickness>6mm

• 440791 - Oak (Sawn Longitudinally, Shaped, Sliced Thickness >6 mm)

Finally, according to the 2022 data of Sinop Provincial Directorate of Industry and Technology, the number of firms operating in the wood products sector in Sinop is 111 and the number of employees employed is 529.

Purpose and Method

The scope of the research consists of the Ayancık district public forestry. The purpose of the research is to examine the general and financial situation of the Ayancık district public forestry. First of all, financial and sectoral data obtained from the Ayancık Forestry Management Directorate, the Sinop Chamber of Commerce and other relevant institutions are classified according to factors such as production, sales, supply chain structure, raw material supply cost and export. The change of these data over the years was examined using the comparative analysis method. Then, the 2018-2022 financial statement data of the revolving fund department of the Ayancık Forestry Management Directorate were analyzed using financial analysis techniques. As a result of the analyses, the current financial situation of the Ayancık public forestry was determined.

Results and Discussion

The findings are explained under two headings: general and financial analysis.

General Analysis of the **Ayancık Public Forestry**

A large part of the Ayancık district is covered with forests. For this reason, the district has an important potential for forestry-related sectors. At the same time, forestry is one of the most important sources of income in the district. However, the number of firms that will process forest products and create economic added value in the district is limited.

The total land of the Ayancık district is 86,600 (Ha). A significant part of this area, 71.86%, is non-agricultural land. Most of the 28.1% agricultural land consists of sloping lands. However, since it has a clayey and calcareous soil structure, it is extremely suitable for the growth of forest products. There are a total of 61,941 (Ha) forest areas in the region, of which 59,058 (Ha) are treed and 2,883 (Ha) are treeless. The district forests contain pine, fir, oak, hornbeam, beech, ash, elm, linden, plane tree, chestnut, poplar and various maquis and shrub species. It is possible to see every shade of green in the district forests. Mediterranean plants can also be found occasionally among the vegetation on the coastline, which consists of various tree species. In the coastal part, broad-leaved forest texture, maquis and heathlands and cultivated plants are common. As you move south, the climate begins to become arid and steppe plants appear (Ayancık District Governorship, 2022).

Some information about the raw material supply structure in the Ayancık forest products production process is included in Table 7.

Table 7: Raw Material Supply Structure in Ayancık Forest Products Production Process (Ayancık Forestry Management Directorate, 2023)

Years	2018	2019	2020	2021
Number of Forest Storages	2	2	2	3
Number of Forest Production Areas	112	157	150	181
Number of Workers in Forest Production	741	802	814	746
Number of Afforested Areas	2	3	1	1
Number of Saplings Planted	3500	15000	2500	3000
Rejuvenation Area (ha.)	232,7	154	379,7	199,5

As can be seen from the table, the number of forest storages increased from two between 2018 and 2020 to three in 2021. The number of production areas increased by approximately 20% compared to the previous year. Despite the increase in the production area, there was no significant change in the number of employed workers, on the contrary, it decreased in 2021. It is thought that this may be due to the pandemic. Although the number of afforested areas decreased from year to year, the number of saplings planted did not change much except in 2019.

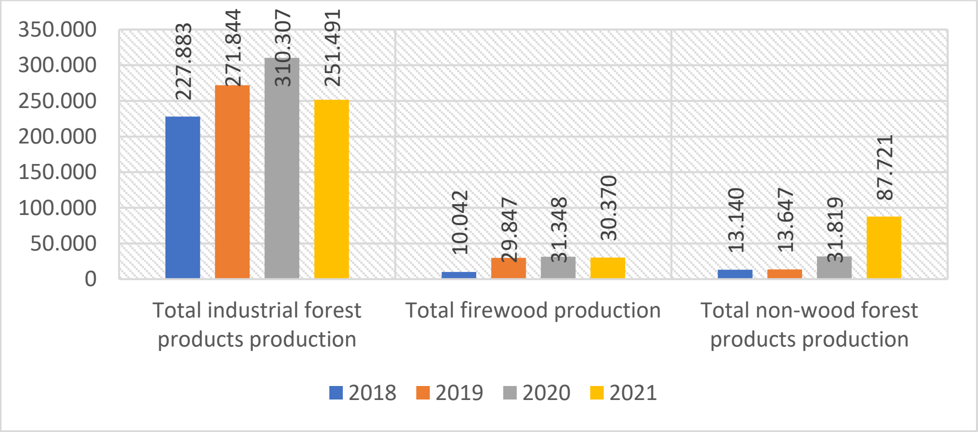

Figure 5: Ayancık Forest Products Production (m3 - m3 - kg) (Ayancık Forestry Management Directorate, 2022)

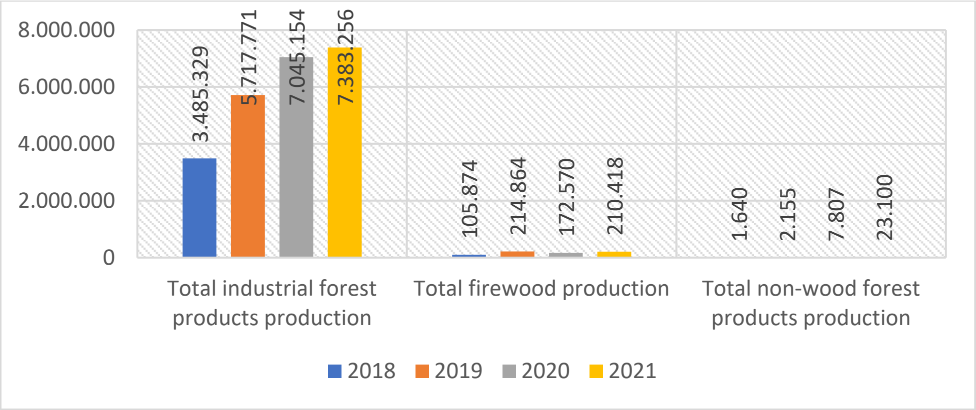

Figure 6: Ayancık Forest Products Production (TL) (Ayancık Forestry Management Directorate, 2022)

Data regarding the production amount of Ayancık forest products between 2018 and 2021 are shown in Figure 5. ık forest products between 2018 and 2021 are shown in Figure 5. As can be seen in the figure, the production amount (m^3) of industrial forest products increased until 2020 and decreased in 2021. A similar situation is also seen in the total firewood production. The upward trend in the production of non-wood forest products has continued increasingly in the last four years. Industrial forest products production was realized in terms of price as shown in Figure 6. Although the decrease in total production (m^3) in 2021 partially caused a decrease in total TL amount, it can be said that the increase in unit m^3 prices prevented the downward trend in total TL amount. Although firewood production increased in total m^3 in 2021, there was a decrease in total TL amount. It is seen that the total production (kg) increase in non-wood forest products production causes a similar trend in total TL amount.

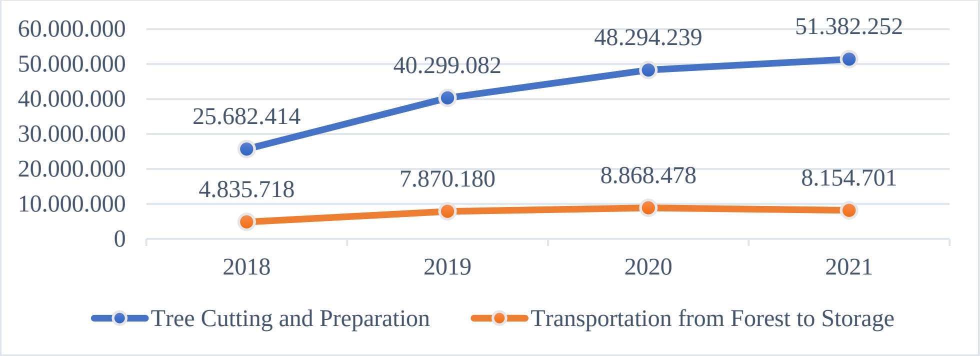

Figure 7: Ayancık Forest Products Raw Material Supply Costs (TL) (Ayancık Forestry Management Directorate, 2022)

As can be seen in Figure 7, the amount paid to producers or the total supply costs incurred for the cutting and preparation of forest products has increased over the years. The total transportation amount paid for transportation from the forest to the stores has increased continuously except for 2021, and there has been a decrease in 2021 compared to the previous year. Of course, when evaluating the amounts here, the increase in the general price index should also be taken into account.

Information on raw material sales after the production of Ayancık forest products between 2018 and 2021 is shown in Figures 8, 9 and 10.

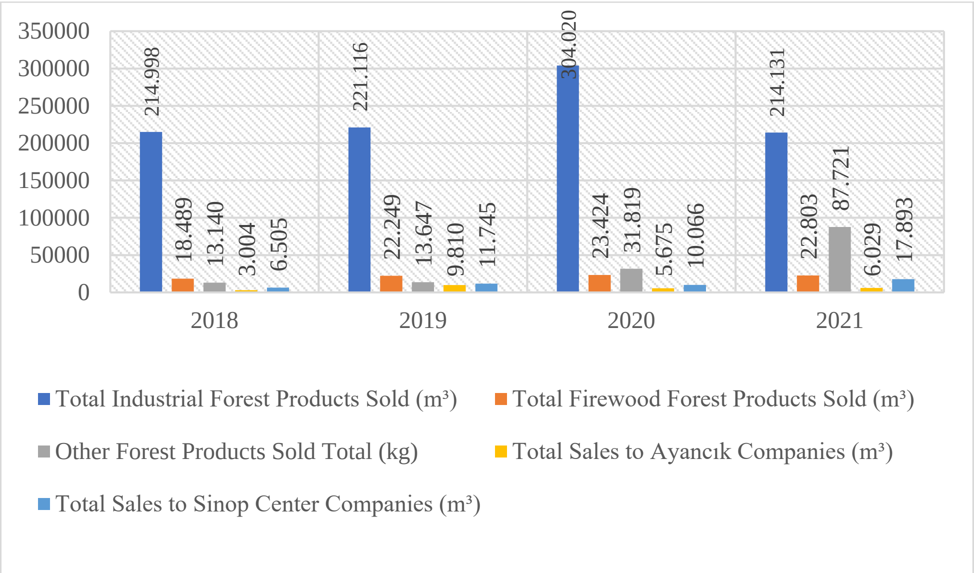

Figure 8: Ayancık Forest Products Raw Material Sales Information (Amount) (Ayancık Forestry Management Directorate, 2022)

As can be seen in Figures 8 and 9, the total amount (m^3) of industrial forest products sold increased until 2020 and decreased in 2021. Despite this, there was no decrease in total sales amounts (TL). It can be said that the increase in unit prices was effective in this result. Sales to Ayancık firms decreased in 2020 and increased again in 2021.

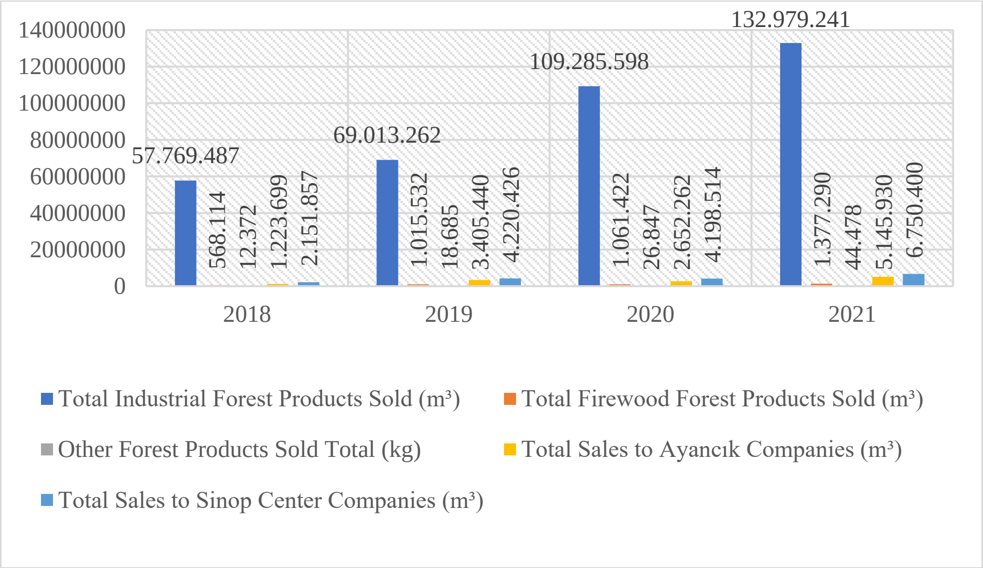

Figure 9: Ayancık Forest Products Raw Material Sales Information (TL) (Ayancık Forestry Management Directorate, 2022)

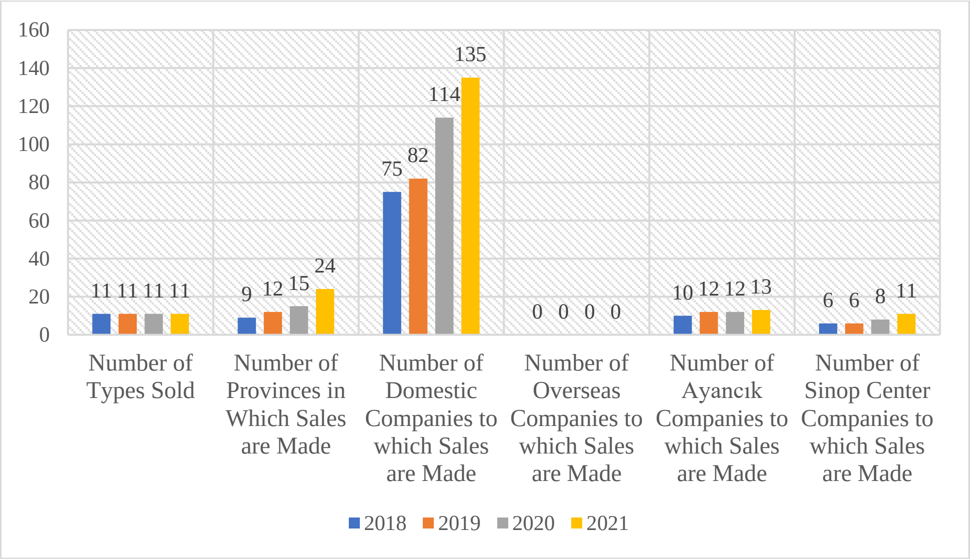

Figure 10: Ayancık Forest Products Raw Material Sales Information (Other) (Ayancık Forestry Management Directorate, 2022)

As can be seen in Figure 10, there has been no change in the number of species sold over the years. The increasing trend in the number of provinces where sales are made is remarkable. While there is no foreign firms to which sales are made, the number of domestic firms has gradually increased over the years. It is seen that the number of firms selling forest products to Ayancık and Sinop center has an increasing trend, albeit slightly.

The number of firms operating in the forest products production sector registered with the Sinop Chamber of Commerce and Industry, according to NACE codes for Ayancık and Sinop in general, is given in Table 8.

Table 8: Number of Firms Operating in the Forest Products Production Sector According to NACE Code (Sinop Chamber of Commerce, 2022)

NACE Code	Explanation	Number of Firms	
		Ayancık	Sinop Total
16.10.01	Timber manufacturing (sawing and shaping trees)	7	15
16.23.90	Manufacturing of construction joinery and carpentry products not classified elsewhere (wooden beams, planks, buttresses, concrete forms, roof shingles, etc.)	-	3
16.10.02	Manufacturing of wooden railway or tram sleepers	1	1
31.01.01	Furniture manufacturing for closed areas such as offices, schools, places of worship, hotels, restaurants, cinemas, theaters, etc. (except those made of stone, concrete, ceramics)	-	6

The names of firmss operating in Ayancık according to the NACE (Statistical Classification of Economic Activities) code are listed in Table 9.

Table 9: Firm Names Operating in Ayancık According to NACE Code (Sinop Chamber of Commerce, 2022)

NACE Code	Explanation	Firm Name
16.10.01	Timber Manufacturing	•Sinop Orüs Orman Ürünleri Sanayi Ve Ticaret Anonim Şirketi •Adnan Örnek Yamanoğlu Orman Ürünleri •Ayancık Mobilya Ve Ders Araçları Üretim Pazarlama Anonim Şirketi •Ar-Taş Orman Ürünleri Nakliyat İnşaat Gıda Ve Madencilik Sanayi Ticaret Limited Şirketi •Zingal Entegre Orman Ürünleri İthalat İhracat Sanayi Ve Ticaret Limited Şirketi •Schieder Ayancık Mobilya Sanayi Ve Ticaret Limited Şirketi •Giresun Alsan Orman Ürünleri Sanayi Ve Ticaret Anonim Şirketi Ayancık Şubesi
16.10.02	Manufacturing of wooden railway or tram sleepers	•Ateşler Orman Ürünleri Nakliyat Sanayi Ve Ticaret Limited Şirketi

Ayancık district is rich in forest products and therefore has a high export potential. However, only one of the firms exporting forest products in Sinop province is in Ayancık district. It is seen that the district cannot make a sufficient progress in the field of exports. These firms are listed below.

•Ateşler Orman Ürünleri Nakliyat Sanayi Ve Ticaret Limited Şirketi (Ayancık)
•Antik Ahşap Mobilya
•Atılganlar Ağaç Mamülleri Sanayi Ve Ticaret Limited Şirketi
•Sinop Orüs Orman Ürünleri Sanayi Ve Ticaret Anonim Şirketi

Financial Analysis of Ayancık Public Forestry

In the financial analysis of Ayancık public forestry, data from the balance sheet and income statement of the revolving fund department of Ayancık Forestry Management Directorate between 2018 and 2022 were used. The end-of-period balance sheet of the revolving fund department of the Forestry Management Directorate is in Tables 10 and 11, the income statement is in Table 12, and some other accounts are in Table 13.

Table 10: Comparative Balance Sheets of Ayancık Forest Management Directorate Revolving Fund Department (TL)

	2018	2019	2020	2021	2022
Current Assets	17.014.800,82	22.315.585,02	34.502.886,98	48.454.284,19	134.760.820,77
Fixed Assets	1.023.034,40	961.979,06	1.146.017,64	949.960,33	1.345.738,65
Total Assets	**18.037.875,22**	**23.277.564,08**	**35.648.904,62**	**49.404.244,52**	**136.106.559,42**
Short Term Foreign Resources	-4.181.633,80	-4.114.629,06	-11.450.353,01	-14.056.018,11	-35.345.106.55
Long Term Foreign Resources	1.719.611,19	1.019.677,28	1.014.680,89	1.187.218,11	1.682.875,57
Equities	20.499.897,83	26.372.515,86	46.084.576,74	62.273.044,52	169.768.790,40
Total Liability	**18.037.875,22**	**23.277.564,08**	**35.648.904,62**	**49.404.244,52**	**136.106.559,42**

The reason why the Short-Term Foreign Resources account class is negative in the balance sheets is that the 393 Central and Branches Current Account gives a debt balance. In the description of the account in Article 326 of the Budget and Accounting Regulation for Revolving Fund Management, it is stated that "The Central and Branches Current Account works as debtor and creditor. It is used to monitor the debt and credit relations of the central office with the branches, the branches with the central office or between themselves." 393 Central and Branches Current Account is used during the year and does not give a balance as a result of consolidating the financial statements of the central and branches at the end of the year. The remaining debts of 393 Central and Branches Current Accounts in Table 13 were transferred to 136 Other Receivables account, and the balance sheets in Table 10 were rearranged as in Table 11 for financial analysis.

Table 11: Comparative Balance Sheets of Ayancık Forestry Management Directorate Revolving Fund Department

	2018	2019	2020	2021	2022
Current Assets	22.753.450,33	29.373.184,88	50.023.062,15	69.357.448,46	211.834.802,77
Fixed Assets	1.023.034,40	961.979,06	1.146.017,64	949.960,33	1.345.738,65
Total Assets	**23.776.484,73**	**30.335.163,94**	**51.169.079,79**	**70.307.408,79**	**213.180.541,42**
Short Term Foreign Resources	1.557.015,71	2.942.970,80	4.069.822,16	6.847.146,16	41.728.875,45
Long Term Foreign Resources	1.719.611,19	1.019.677,28	1.014.680,89	1.187.218,11	1.682.875,57
Equities	20.499.897,83	26.372.515,86	46.084.576,74	62.273.044,52	169.768.790,40
Total Liability	**23.776.524,73**	**30.335.163,94**	**51.169.079,79**	**70.307.408,79**	**213.180.541,42**

Table 12: Ayancık Forest Management Directorate Revolving Fund Department Comparative Income Statements

	2018	2019	2020	2021	2022
NET SALES	**58.356.251,20**	**70.209.286,50**	**110.382.034,48**	**134.404.771,19**	**343.421.687,20**
Cost of sales (-)	27.012.053,75	34.453.383,49	51.997.205,82	45.518.087,11	85.396.974,88
GROSS SALES	31.344.197,45	35.755.903,01	58.384.828,66	88.886.684,08	258.024.712,32
Operating expenses (-)	14.286.537,55	13.009.752,22	19.677.872,14	28.556.786,57	104.151.491,62
OPERATING PROFIT	17.057.659,90	22.746.150,79	38.706.956,52	60.329.897,51	153.873.220,70
PERIOD PROFIT	18.749.897,83	24.622.515,86	41.584.576,74	57.773.044,52	165.268.790,40

Table 13: Other Comparative Accounts of Ayancık Forestry Management Directorate Revolving Fund Department

	2018	2019	2020	2021	2022
Stocks	2.260.133,99	7.644.391,49	4.668.419,25	1.762.531,23	30.193.618,69
Liquid Assets	120,83	5.330,04	0,19	5.000,00	-
Stocks and Bonds	-	-	-	-	-
Trade Payables	269.249,31	401.451,68	580,75	1.474.734,26	14.636.771,97
Trade Receivables	14.739.203,05	14.663.226,37	29.831.830,42	46.686.752,96	104.567.202,08
Financial Expenses	-	-	-	-	-
Central Branch Current	-5.738.649,51	-7.057.599,86	-15.520.175,17	-20.903.164,27	-77.073.982,00

The results of vertical (percentage analysis), horizontal (comparative table analysis) and ratio analysis within the framework of the 2018-2022 data of Ayancık Forestry Management Directorate Revolving Fund Department in Tables 11, 12 and 13 are as follows.

Vertical (Percent) Analysis Results

In this analysis method, financial statement accounts are expressed as a percentage. In other words, the balance sheet general or group total is accepted as 100, and other accounts are percentageed accordingly. In the income statement, the net sales account is accepted as 100. Vertical analysis results calculated according to the values in Tables 11 and 12 will be as in Tables 14 and 15.

Table 14: Ayancık Forestry Management Directorate Revolving Fund Department Balance Sheets Vertical Analysis Results

	2018	2019	2020	2021	2022
Current Assets	95,7	96,8	97,8	98,6	99,4
Fixed Assets	4,3	3,2	2,2	1,4	0,6
Total Assets	**100**	**100**	**100**	**100**	**100**
Short Term Foreign Resources	6,6	9,7	8,0	9,7	19,6
Long Term Foreign Resources	7,2	3,4	2,0	1,7	0,8
Equities	86,2	86,9	90,0	88,6	79,6
Total Liability	**100**	**100**	**100**	**100**	**100**

As seen in Table 14, the percentage of current assets in total assets has been in an increasing trend since 2018, and the percentage of fixed assets has been in a decreasing trend. It is seen that the percentage of long-term foreign resources within total resources decreased over the years after 2018, while the percentage of equities increased until 2020 and decreased thereafter.

Table 15: Ayancık Forestry Management Directorate Revolving Fund Department Income Statements Vertical Analysis Results

	2017	2018	2019	2020	2021	2022
NET SALES	100	100	100	100	100	100
Cost of sales (-)	48	46	49	47	34	25
GROSS SALES	52	54	51	53	66	75
Operating expenses (-)	27	24	19	18	21	30
OPERATING PROFIT	26	29	32	35	45	45
PERIOD PROFIT	27	32	35	38	43	48

In Table 15, when the net sales of all years are assumed to be 100, it is seen that the percentage of sales costs tends to decrease after 2019, while the gross profit rate tends to increase. It is seen that operating expenses decreased compared to sales until 2020 and then started to increase. Operating profit and period profit percentages compared to net sales tend to increase continuously over the years. As a result, it can be said that costs tend to decrease and profitability tends to increase compared to net sales.

Horizontal (Comparative) Analysis Results

In this analysis method, financial statement accounts are compared over the years and their changes are examined. Since there are more than two years here, each year will be compared with the previous year. However, removing these values from the effect of inflation will provide more meaningful information. For this reason, the table values will be corrected using the Domestic Producer Price Index (D-PPI) values and then the analysis will be carried out. This correction is not an inflation accounting process, but a process of bringing all accounts to the purchasing power of the current period. Relevant index values by years are as in Table 16.

Table 16: D-PPI and Correction Coefficient (TSI, 2023)

Years	December Index (2003=100)	Correction Coefficient
2017	316,48	6,39
2018	422,94	4,78
2019	454,08	4,45
2020	568,27	3,56
2021	1022,25	1,98
2022	2021,19	1,00

Tables 11 and 12 have been adjusted according to the D-PPI index, and the adjusted tables are as in Tables 17 and 18.

Table 17: Comparative Balance Sheets Adjusted According to D-PPI index

	2018	2019	2020	2021	2022
Current Assets	108.761.492,58	130.710.672,72	178.082.101,25	137.327.747,95	211.834.802,77
Fixed Assets	4.890.104,43	4.280.806,82	4.079.822,80	1.880.921,45	1.345.738,65
Total Assets	**113.651.597,01**	**134.991.479,53**	**182.161.924,05**	**139.208.669,40**	**213.180.541,42**
Short Term Foreign Resources	7.442.535,09	13.096.220,06	14.488.566,89	13.557.349,40	41.728.875,45
Long Term Foreign Resources	8.219.741,49	4.537.563,90	3.612.263,97	2.350.691,86	1.682.875,57
Equities	97.989.511,63	117.357.695,58	164.061.093,19	123.300.628,15	169.768.790,40
Total Liability	**113.651.788,21**	**134.991.479,53**	**182.161.924,05**	**139.208.669,40**	**213.180.541,42**

Table 18: Comparative Income Statements Adjusted According to D-PPI index

	2018	2019	2020	2021	2022
NET SALES	**278.942.880,74**	**312.431.324,93**	**392.960.042,75**	**266.121.446,96**	**343.421.687,20**
Cost of sales (-)	129.117.616,93	153.317.556,53	185.110.052,72	90.125.812,48	85.396.974,88
GROSS SALES PROFIT	149.825.263,81	159.113.768,39	207.849.990,03	175.995.634,48	258.024.712,32
Operating expenses (-)	68.289.649,49	57.893.397,38	70.053.224,82	56.542.437,41	104.151.491,62
OPERATING PROFIT	81.535.614,32	101.220.371,02	137.796.765,21	119.453.197,07	153.873.220,70
PERIOD PROFIT	89.624.511,63	109.570.195,58	148.041.093,19	114.390.628,15	165.268.790,40

Horizontal analysis results calculated according to Tables 17 and 18 will be as in Tables 19 and 20.

Table 19: Ayancık Forestry Management Directorate Revolving Fund Department Balance Sheet Horizontal Analysis Results

	2018	2019	2020	2021	2022
Current Assets	-8	20	36	-23	54
Fixed Assets	47	-12	-5	-54	-28
Total Assets	**-6**	**19**	**35**	**-24**	**53**
Short Term Foreign Resources	-60	76	11	-6	208
Long Term Foreign Resources	-18	-45	-20	-35	-28
Equities	6	20	40	-25	38
Total Liability	**-6**	**19**	**35**	**-24**	**53**

When Table 19 is examined, it is seen that current assets decreased in 2018 and 2021 compared to the previous year, and increased in other years. Fixed assets increased only in 2018 compared to the previous year. Long-term foreign resources decreased in all years compared to the previous year. The only year in which there was a decrease in equity compared to the previous year was 2021, and there was an increase in other years. This may be due to the fact that the effects of complete closures due to the pandemic were felt more in the relevant year.

Table 20: Ayancık Forestry Management Directorate Revolving Fund Department Income Statement Horizontal Analysis Results

	2018	2019	2020	2021	2022
NET SALES	**-8**	**12**	**26**	**-32**	**29**
Cost of sales (-)	-10	19	21	-51	-5
GROSS SALES PROFIT	-5	6	31	-15	47
Operating expenses (-)	-15	-15	21	-19	84
OPERATING PROFIT	4	24	36	-13	29
PERIOD PROFIT	10	22	35	-23	44

According to Table 20, net sales decreased in 2019 and 2021 compared to the previous year, and this caused a similar situation in gross sales profit. The highest net sales increase and gross profitability increase compared to the previous year was realized in 2022. It can be said that the decrease in costs in the previous year also had an impact on this situation. Operating expenses decreased in 2018, 2019 and 2021 compared to the previous year. The highest increase occurred in 2022. The only year in which the period profit decreased compared to the previous year is 2021. Except for the relevant year, there is a general increasing trend in period profit compared to the previous year. However, it is seen that all accounts decreased in 2021 compared to the previous year.

Ratio Analysis Results

With ratio analysis, financial statement accounts that have meaningful relationships between them are compared to each other and important information can be provided on issues such as financial structure, profitability, efficiency, liquidity situation, and effective use of assets (Akdoğan and Tenker, 2007; Çabuk and Lazol, 2014). The ratio analysis results calculated according to Tables 11, 12 and 13 will be as in Table 21.

Table 21: Ayancık Forestry Management Directorate Revolving Fund Department Ratio Analysis Results

	2017	2018	2019	2020	2021	2022	Ideal
Liquidity Ratios							
Current Ratio (CA / STFR)	6	15	10	12	10	5	≥2
Acid Test Rate (FA-Stocks) / STFR	5	13	7	11	10	4	≥1
Fiscal (Financial) Structure Ratios							
Leverage Ratio (Total Foreign Resources / Total Liabilities)	0,23	0,14	0,13	0,10	0,11	0,20	≤0,50
Equities Ratio (Equities / Total Liabilities)	0,77	0,86	0,87	0,90	0,89	0,80	≥0,50
Short Term Foreign Resources Ratio (STFR / Total Liabilit.)	0,15	0,07	0,10	0,08	0,10	0,20	≤0,33
Long Term Foreign Resource Ratio (LTFR/ Total Liabilities)	0,08	0,07	0,03	0,02	0,02	0,01	≤0,50
Financing Ratio (Equities / Total Foreign Resources)	3,26	6,26	6,66	9,06	7,75	3,91	≥1
Fixed Assets / Equities	0,04	0,05	0,04	0,02	0,02	0,01	≤1
Fixed Assets / Constant Capital	0,03	0,05	0,04	0,02	0,01	0,01	≤1
Operating Ratios							
Stock Turnover Ratio (Cost of Sales / Average Stock)	5,54	11,95	4,51	11,14	25,83	2,83	
Receivables Turnover Ratio (C. Net Sales / Avg. Trade Rec.)	3,46	3,96	4,79	3,70	2,88	3,28	
Receivable Collection Period (360 / RTR)	104	91	75	97	125	110	
Asset Turnover Rate (Net Sales / Total Asset)	2,49	2,45	2,31	2,16	1,91	1,61	
Equities Turnover Rate (Net Sales / Average Equities)	3,25	2,85	2,66	2,40	2,16	2,02	
Profitability ratios							
Gross Sales Profit Ratio (Gross Sales Profit / Net Sales)	0,52	0,54	0,51	0,53	0,66	0,75	
Operating Profit Ratio (Operating Profit / Net Sales)	0,26	0,29	0,32	0,35	0,45	0,45	
Period Profit Ratio (Period Profit / Net Sales)	0,27	0,32	0,35	0,38	0,43	0,48	
Cost of Sales Ratio (Cost of Sales / Net Sales)	0,48	0,46	0,49	0,47	0,34	0,25	

Even though it has a decreasing trend after 2018, the fact that the current ratio is well above 2 shows that the general liquidity situation of the Forestry Management

Directorate is quite good and the net working capital is sufficient. The assist test ratio makes the current ratio more meaningful by removing low-liquid stocks from current assets, and a ratio above 1 is positive. Although it is positive that liquidity ratios are above ideal values, it is noteworthy that they tend to decrease. The ratio of foreign resources within total resources has been in a downward trend since 2017, and has started to rise again after 2021. If the ratio is below 50%, it indicates that the company finances its assets with its own resources. It is seen that other financial structure ratios are also realized within the framework of ideal values.

The stock turnover rate, which shows effective stock management, how quickly stocks turn into production and sales, and how assets are used effectively, and is expected to be high, increased in 2018, 2020 and 2021, and a significant decrease occurred in 2022. However, it is seen that the receivables turnover rate, which shows how quickly the receivables are collected and is expected to be low, generally follows a horizontal trend, and the receivables collection period varies between 90 and 125 days.

It is seen that the gross sales profit, operating profit and period profit ratio of the orestry Management Directorate generally follow a horizontal trend until 2021 and start to increase in 2021 and thereafter. Similarly, it can be seen that the cost of sales ratio has also decreased. Although it has been seen that the profitability level has increased in recent years compared to sales, the ratios will be more meaningful when compared with the results of other companies or the consolidated financial statement ratios.

Conclusion

Ayancık district of Sinop province is very rich in terms of forest assets. In addition, the district is an important and high-quality raw material source for firms using forest products. In this study, the general and financial analysis of the district's public forestry was examined.

In terms of production, it has been determined that the total amount (kg, m^3) and amount (TL) of industrial forest products production and firewood production tended to increase in the relevant years (except 2020). The total production amount (kg, m^3) and amount (TL) of non-wood forest products increased uninterruptedly in the relevant years. With the increase in production amount, supply costs also increased.

The total amount of industrial forest products sold is on an increasing trend throughout the relevant years (except 2021). However, there was no decrease in total sales amounts (TL) due to the increase in unit product prices. Total sales to Ayancık firms increased except for 2020. However, there was no change in the number of species sold. However, the increase in the number of provinces where sales are made is important. The number of domestic firms to which sales are made has gradually increased over the years. It has been observed that the number of firms selling forest products to Ayancık and Sinop center has an increasing trend, albeit slightly. Although the number of firms selling forest raw materials after processing them in the district is relatively good, it has been determined that the number of Ayancık firms exporting is insufficient.

According to the vertical analysis of the financial data of the Revolving Fund Department of Ayancık Forestry Management Directorate, it can be said that current assets tend to increase, fixed assets tend to decrease according to the balance sheet total, long-term foreign resources tend to decrease, and the increasing trend of equities continues until 2020. According to the vertical analysis of the income statement, it has been observed that costs tend to decrease and profitability tends to increase compared to net sales.

According to the results of the horizontal analysis based on the previous year, it can be stated that there is a decrease in fixed assets and short-term foreign resources and an increase in equities. According to the horizontal analysis of the income statement, it can be said that there is a general increasing trend in the period profit compared to the previous year, except for 2021.

According to the ratio analysis results, it can be said that the liquidity ratio values are well above the ideal ratios, but it is also noteworthy that there is a decreasing trend. It can be stated that the assets are largely financed with equities. Comparing the turnover rates, which fluctuate with ups and downs over the years, and the increasing profitability rates with other business rates will provide a more meaningful interpretation. In addition, it can be said that the pandemic, which caused disruption in the supply chain and a slowdown in trade, had an impact on the financial statement analysis results.

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Chapter 7

Evaluation Within The Scope Of Ecological Footprint And Sustainable Forestry

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Abstract.

One of the effective methods that can be used as a concrete indicator of sustainability is the ecological footprint. Environmental problems have affected the world due to reasons such as technological progress, industrialization, urbanization and population growth. All of these increase the consumption of natural resources and affect environmental quality. The ecological footprint measures the ecological assets (plant-based food products, animal and fish products, and forest products) needed to produce the natural resources consumed by a given population or individual. The ecological footprint is designed to compare the biocapacity of the ecosystem to tolerate the consumption of biological resources by individuals and the resulting waste. There are many factors among the indicators of environmental pollution. But the most comprehensive of these indicators is the ecological footprint. Carbon sequestration, agricultural land, forest, grassland, built-up area and fishing ground footprint are the components of the ecological footprint. The forest footprint is obtained by calculating the area of forest required to meet the amount of wood products, logs, pulp and firewood consumed. The excessive use of resources increases the pressure on the ecological system of the world and this is a major obstacle to sustainable development.

Keywords: Ecological footprint, Sustainability, Forest, Component

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Since the beginning of human existence on Earth, humanity has coexisted with nature, leaving both positive and negative permanent marks on the wold. However, the chain of threats to nature is growing due to the rapid increase in the world population, industrial activities, changes in technology, and unconscious and unlimited consumption. The interconnection between unconscious and excessive consumption has resulted in numerous environmental problems, including reduced biodiversity, global warming, acid rain, water, soil, and air pollution, unplanned urbanization, and depletion of natural resources. This event has also increased the carrying capacity of the ecosystem. To measure sustainability, the term ecological footprint has been introduced as an indicator. The given indicator enables predictions to be made regarding sustainable land use, economy, and population by comparing the relationship between social and economic metabolism and land use with the pressure of society on the environment.

The environment encompasses all natural and artificial surroundings in which people reside, including all living and non-living elements in the universe. Environmental issues are a global concern, as any problem occurring in one area can threaten the life cycle of other areas. The issue in this area has global implications, affecting the sea, oceans, and atmosphere, and posing a threat to all living and non-living entities (Aydın, 2017). As a result, the ecosystem's carrying capacity has been exceeded, and human harmony with nature is gradually diminishing.

Raising awareness of 'Sustainable Development' among individuals is crucial for restoring harmony between humans and the environment. It is important to prioritize the protection and sustainability of the environment in our attitudes and behaviours (Keleş, 2007).

Sustainable Forestry

The promotion of awareness of sustainable development is crucial. It is important to encourage individuals to adopt attitudes and behaviours that protect the environment and ensure its sustainability (Keleş, 2007; Öztürk et al., 2020).

Sustainable forest management involves maintaining the continuity of the forest ecosystem, including its vegetation, wildlife, micro-organisms, mineral substances, hydrological and microclimatic features, and the relationships between them, while also providing for their utilization (Aydın et. al., 2018). Additionally, it encompasses the preservation of social benefits such as soil and water conservation and erosion prevention provided by forest resources (Kurnaz and Güneş Şen, 2023). The social dimension of forest management includes considerations such as taking into account the wishes of influence and interest groups, their participation in planning and decision-making processes, and ensuring the social and economic development of local people who depend on forestry. The economic dimension, on the other hand, involves ensuring the continuity of the units responsible for forest management activities (Anonim, 1996; Türker, 2003).

To ensure sustainable forest management, it is important to relate indicators and criteria to biodiversity and involve stakeholders in the planning process. Forest ecosystems play a crucial role in protecting and promoting biological diversity.The main environmental problems that threaten global sustainability are global climate change, soil and water pollution, and the resulting depletion of natural resources (Tosunoğlu, 2014).Biological diversity refers to the variety and multiplicity of life, including species richness, rarity, and endangerment. It encompasses four main components: genes, species, ecosystems, and ecological events in a given region. The first three parts are structural elements, while the fourth is a functional element (Alkan et al., 2010; Işık et al., 1997).

Forest resources and the global carbon cycle, the health, vitality, and integrity of forests, the production capacity and functions of forests, biological diversity, protective functions of forests, and socio-economic functions of forests can be considered as criteria and indicators for sustainable forest management (Hakverdi, 2020).

The ecological footprint is a measure of the interaction between nature and human beings, aimed at achieving environmental sustainability.It quantifies the current pressure on natural resources and identifies the factors or attitudes that contribute to this pressure (Tosunoğlu, 2014).Sustainable development is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs.The statement suggests that sustainability can be ensured by adopting an attitude of simultaneous and equal development in economic, social, and ecological terms.This text investigates the relationship between the speed of human consumption of aboveground and underground reserves and the sustainability of the ecosystem. It aims to determine whether a conscious or unconscious attitude towards consumption affects the achievement of sustainability. The importance of the environmental dimension in ensuring sustainable development is highlighted. The sources cited are Tosunoğlu (2014) and Ozturk & Ubay Tonuk (2017).

Ecological Footprint

Ecology is derived from the Greek words 'Oikos' and 'Logos'.'Oikos' refers to home, place, dormitory, or living relationships, while 'Logos' means work (Sevgi, 2015; Gürler et al. 2017).Ecological transparency refers to the difference between the amount of natural resources produced in the world and the ecological value required for people to consume these resources while nature tolerates the wastes generated after consumption.Furthermore, ecological deficits are indicative of the strain on the natural world.Present-day research shows that the burden on the environment, caused by escalating technological and economic development, is exacerbating environmental pollution and excessive consumption (Mızık & Avdan, 2020).

The increasing impact of environmental problems has become more evident over time and has manifested in various ways.To draw attention to these issues, new concepts have emerged, including the ecological footprint (Tosunoğlu, 2014).This term measures the amount of natural areas we use and own, making it a crucial parameter.Ecological footprint is a measure of an individual's or community's impact on the environment. It is expressed as the amount of resources consumed (URL 2). In essence, the ecological footprint is a measure of the impact of human activities on natural resources and the amount of natural production area needed to replace them.It provides data on the amount of space individuals use in nature with their consumption habits and the space they will require while maintaining these habits. This information can be used to regulate habits in favour of the environment (Öztürk, 2010).

The ecological footprint is a method used to measure the impact of human activities on ecosystems.It reveals the interaction between the supply and demand for natural resources, providing a scientific basis for recognising imbalances and producing solutions to eliminate them. Therefore, studies aimed at reducing the ecological footprint are becoming increasingly important. In current conditions, economic growth is pursued with the aim of increasing welfare. The development of resources has led to changes in consumption habits. As a result, humanity has ignored the world's ecosystem reserves and continued to live unsustainably (Ensarioğlu, 2023).

The assessment of ecological footprints is related to biologically productive area or biological capacity.Ecological footprints measure regular demand, while biocapacity refers to uninterrupted supply.These figures vary from year to year based on population, per capita consumption, production efficiency, and productivity.Additionally, carbon footprint and water footprint are derived from ecological footprints.The concept has gained popularity globally due to the growing concern over climate change (URL 2).

Ecological footprint elements, which measure requirements for productive areas, include arable land, pastures for animal products, forested areas for producing wood products, marine areas for fishing, built-up areas for housing and infrastructure, and forested areas needed to absorb carbon dioxide emissions from energy consumption, etc. (URL 2). Ecological footprint analysis can determine whether a country is living within the biological capacity of its territory or if it is an 'ecological debtor' that relies on the ecological 'capital' of other parts of the world (URL 2).

The rising demand for wood products, coupled with the growth of the world's population, poses a threat to natural and semi-natural forests worldwide, particularly in the tropics, if it results in forest degradation or loss (Pendrill et al., 2019; IPBES, 2019; IPCC, 2019; Meyfroidt et al., 2014; Geist and Lambin, 2002). According to Watson et al. (2018), natural forests provide a unique combination of globally significant environmental benefits when compared to degraded forests. These benefits include biodiversity, carbon sequestration and storage, water supply, indigenous culture, and human health. Therefore, it is important to extract forest biomass sustainably (Innes & Tikina, 2017; MacDicken et al., 2015) to prevent the depletion of carbon stocks and loss of forest functionality, which can lead to deforestation (FAO, 2017; Sanz et al., 2017). Currently, 80% of energy is supplied by fossil-based production facilities, contributing to climate change, despite a 40% increase in energy consumption compared to previous years(URL 1).

The ecological footprint is calculated based on the production and use of goods and services, which depend on different forms of ecological productivity. To correspond to their land area, their ecological productivity is modified.

Consumption is categorized into five categories: food, transport, housing, consumer goods, and services (Wackernagel & Rees, 1996; Çetin, 2015). The ecological footprint concept estimates the area of land required to sustain human activity at local, regional, and global scales. Ecological footprint analysis compares the area in question to the total productive area in terms of living diversity to determine if it can sustain its vital activities within its borders. If the ecological footprint exceeds the total productive area in terms of biodiversity, it indicates that the area is consuming more forest, cultivated land, and other resources than its economy can sustain, resulting in waste beyond its capacity to handle (Keleş, 2007).

The ecological footprint is evidence of how quickly we are consuming Earth's resources.Preventing and reducing the growth of ecological footprints should be a goal or duty that is achieved through peaceful methods and attitudes for the future of humanity and the environment. This must be done with an awareness of international responsibility for environmental values (Tosunoğlu, 2014).

The ecological footprint is a measure of the amount of water and land required to meet the needs of an individual based on their consumption habits.It also serves as a tool to assess the ecological balance of countries and identify steps towards sustainable development.Predictions can be made by comparing the ecological footprint calculations of human beings with the self-renewal capacity of the world(Kaypak, 2012).

Issues concerning the natural environment have evolved from a minor concern to a significant threat, such as global warming and damage to the atmosphere caused by ozone-depleting gases like chlorofluorocarbons. These issues not only harm humanity but also endanger all living beings and the world's biodiversity (Yılmaz & Öztürk, 2023; Kaypak, 2012).As is widely acknowledged, the Earth's temperature has been rising since the Industrial Revolution. The use of non-renewable energy sources has led to the emission of greenhouse gases, which are responsible for global warming.Human activities are the primary cause of this temperature increase (Kaypak, 2012).Greenhouse gases, such as carbon dioxide (CO2), nitrous oxide, and methane, have altered the chemical composition of the atmosphere, one of the four natural environments. Global warming is expected to cause changes in climate conditions, leading to disasters such as drought and desertification, which will have adverse effects on many living organisms. Therefore, it is crucial to monitor the impact of a product or service on greenhouse gases, also known as its carbon footprint (Kaypak, 2012). Human beings are an integral part of nature and rely on it to meet their biological, social, and cultural needs. Despite the misconception that humans are dominant and separate from nature, they must recognize their impact on the environment. Urban life can sometimes disconnect people from this awareness, making them unaware of their impact on nature while fulfilling their needs.Changes in lifestyle and attitudes towards nature directly impact the growth of the ecological footprint.In the modern world, different countries have varying ecological footprints due to differences in natural resource usage, leading tothe formation of ecological deficits.Maintaining a balance between ecological footprint and biological capacity is crucial for all members of society. This balance serves as an important indicator that should be kept in the foreground during decision-making processes. Ecological footprint calculations concretely express the fact that we do not have another habitable world (Kaypak, 2012). The ecological footprint is an accounting tool that quantifies the use and depletion of resources by living organisms, revealing the impact of human activity on the natural world. Despite their differences, all living creatures inhabit the same ecosystem and have equal rights (Penna, 2010).

Calculation of Ecological Footprint

There is a relationship between ecological footprint and biological capacity. The biological capacity per capita is determined by the number of productive hectares, their productivity, and the number of people sharing this biological capacity (URL 4).

Ecological footprint calculations are important for various reasons. Ecological footprint calculations (Tosunoğlu, 2014) can be used to evaluate the impact of human activity on the environment. This method calculates the amount of biologically productive area consumed globally, as well as the land and water areas required for waste disposal. It also determines the biologically productive area used by countries, cities, families, or individuals.

When calculating ecological footprints, it is important to consider the resources consumed and waste generated, as well as the biologically productive area required for waste disposal. The resulting ecological footprint indicates the biologically productive area used by individuals in the production and consumption cycle. National Footprint Accounts are used for calculating ecological footprints on a national scale. The NFA formula, as expressed by Tosunoğlu (2014), is:

Ecological footprint= Consumption X Production Area X Population

1. Ecological Footprint Components

The ecological footprint can be calculated for individuals, cities, regions, and the world. Biological capacity refers to the demonstrated capacity of a region to produce its natural resources. Two factors affect biological capacity: the agricultural land, fishery, and pasture area within the borders of the country, and the area of the forest and its productivity.Biological capacity and ecological footprint are expressed in 'global hectares' (kha) and calculated in terms of area (URL4).

Carbon Footprint: The text describes the calculation of the forest area needed to sequester CO2 emissions from various sources, including the oceans, fossil fuel consumption, land use changes, and chemical processes.Turkey's total Ecological Footprint is largely influenced by the demand for sequestering CO2 emissions, which accounts for 46-49% (1.24-1.36 kha per capita).Between 1961 and 2007, the Footprint of all land categories has increased, with the highest increase occurring in the Carbon Footprint.

Agriculture Footprint: The Agriculture Footprint is the calculation of the area used for producing food for human consumption, fibre, animal feed, oil crops, and rubber. In Turkey, approximately 35% of the Ecological Footprint is a result of the demand for agricultural land, which amounts to about 0.96 kha per capita. Food-related activities account for 83% of the Agriculture Footprint.

Forest Footprint: The Forest Footprint is the calculation of the forest area needed to meet the demand for logs/timber, pulp, wood products and firewood. In Turkey, the demand for forest products accounts for 11% of the national Footprint (0.29 kha per capita). Between 1961 and 2007, the Forest Footprint experienced the smallest growth.

Grassland Footprint: The calculation determines the area utilized for livestock production, including meat, milk, leather, and wool products. Grazing land use in Turkey comprises only 3% of the national Footprint, which is equivalent to 0.08 kha per person.

Built-up Area Footprint: This includes infrastructure and superstructure related to meeting human needs, such as housing, transport, industrial structures, and power plants.Built-up land use accounts for only 3% of the total Footprint, at 0.07 global hectares per person.

Fisheries Footprint: The calculation of the required marine and freshwater area to obtain consumed fish and seafood is known as the Footprint of Fish and Seafood Consumption.In Turkey, the per capita Footprint of Fish and Seafood Consumption resulting from fishing and seafood usage is 0.06 hectares, slightly over 2% of the country's total Footprint.

The increase in environmental disasters and the depletion of natural resources have led to the quantification of ecological resources by determining their consumption levels. The concept of ecological footprint allows for a comprehensive evaluation by examining resource consumption and production in various dimensions. The Ecological Footprint is evaluated based on six biologically productive areas, providing a significant advantage in managing human consumption. In the assessment of the Ecological Footprint, another important term is the biocapacity that provides a resource for humans. It is of great importance in managing global resources and identifying ecological deficits. The term ecological deficit represents the difference between the ecological footprint, which represents consumption, and the biocapacity, which represents production.To ensure a sustainable future, it is necessary to reduce the ecological deficit, that is, to decrease the ecological footprint or increase the biocapacity.Reducing the Ecological Footprint is of great importance due to the low probability of increasing the amount of biocapacity in a short period of time.To prevent this, resources must be used correctly, production must be carried out sustainably, and humanity must transition to a sustainable lifestyle.

The biocapacity value, which is of great importance in the sustainability of ecological resources, is 1.5 global hectares according to the calculations of the Global Footprint Network in 2016.The difference between Ecological Footprint and biocapacity is (-) 1.9 global hectares, indicating a deficit in ecological resources.To prevent this, resources must be used correctly to reduce Ecological Footprint values.

It is necessary for sustainability to be achieved and for humanity to transition to a sustainable lifestyle (Mızık and Avdan, 2020).

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Chapter 8

Occupational Health And Safety In The Forestry Sector For Türkiye

Keriman YÜRÜTEN ÖZDEMİR[1], Gökhan ŞEN[2]

Abstract

The aim of occupational health and safety is to ensure the systematic and comprehensive management of health and safety in the workplace in order to prevent occupational accidents or occupational diseases and to promote the general well-being of employees in the workplace. The forestry sector, which incorporates different hazard classes, is a sector where more dangerous and hazardous works are carried out. Forests, which constitute approximately 29,8% of Türkiye's surface area, have provided employment opportunities and income for many people from past to present. The forestry sector, where men work more due to heavy workload and physical strength, is a sector where occupational accidents occur due to different factors (working outdoors, use of cutting and piercing tools, exposure to the sun, working in the cold, etc.). For this purpose, forestry activities in Turkey and occupational accidents within the scope of occupational health and safety are mentioned in this section.

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World Health Organization (WHO), Occupational Health and Safety (OHS) is a multidisciplinary activity to: (1) protect and promote the health of workers by taking precautions against occupational accidents and diseases; (2) develop and promote healthy and safe work, work environment, and work organizations; (3) improve the physical, mental, and social well-being of workers; and (4) enable workers to live productive social and economic lives (International, 2013).

The OHS encompass the systematic and comprehensive management of health and safety in the workplace, to prevent work-related injuries and illnesses and promote workers' overall well-being of (Alim et al., 2021). This concept involves the identification of hazards and risks in the workplace and implementing control and preventive measures to ensure the safety and health of workers (Nnaji-Ihedinmah & Ugwu, 2016). OHS management systems play a crucial role in minimizing work accidents and creating optimum business life conditions (Indrayani & Kusumojanto, 2020). Furthermore, organizations committed to occupational safety prioritize integrating safety values into their employee-selection processes to ensure a better fit and a safer work environment (Zacharatos et al., 2005). OHS measures intend to ensure that occupational accidents and diseases do not occur or are reduced to an acceptable level (Inanç & Agyürek, 2019). In business life, the most crucial factor that makes a business successful or unsuccessful is the employees, and the awareness of creating a safe and healthy environment for the psychological and physical conditions of employees and their behaviors related to their work increases the importance of occupational health and safety day by day. An occupational accident is defined by the International Labor Organization (ILO) as an unexpected or unplanned occurrence that causes physical injury, disease, or death (ILO, 2020).

Forests, one of our world most important natural resources, have many ways of working due to their characteristics and have been an important source of livelihood for people since ancient times (Laschi et al., 2016; Çalışkan, 2018). The burning of dry trees helped to keep warm, the fruits of the trees were collected and the branches falling to the ground were used in the construction of shelters. With industrialisation, the area of use of timber obtained from forests has gradually increased (Colfer et al., 2006). Raw materials obtained from forests are widely used in various sectors, including furniture, paper, and wood industries. Therefore, ensuring the sustainability of forests requires comprehensive strategies for forest planning, management, and conservation (Güngör, 2021). Developing mechanisms to facilitate the prudent use of forest resources and effective support structures for interactions between forests and communities is crucial (Şen & Güngör, 2019; Güngör & Şen, 2020).

Forestry, which supplies raw materials and semi-finished products to many industries, is widely recognised as one of the world's most hazardous professions. (Lilley et al., 2002; Bentley et al., 2005; Lindroos & Burström 2010; Rhee et al., 2013; Klun & Medved 2017). Likewise, in forestry, it is aimed to increase productivity in the workplace by ensuring production and operational safety. Since forestry activities are generally open to nature, they are defined as a combination of many biotic and abiotic risks. Forestry activities on sloping lands within forests and adverse weather conditions are among the most important risks. In addition to these risks, non-ergonomic working environment, food and beverage problems, unsuitable equipment and problematic tools and equipment can be mentioned (Güngör and Çakmaklı, 2020).

Forestry work, which includes silviculture and logging, is commonly descripted as dangerous, difficult, and dirty (3D) (Poschen 1993; Laflamme & Cloutier, 1998; Potocnik &Poje, 2017; Gumus et al., 2020). The issues related to the dangerous nature of forestry work can be linked to the environment (rugged terrain, climatic conditions, biological agents, and exposure to noise, vibrations, and exhaust fumes) and to the tools and processed material: the use of sharp and/or power tools, heavy loads, and heavy machinery (Jankovský et al., 2019). Difficulties are common to manual tree felling and processing work, which demand skills to control safety risks and physical conditions to tolerate workload (Lindroos & Burström, 2010; Tsioras et al., 2022). The dirty component of the work can be seen when manual harvesting is compared to work in other industries, particularly in tropical countries, where the heat and rainy season makes working conditions sweaty and muddy (Staal Wästerlund, 2018). Since forestry work is carried out in nature, workers can be exposed to extreme cold, extreme heat, heavy snowfall, heavy rainfall and ultraviolet radiation (UV). In addition, there is always the risk of sinking in mud, the environment being full of giant plants and similar severe conditions (Ozden et al., 2011).

Forestry activities on sloping lands within forests and adverse weather conditions are among the most important risks. These risks can be added to the list. In addition to these risks, non-ergonomic working environment, food and drink problems, unsuitable equipment and problematic tools and equipment can be mentioned. As such, working conditions in the forest become more difficult. Therefore, forestry continues to be one of the most hazardous industrial sectors in most countries. Around the world, there are often discouraging trends of rising accident rates, a high incidence of occupational diseases, and early retirement among forestry workers (Yoshimura & Acar, 2004). However, clear evidence shows that good safety and health performance in forestry is feasible. Many International Labour Organization (ILO, 1919) constituents recognize that safety at work is an ethical imperative, and it makes "dollars and sense". In forestry, it is also a prerequisite for environmentally sound management and utilization of natural resources. Significantly, these governments, enterprises, employers' and workers' organizations are willing to do something about it.

There are two common classification systems in labor assessment and classification; these are set by the ILO and, in France, the Nomenclature des Activités Économiques dans la Communauté Européenne (NACE).

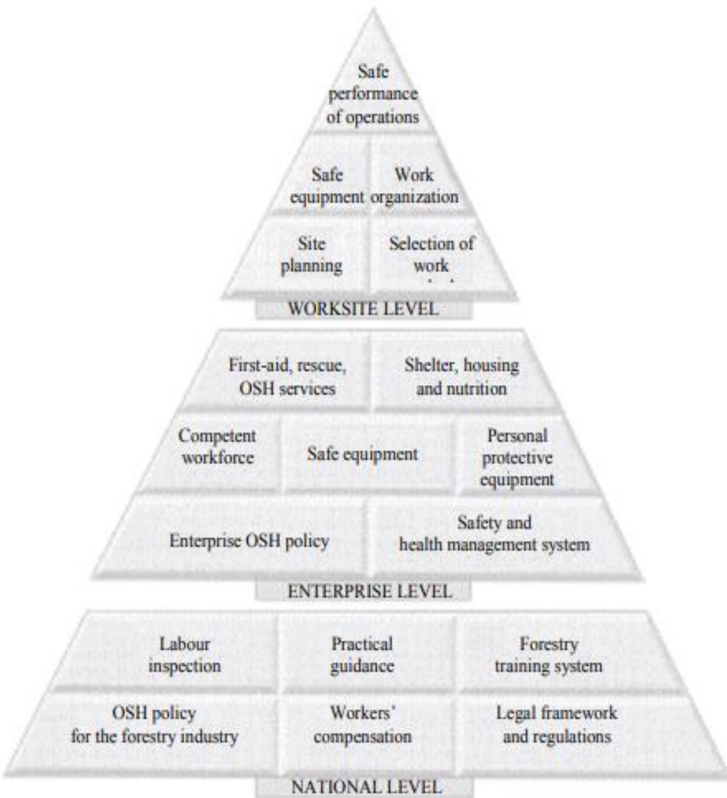

Figure 1. Safety and health measures at national, enterprise and worksite level (Draft Code of practice on safety and health in forestry work, Geneva, ILO, 1997, p. 5)

Türkiye's forested area covers around 23.245 million hectares, comprising approximately 29.8% of the country's total land area and contain many biological diversity and constitute an important employment area (GDF, 2023) (Figure 2). The forest area of Turkiye, 95.71% is managed as forest and 4.29% as coppice, with a total tree wealth of approximately 1.73 billion m^3 and a yield of 47.8

million m^3, which is an indicator of the wood raw material yield power of forests(GDF, 2023). Approximately 80% of the wood raw material needs of the forest industry in Turkiye are met by the General Directorate of Forestry (GDF). The provincial organization of GDF consists of 243 forest enterprises affiliated to 28 Forestry Regional Directorates. There are 1406 forest management chief offices and 467 forest warehouses affiliated to these enterprises (GDF, 2022). A significant portion of the total 31.8 million m3 of wood raw material produced by GDF, including 27.7 million m^3 of industrial and 4.1 million m^3 of firewood, is distributed from forest warehouses to different organizations of the forest industry (GDF, 2021).

Figure 2. Forest resources map of Turkey
(The General Directorate of Forestry, 2023)

Table 1. Status of forest areas in Turkiye by years (GDO, 2023)

Years	Forest form	Forest		Gapped Closed Forest		Total	
		Hectare	Percent	Hectare	Percent	Hectare	Percent
2015	Grove	11.919.061	53.35	7.700.657	34.47	19.619.718	87.87
	Coppice	785.087	3.51	1.938.130	8.67	2.723.217	12.19
	Total	**12.704.148**	**56.86**	**9.638.787**	**43.14**	**22.342.935**	**100**
2020	Grove	12.914.800	56.31	8.741.566	38.12	21.656.366	94.43
	Coppice	349.629	1.53	927.005	4.04	1.276.634	5.57
	Total	**13.264.429**	**57.84**	**9.668.571**	**42.16**	**22.933.000**	**100**
2022	Grove	13.357.019	57.46	8.891.661	38.25	22.248.680	95.71
	Coppice	350.824	1.51	645.496	2.78	996.320	4.29
	Total	**13.707.843**	**58.97**	**9.537.157**	**41.03**	**23.245.000**	**100**

The forest is like a very large factory not only with the biodiversity it contains but also with its employees. Not only wood is obtained from forests, but also resin, aromatic plants, fruits, teas, etc. substances are obtained and used in many areas such as wood industry, paper industry, pharmaceutical and food industry. Since forestry activities are generally open to nature, they are defined as a combination of many biotic and abiotic risks.

Working area, field conditions, tools, equipment, labor in the activities carried out in Türkiye forestry and machinery factor, climatic differences, nature of chemicals used, production technology and methodology, and many differences stand out. The inaccessibility of our country's forests, which are far from settlements and are located in steep and mountainous areas, and the inadequate transportation facilities, as well as the low number of working days in cutting and transportation works, make it necessary to store the products obtained during the harvest period for production throughout the year (Engur, 2022). Forestry activities are classified according to different dangerous classes because they involve many different business lines.

Although forestry workers were excluded from the scope of the Labor Law for many years, the current Occupational Health and Safety Law No. 6331 includes forestry activities within the scope of the law. In order to understand more clearly the scope of the boundaries drawn by this law, which has a significant impact on the provision of OHS services in forestry, the relevant articles have been put forward. In this context; Article 6 of Law No. 6331 on occupational health and safety services and Article 7 on occupational health and safety provide information on how their services will be supported.

Forests also create various business areas in terms of working people and host different business lines. In terms of hazard classification, it is a work area where there are employees from all areas from the very dangerous class to the less dangerous class (ÇSGB, 2012). Activities and hazard classes for forestry are given in Table 2.

Table 2. The dangerous occupational classifications for some forestry work list (ÇSGB, 2012b).

Labour	Dangerous occupational classifications
Protecting the forest against pests (insects and diseases) activities	**More Dangerous**
Industrial and fuel wood production, cultivation of coppiced forests	**Dangerous**
Supporting activities in the forest such as felling trees, clearing branches, peeling, etc.	**Dangerous**
Cut and cleared trees in the forest transportation, stacking and loading activities	**Dangerous**
Silvicultural service activities in the forest (thinning, pruning, replanting, etc.)	**Dangerous**
Forest against fire and illegal felling (unauthorized cutting) conservation activities	**Dangerous**
Forest protection and maintenance purposes forest road construction and maintenance activities	**Dangerous**
Production of seedlings and seeds to grow forests	**Less dangerous**
The cultivation of forest trees	**Less dangerous**
Collection of non-wood products other than trees	**Less dangerous**
Other forestry activities (forestry inventories, forest management, forest management consultancy services, etc.)	**Less dangerous**

Forest sector workers have many problems such as deficiencies in legal regulations, social security, wages, working conditions, seasonal work, etc. Forestry work shows a different structure from other branches of work due to reasons such as the difficulty of the work, high accident rate, working outdoors, the need for accommodation in the field, the variability of working hours and working time, lack of work continuity, social and economic inadequacies (Acar & Şentürk, 1999). Work accidents or occupational diseases are the biggest problems. Forestry sector jobs are a field that affects workers in different ways, from the use of various motorized tools, to the use of hand tools, to jobs that require muscle power (Enez, 2008).

In forestry activities, occupational accidents are predominant. However, the more important and unrecognised health problem is the occupational diseases that arise due to the effect of hot or cold weather conditions that create excessive and effective physical stress, noise, vibration and uncontrollable environmental factors. Hearing impairment is caused by constant pressure and noise (Poschen, 1993).

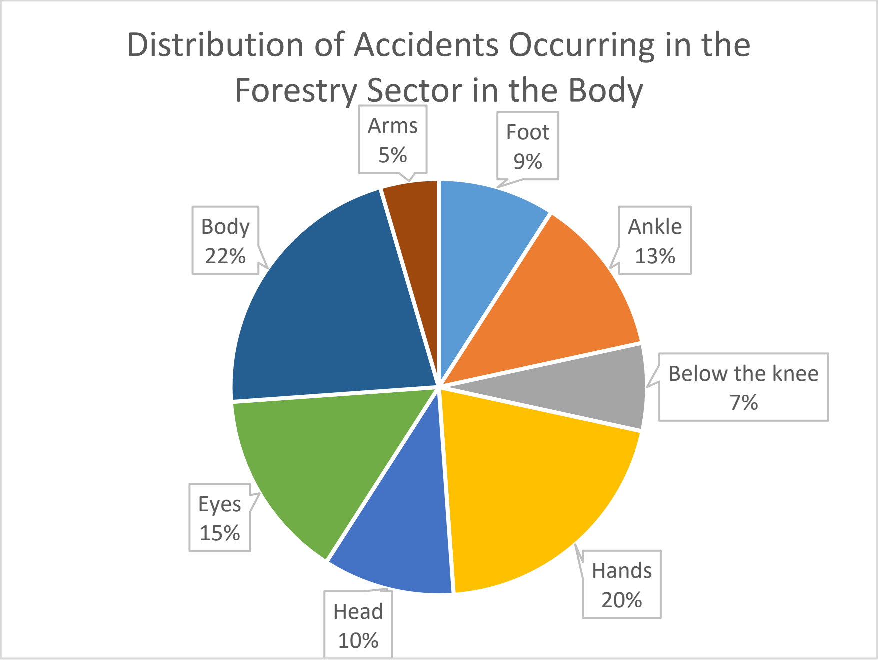

Figure 3. Distribution of accidents occurring in the Forestry Sector in the body for Turkiye (ÇSGB, 2022).

When it comes to production works in forestry, it is understood that the tree is cut and felled, the branches are cut, the bark is peeled when necessary, the division and classification works, the products obtained are removed from the compartment, loading, transport, stacking and delivery to the final warehouse. Many occupational accidents may occur during all these work phases. For this purpose, Table 3 presents the figures of occupational accidents occurring in forestry, logging and industrial wood production in Turkey between 2013 and 2022.

Table 3. Distributaion of the Number of Insured Having Forestry and Logging Work Accident by Classification of Economic Activity and Gender (Under Aticle 4-1/a of Act 5510)

Years	Number of insured having work accident by incapacity days						
	Male						
	Accident day (at work)	**Accident day (incapacity)**	**2**	**3**	**4**	**5+**	**Total**
2013	89	1	5	9	0	75	**179**
2014	114	2	4	7	2	61	190
2015	152	6	8	17	3	134	320
2016	168	3	16	8	5	106	306
2017	480	15	17	35	9	244	389
2018	349	1	5	1	0	61	417
2019	287	9	14	24	6	120	460
2020	299	4	13	19	5	145	485
2021	415	11	20	35	7	184	672
2022	480	15	17	35	9	244	800
Female							
2013	7	0	0	0	0	6	**13**
2014	10	0	0	0	1	1	12
2015	66	1	2	5	0	40	114
2016	21	1	1	4	0	12	39
2017	45	0	0	2	0	11	58
2018	62	1	0	0	0	6	69
2019	30	0	2	6	0	10	48
2020	13	0	2	0	0	7	22
2021	20	0	2	1	1	7	31
2022	36	1	0	6	2	15	60

To work effectively and safely in the forest, it is important to know how to avoid unnecessary strain. The aim is to protect the health and safety of the worker and to increase productivity and efficiency. Occupational safety, which aims to protect from workplace hazards and factors that may harm health and to create a good working environment, is of particular importance in the forest sector.

Since forestry production jobs are in the group of difficult and hazardous work requiring physical strength, it is seen that more male workers are generally employed. It is a known fact that occupational accidents and occupational diseases are caused by inadequate health services and social security, use of inappropriate equipment or lack of personal protective equipment, inadequate training and work organisation, and poor working conditions, which constitute a vicious circle in forestry activities. In order to eliminate these negativities, it is very important to increase the training of workers in the forestry sector, to utilise machines instead of the use of physical power and especially to keep OHS measures at maximum level.

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Chapter 9

Sustainable Inland Aquaculture And The Current Situation In Türkiye

Rahmi Can ÖZDEMİR[1]

Abstract

This book chapter emphasizes the critical importance of water as a vital resource for sustainable development. It attempts to interpret the impact of population growth, industrialization, climate change, and technological advances on fish production in inland water resources. Drought, a global problem, is analyzed regarding its effects on water resources, especially in semiarid regions such as Turkey. The hydrological cycle is explained, emphasizing the continuous circulation of water on Earth and the vital role of forests in regulating this cycle.

Turkey's inland aquaculture sector is examined with a detailed analysis of production trends and the transition from river-based facilities to cage farming in reservoirs. The importance of sustainable aquaculture practices and their impacts on water resources are commented on.

In conclusion, a holistic and interdisciplinary approach is needed to integrate aquatic and forest ecosystems. Sustainable management practices focusing on ecosystem health, water conservation, and aquaculture practices are considered necessary to preserve water resources and fish stocks. Restoration or protection of degraded forest ecosystems is vital to mitigate the impacts of climate change on water resources and to promote the health and productivity of aquatic ecosystems and fisheries.

Keywords: Climate change, inland water, the relation between forests and hydrological cycle, natural disaster, inland aquaculture, Türkiye

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Water is one of the most critical vital resources for sustainable development. The negative impact of the increasing population on the environment and natural resources, together with industrialization and technological developments, affects water resources, which are limited, and increases the water demand. In the 20th century, although the world population increased three times compared to the 19th century, the use of water resources increased six times. Water is essential for all living beings for several reasons. Water is crucial for the survival of living organisms. It is necessary for hydration, maintaining body temperature, carrying out essential biological processes, and serving as a medium for transporting nutrients and oxygen throughout the body of living organisms, including plants and animals. Water provides a habitat for numerous species, including aquatic plants, fish, and other microorganisms. It also supports diverse ecosystems and biodiversity. One of the crucial roles of water is environmental balance, regulating the Earth's climate, helping the water cycle, and maintaining the balance of ecosystems.

The interaction of environment, forest, and fisheries can be explained as a chain effect in the following way;

Environment: The environment provides the necessary conditions for the growth and sustenance of forests and fisheries. It includes factors such as climate, soil, and water quality, which directly impact the health and productivity of these ecosystems.

Forest: Forests are crucial in maintaining a healthy environment and supporting fisheries. They act as a carbon sink, regulate the water cycle, and provide habitat for diverse species. Forests also help to prevent soil erosion and maintain water quality, which is essential for the survival of fish and other aquatic organisms.

Fisheries: Fisheries depend on healthy forests and a clean environment for survival. The quality of water and the availability of food sources are directly linked to the health of forests, impacting the productivity and sustainability of fisheries. Overfishing and habitat destruction can also have a negative impact on forest ecosystems, creating a feedback loop that further affects the environment.

Overall, the interaction of the environment, forests, and fisheries forms a complex chain effect, where the health of one component directly influences the health and productivity of the others. Protecting and conserving these ecosystems is essential for maintaining a balanced and sustainable environment.

Hydrological cycle and Effects of natural disaster on inland water resources

Natural disasters have always occurred and will continue to occur throughout human history. Humanity has continuously struggled with disasters to the extent of the possibilities and knowledge of the age in which it exists. The rapid increase in world population, the concentration of people in disaster-prone areas, excessive consumption of natural resources, industrialization, unplanned urbanization, and inadequate infrastructure can lead to natural disasters and increase potential risks (Şahin & Sipahioğlu, 2002). Turkey is a risk group for the potential impacts of global climate change countries. In Turkey, natural disasters, including forest fires, storms, floods, hail, heat waves, landslides, and avalanches, are expected to increase due to climate change. The irregular, sudden, and heavy rainfall and floods we experience with the changing climate increase landslides, erosion, and desertification. Drought, famine, forest fires, heat waves, locust infestations, pests such as ticks, mosquitoes, etc., and related long-distance migrations are also increasing. Increasing windstorms cause heavy rain, hail, tornadoes, lightning, flash floods, and urban floods; disasters like the one we're facing are becoming more frequent, more severe, longer lasting, and effective everywhere (Kadıoğlu, 2012).

Drought is a normal part of the climate and occurs in any climatic regime in the World, even in deserts and rainforests. Drought can occur anytime in many areas, affecting the economic sector and people. The costliest natural hazard with widespread impacts is one of the disasters [8]. Droughts are recurrent events that affect large areas around the World every year. The duration of drought events is highly variable, ranging from a few weeks to several years. Drought events are challenging to identify and manage due to their slow onset (in most cases) and uncertain end [9]. Between 2000 and 2019, approximately 1.4 billion people were affected by drought disasters worldwide. Regarding the number of people affected by natural disasters, drought ranks second after floods (41%) with 35% [4].

The majority of Turkey is semiarid and under the influence of climatic conditions. The amount of arid and semiarid areas in Turkey is 51 million hectares. In other words, 37.3% of Turkey is under semiarid climate conditions. Therefore, water resources and dry agriculture, which are generally dependent on rainfall in the amount and distribution of precipitation due to changes that may occur, are severe and can make their impact felt somehow (Figure 2).

Figure 2. Droughts effects on water resources (Anadolu Agency (AA))

Water is in constant circulation in our World depending on its physical properties. Humidity in the atmosphere comes from the evaporation of the water circulating on the Earth's surface. Water vapor, formed by the sweat of plants, moist soils, rivers, lakes, seas, and oceans, rises upward with air current and condenses in the atmosphere. Most of the evaporated water, about 85%, originates from the oceans. A small part of the remaining part comes from inland waters, and a large amount of it consists of the water that plants draw from the soil through their roots and give to the air through their leaves. Thus, plants act as a pump for mixing groundwater into the atmosphere. Some of the water returning to the ground as rain, hail, and snow from the atmosphere is retained by the plants when it reaches the soil. Some forms of surface water, such as rivers, lakes, seas, and ground waters, seep through different soil layers. These groundwaters feed the surface rivers and lakes, and water circulation starts again with the evaporation of surface water (Figure 1).

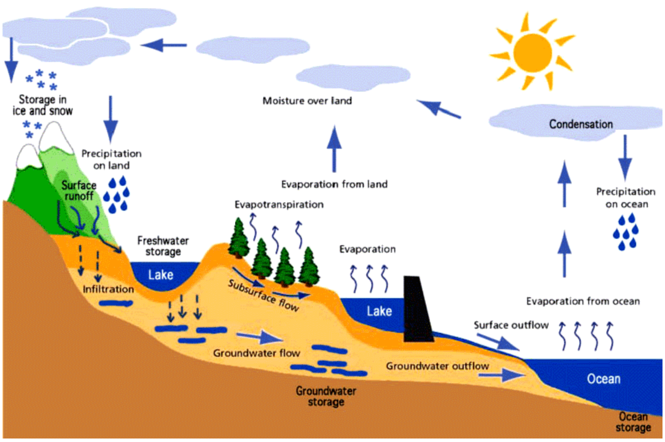

Figure 1. Hydrological cycle (WordPress, 2013)

Integrating water and forest ecosystems is critical to sustainable natural resource management. Understanding the complex interactions between forests and water sources is essential for ecosystem health, water conservation, and human well-being. Research has highlighted the multifaceted nature of these interactions, emphasizing the need for comprehensive approaches to ecosystem management.

As a result, the contribution of forest ecosystems to the global water cycle has recently been one of the most emphasized issues. Forest ecosystems, hydrological functions, and protective properties prevent sedimentation and filling of sub-basins and dams, thus protecting agricultural areas and settlements providing irrigation and potable water. The provision of clean water is guaranteed. In this context, the importance of our country's forest to resources, especially to water, "Forestry and Water Affairs" emerges from the ministry.

Studies have shown that forest cover plays a significant role in influencing water yield and quality, with the relationship between forests and water is a subject of ongoing debate and research (Ellison et al., 2011; Wang et al., 2011; Aydın et. Al., 2018). The joint production of timber and water has become increasingly important in sustainable forest management, underscoring the need to integrate water production values into forest management models (Keleş & Başkent, 2011; Başkent & Keleş, 2008). Furthermore, the characterization and monetization of ecosystem watershed services have highlighted the vital role of biodiversity, including forest ecosystems, in water supply and other benefits (Bubicha & Mwaura, 2021).

The effects of forestry best management practices on water quality and quantity have been extensively studied, emphasizing the importance of refining these practices to enhance their performance and ensure long-term benefits to the freshwater environment (Cristan et al., 2016; Broadmeadow & Nisbet, 2004, Güneş Şen, 2021). Additionally, the reconciliation of research on forest carbon sequestration and water conservation has been proposed as an integrated framework for future research in forest management (Farooqi et al., 2020).

Ecohydrological research has emphasized understanding the functional interactions among vegetation, soils, and hydrologic processes at multiple scales, highlighting the linkages between upland, riparian, and aquatic components (Vose et al., 2011). Furthermore, the evaluation of the water conservation capacity of forest ecosystems has underscored the importance of forests in conserving soil water, groundwater recharge, and regulating runoff (Gong et al., 2017).

The relationship between inland water temperature and climate change has been the subject of extensive research, revealing various significant connections. Studies have shown that inland water bodies have experienced rapid surface warming since 1985 (Woolway et al., 2017), indicating a strong influence of climate change on their temperature trends Schneider & Hook (2010). Additionally, the impact of climate change on inland water carbon dynamics has been highlighted, with emissions from dry inland waters representing a significant and likely increasing component of the inland waters carbon cycle (Keller et al., 2020). Furthermore, the velocity of climate change in inland standing waters is comparable to that calculated for surface air temperatures over land, despite the median rate of warming in the latter being twice as fast (Woolway & Maberly, 2020).

Moreover, the influence of weather forecast resolution on the circulation of inland water bodies has been studied, with global warming causing the surface temperature of inland water bodies to rise across the planet (Auger et al., 2021). The impact of climate change on the water resources of inland valleys has been simulated, emphasizing the importance of integrating human behavior in climate change analysis, particularly in shallow, hydrologically distinct water bodies that may be particularly susceptible to warming (Gabiri et al., 2020; Fiorella et al., 2021). Additionally, the variation characteristics and influencing factors of the base flow of inland rivers have been studied, indicating that the climate is becoming warmer and more humid in the inland areas of certain regions (Lei et al., 2021).

Furthermore, cryospheric melting has been found to enhance methane emissions from inland waters, leading to changes in inland water status, such as increasing river runoff, expanding lake areas, and emerging glacier lakes (Gao et al., 2023). The effects of climate change on inland alpine lakes have also been investigated, highlighting the importance of inland lakes as water resources in arid and semiarid regions (Chai et al., 2013). Additionally, the response of water temperatures of large natural systems to the atmospheric warming trend has been studied, emphasizing the nonlinearities, geographic variability, and feedback mechanisms that may lead to unexpected responses (Austin & Colman, 2008).

In summary, the relationship between inland water temperature and climate change is multifaceted, impacting various aspects of inland water dynamics, carbon cycles, methane emissions, and water resources, highlighting the need for comprehensive understanding and management of these vital ecosystems in a changing climate.

Inland aquaculture

The rapidly increasing world population and access to consumable water, which is the primary vital need of human beings, has become quite tricky. The importance of water resources is increasing day by day. With the increasing importance of water resources, sustainable management of food and income resources obtained from water comes to the fore (Özden, O. & Tolunay, A., 2020). The inland fish aquaculture sector, which needs clean water resources and these clean water resources for production with increasing protein needs, has changed its production systems due to climate change, developing industry, and natural or artificial destruction of agricultural production areas. When the amount of inland fish production worldwide is analyzed, it is seen that the European continent has about 10 percent of the total production amount (Table 1).

Table 1. Worldwide production of inland aquaculture (FAO, 2022)

	Africa	Americas	Asia	Europe	Oceania	World	Total (%)
(*tonnes, live weight*)							
Finfish	1 857 209	1 179 727	45 526 599	551 802	5 124	49 120 461	90.2
Crustaceans	2	72 541	4 401 336	3 145	177	4 477 201	8.2
Molluscs			192 671			192 671	0.4
Other aquatic animals		370	593 161	176		593 707	1.1
(*Aquatic animals subtotal)*	*1 857 211*	*1 252 638*	*50 713 767*	***555 123***	*5 301*	*54 384 040*	*(99.9)*
Algae	150	1 321	62 670	349		64 490	0.1
Inland Aquaculture	1 857 361	1 253 959	50 776 437	**555 472**	5 301	54 448 530	100

Indeed, the sustainability of aquaculture practices is a critical aspect of responsible resource management. Implementing sustainability standards is essential to reduce the environmental impact of aquaculture facilities and protect water resources. Preventing water pollution, reducing water consumption, and protecting natural habitats are critical for aquaculture facilities' sustainability.

Between 2010 and 2020, while inland aquaculture production in our country increased from 79 to 128, the production facilities built on river lines were replaced by cage farming on dam lakes or lakes used for agricultural irrigation (Table 2). This has necessitated the use of production systems with high stock densities, which are needed in direct proportion to the increasing demand for nutrients. Therefore, there is a significant increase in the number of cages produced. The decrease in fish production facilities on rivers, abnormal meteorological weather events caused by 1-2 degree increases in land, air, and seawater temperatures related to climate change, and destruction of forests and river basins seriously reduce the efficiency of inland water fish production facilities.

Table 2. Inland fish production by country (FAO, 2022)

	2010			**2015**			**2020**		
	Total production	Cage production.	Contri. (%)	Total prod.	Cage prod.	Contri. (%)	Total prod.	Cage prod.	Contri. (%)
Cage culture									
China	19 913	1 131	5.7	24 642	1 379	5.6	25 864	321	1.2
Indonesia	1 332	121	9.1	2 955	191	6.5	3 390	650	19.2
Bangladesh	1 147			1 831	2	0.1	2 294	5	0.2
Egypt	920	160	17.4	1 175	173	14.7	1 592	201	12.6
Thailand	404	40	9.9	391	33	8.4	369	32	8.7
Philippines	308	103	33.3	303	95	31.2	285	74	26.0
Russian Federation	115	25	21.6	138	30	21.6	189	59	31.2
Colombia	68	23	33.5	93	19	20.8	173	30	17.5
Türkiye	**79**			101	**70**	69.0	128	**100**	78

Rainbow trout is Turkey's most produced fish species in inland water aquaculture. Although there has been a significant increase in production in recent years, it is around 146 thousand tons. Alternative fish species are produced today, although not as many as rainbow trout. These include trout, carp, tilapia, European catfish, and sturgeon, which are produced for caviar production and to increase the amount of fishing (Table 3).

Table 3. Total aquaculture product of inland water in Türkiye (TUİK, 2023)

	2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Aquaculture products	(*Tonnes*)							
Inland water total	**101 455**	**101 601**	**104 010**	**105 167**	**116 426**	**128 236**	**136 042**	**146 063**
Rainbow trout	100 411	99 712	101 761	103 192	113 678	126 101	134 174	144 347
Trout (Salmo sp.)*	755,0	1 585	1 944	1 695	2 375	1 804	1 558	1 302
Carp	206,0	196	233	212	203	173	171	293
Sturgeon*	28,0	6.0	13	2		14		1
Tilapia*	12,0	58.0	8	12	6	13	6	
European catfish**	-	-	8	5	121	92	84	95

In conclusion, integrating water and forest ecosystems requires a holistic and interdisciplinary approach considering ecological, economic, and social dimensions. The research literature provides valuable insights into the complex relationships between forests and water sources, emphasizing the need for sustainable management practices that prioritize ecosystem health and water conservation. The aquaculture industry has the potential to be a gateway for the introduction of exotic species into new environments, which can have detrimental effects on water resources and native species.

Water quality is the most critical factor affecting the success of aquaculture operations, and maintaining good water quality is essential for sustainable aquaculture practices. Ecological aquaculture emphasizes minimizing environmental impacts and protecting water resources through sustainable aquaculture practices. The growth in aquaculture production has implications for the sustainability of ocean fisheries, stressing the need for responsible and sustainable aquaculture practices to protect water resources and fish stocks. The sustainable use of fish meal and fish oil in aquafeeds is essential for reducing the environmental impact of aquaculture and protecting marine resources, including water quality and fish stocks.

Restored forests can also help mitigate the impacts of climate change on water resources, contributing to the resilience of aquatic habitats and the fisheries they support (Danovaro et al., 2021).

Overall, restoring degraded forest ecosystems is crucial for protecting water resources and creating suitable habitats for fisheries. Restored forests support aquatic ecosystems' and fisheries' health and productivity by enhancing water quality, regulating water flow, and providing essential habitat components.

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Chapter 10

Effects of Natural Enemies on Coniferous Forest Insects from the Perspective of Forest Sustainability: Cases from Türkiye

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Abstract

Forests, including conifers, play a critical role in terrestrial ecosystems. They provide ecological, economic, and social functions. Coniferous trees are found primarily in the Northern Hemisphere. They are widely used in afforestation efforts. However, these forests are threatened by various biotic and abiotic factors that often interact to harm the trees. Insects are one of the most critical biotic factors that threaten coniferous forests and are expected to become even more important with climate change. Various methods exist to control insects, and biological control is one of the most effective. Due to global climate change, insect damage is expected to increase in intensity and spatial distribution. In Türkiye, biological control activities have been carried out to control insects damaging conifer forests. Within the framework of this study, information about coniferous forests, insects, and biological control activities against insects in coniferous forests of Türkiye is given.

Key words: Coniferous Forest, Insects, Biological Control, Predators, Parasitoids, Türkiye.

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Forests are one of the terrestrial biomes, covering 31% of the world's land surface(URL-1). They have multiple functions, such as producing wood, conserving soil, supporting wildlife, and cycling carbon. Forests contribute economically to society with their unique characteristics. Forests are ecosystems that serve various functions, including timber production, soil conservation, wildlife habitat, and carbon cycling. They contribute economically to society due to their unique characteristics. Forest ecosystems, which are unparalleled in their contribution to the balance of nature and benefits to all living beings, including humans, are seriously threatened by both biotic and abiotic factors due to the accelerating effects of climate change.

Coniferous forests are one of the most essential forest vegetation types and are predominantly distributed in the Northern Hemisphere, including Türkiye. Boreal, temperate, and tropical coniferous forests are the three distinct categories that are prevalent in the Northern Hemisphere. These forests are significantly threatened by insect damage (URL-2). Insect pests are a major biotic threat to forests both presently and in the future. These insects not only damage forests but also disrupt, contract, and harm wildlife habitats, causing harm to biodiversity as well (URL-3).

Approximately 35 million hectares of forest are damaged by insect pests yearly, primarily in the temperate and boreal zones (Ridder, 2007). The impact of these insects on coniferous forests is predicted to continue increasing due to their expected northward expansion and an anticipated increase in generation numbers associated with global warming, according to future climate scenarios.

Biological control is one of the most effective methods to control insect damage, which is expected to increase in spatial extent and intensity due to global climate change. Beneficial organisms, such as predators, parasitoids, and pathogens, control harmful species, reducing dependence on synthetic pesticides and minimizing their potential adverse effects on the environment, non-target organisms, and human health. Biological control is a crucial component of Integrated Pest Management (IPM). It involves releasing natural enemies into forested areas or increasing their populations to suppress long-term pest damage. This approach also supports biological diversity and ecosystem resilience (URL-4).

Forest sustainability is the practice of managing forests to meet present needs without compromising the ability of future generations to meet their own needs. It involves balancing society's demands on forests with the need to preserve forest health and diversity (URL-5). To ensure forest sustainability, addressing threats such as insect damage promptly and with appropriate methods is crucial. Biological control is currently the most precise method of control available. In

Türkiye, biological control practices are employed to manage pests and promote the sustainable management of coniferous forests.

The use of Natural Enemies Against Conifer Forest Pests in Türkiye

The use of natural enemies to control forest pests is becoming increasingly popular because of their environmental benefits. Any organism that feeds on another species or group of species during at least one developmental stage is considered a 'natural enemy'. This category includes predators, parasitoids, and pathogens that attack forest insects (Grégoire & Gould, 2023). Natural enemies play a crucial role in the functioning of forests. Potential pest species are regulated by herbivore consumption, making them effective top-down regulators (Staab & Schuldt, 2020).

The following provides information on some essential biological control agents in Turkish coniferous forests.

- **Biological Control Agents Against Bark Beetles**

The predators reared for the biological control of bark beetles (Curculionidae: Scolytinae) are *Thanasimus formicarius* (L.) (Col., Cleridae), *Rhizophagus grandis* (Gyll.), *R. depressus* (Fabr.), and *R. dispar* (Paykull) (Col., Monotomidae) in Türkiye.

***Thanasimus formicarius* (L.) (Coleoptera: Cleridae)**

Thanasimus formicarius (L.) (Col., Cleridae) (Figure 1) is one of the most common and well-known predator insects of bark beetles (Ünal, 2010; Ünal and Yaman, 2018). Adults of *T. formicarius* are between 7 and 12 mm long and react to the pheromones released by the bark beetles and the volatile compounds released by host plants (Kaygın, 2003; Anonymous, 2016; Koçoğlu and Özcan, 2018; Ünal and Yaman, 2018). A recent study reports that a new species, *T. femoralis* (Zetterstedt), has been reported in Türkiye. This species is also an effective predator of *Ips sexdentatus* (Börner) and *I. typographus* (L.) (Col., Curculionidae) (Öztürk and Yüksel, 2023).

Figure 1. *Thanasimus formicarius* (Col., Cleridae) adult (Anonymous, 2016)

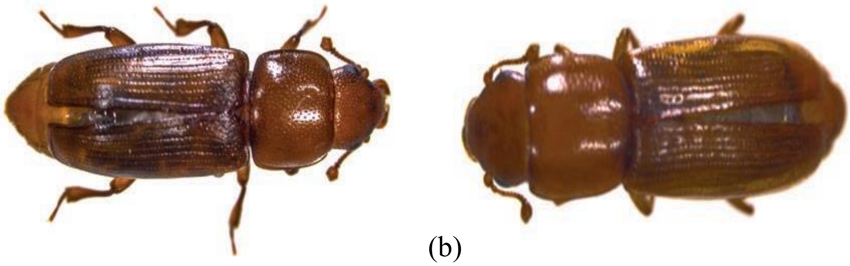
When *T.formicarius* adults reach bark beetle-infested trees, they feed on the adult bark beetles and then lay eggs on the bark of trees. Once the eggs have hatched, the larvae penetrate the bark beetle galleries and feed primarily on the bark beetle's eggs, larvae, and pupae as their primary food source. Mature larvae pupate in suitable places in the outer parts of bark (Ünal and Yaman, 2018).

T. formicarius is bred in controlled laboratory conditions and later deployed into forests to assist in the natural regulation, primarily targeting populations of *Ips* spp. and *Tomicus* spp., *Orthotomicus* spp., *Dendroctonus micans* (Kug.), *Cryphalus* spp., *Pityokteines* spp., *Pityophthorus pityographus* (Ratz.), *Pityogenes bidentatus* (Herbst) (Yüksel and Akbulut, 2005; Sarıkaya and Avcı, 2009; Ünal, 2010; Ünal and Yaman, 2018; Meteris and Yıldız, 2019; Tefek et al., 2022). In the laboratory environment, *T. formicarius* specimens obtained from pheromone traps are introduced to bark beetle adults within bark dust to facilitate mating (Koçoğlu and Özcan, 2018; Ünal and Yaman, 2018; Alkan Akıncı, 2022). *T.formicarius* adults prey on the bark beetle larvae and adults. However, *T.formicarius* consumes bark beetle larvae four times more than adults (Koçoğlu and Özcan, 2018; Özcan and Koçoğlu, 2021).

The newly hatched larvae of *T. formicarius* are individually transferred into freshly prepared glass tubes (one larva per tube), alongside a beetle larva as their prey. For a period lasting 56-65 days, the larvae of *T. formicarius* are given a daily diet consisting of a bark beetle larva. When *T. formicarius* larvae reach their final larval stage, they can be transported to forest areas using specialized refrigerated insect transportation containers and then set free onto the trunks of trees (Ünal and Yaman, 2018). The ecological balance between *I.typographus* and *T.formicarius* has been established in Turkish forests since 2006 (Aksu et al., 2014).

***Rhizophagus* spp. (Coleoptera: Monotomidae)**

Rhizophagus grandis (Gyll.), *R. depressus* (Fabr.), and *R. dispar* (Paykull) (Col., Monotomidae) (Figure 2) are polyphagous predatory insects (Ünal and Yaman, 2018). They prey on various insects, including *Dendroctonus micans* (Kug.), *Tomicus minor* (Hartig), *T.piniperda* (L.), *Ips typographus* L., *I.sexdentatus* (Börner), *I.acuminatus* (Gyll.), *Cryphalus piceae* (Ratz.), *Orthotomicus erosus* (Woll.), *Pityokteines curvidens* (Germ.), *P. Vorontzovi* (Jacobson), *Pityogenes bidentatus* (Herbst), *Pityophthorus pityographus* (Ratz.) (Yüksel and Akbulut, 2005; Sarıkaya and Avcı, 2009; Ünal, 2010).



(a) (b)

Figure 2. *Rhizophagus grandis* (Gyll.) adult (a) and *R.depressus* (Fabr.) adult (b) (Col., Monotomidae) (Anonymous 2016)

In 1985, mass breeding of *R. grandis* began in the biological control laboratories of the Regional Forest Directorates in Artvin, Giresun, and Trabzon to control *D. micans* in *Picea orientalis* (L.) Link forests. Over 150,000 hectares of forest area were treated with 8 million *R. grandis* adults released until 2003. Since 1989, 14150 *R. dispar* have been reared and released; since 2007, 34430 *R. depressus* have been released into damaged forests. Currently, an ecological balance between *D. micans* and *R. grandis* has been established in the Oriental spruce forests of Artvin and Giresun provinces (Aksu et al., 2014a,b; Alkan Akıncı, 2017; Göktürk, 2019).

Rhizophagus spp. inhabit bark beetle galleries, where they consume eggs, larvae, pupae, and adult bark beetles as their primary food source. They have a one-year generation and breed when the air temperature reaches 18°C, typically between the first weeks of April and September, depending on the temperature. Adults and larvae overwinter in the main and larval galleries of *Ips* spp. This species plays a beneficial role by preying on the eggs, larvae, and pupae of bark beetles (Ünal and Yaman, 2018).

Various mass-production methods of *Rhizophagus* spp. in laboratory conditions exist. However, in Türkiye, the trunk method is commonly used. A positive and cost-effective second trial in Türkiye was conducted using the box method. Breeding this predatory insect continues with the box method (Aksu et al., 2014b; Ünal and Yaman, 2018). However, Zengin et al. (2023) reported a new breeding method called the Giresun method. The breed and release methods for Rhizophagus spp. are similar to those for Thanasimus species (Ünal and Yaman, 2018).

- **Biological Control Agents Against the Pine Processionary Moths**

In Türkiye, biological control measures against Pine Processionary Moths (PPM) (*Thaumetopoea pityocampa* and *T. wilkinsoni*) involve rearing the predator insect *Calosoma sycophantha*, and using the larval and pupal parasitoid

Phryxe caudata. Additionally, experimental studies were conducted on *Ooencyrtus pityocampae*.

***Calosoma sycophantha* (L.) (Coleoptera: Carabidae)**

Calosoma sycophanta L. (Col., Carabidae) is a significant predator of Lepidoptera species, especially *T. pityocampa*, *T. wilkinsoni*, *T. processionea* (L.), *T. solitaria* Frey (Lep., Notodontidae), *Lymantria dispar* L., *Euproctis chrysorrhoeea* L. and *Calliteara pudibunda* (L.) (Lep.,) (see Figure 3). *C. sycopantha* has been identified as a predator of various caterpillars (e.g., [*Lymantria dispar* (Lep., Erebidae), *Dendrolimus pini* (L.) (Lep., Lasiocampidae), *Tortrix viridana* L. (Lep., Tortricidae), *Hyphantria cunea* (Drury) (Lep., Arctiidae)] and has been known for a long time (Kanat and Mol, 2008; Ünal and Yaman, 2018; Erkaya, 2020). *C. sycopantha* was first released in New England, USA in 1906 to control *L. dispar* outbreaks (Mott and McCullough, 2001; Usta and Usta, 2021). In Türkiye, *C. sycophanta* has been cultivated and released for biological control of PPM in most of the 55 biological control laboratories under the Regional Directorates of Forestry in Türkiye (Serttaş and Çetin, 2014; Büyükgüzel et al., 2017; Ünal and Yaman, 2018; Laz, 2020).

Figure 3. *Calosoma sycophantha* (Coleoptera:Carabidae) adult and *Thaumetopoea* spp. larvae. (Anonymous 2016)

C. sycophantha adults follow the larvae of pine processionary moths until they pupate. Females then lay eggs. Additionally, *C. sycophantha* feeds on the PPM's larvae and newly formed pupae (Kanat and Mol, 2008; Onaran and Katı, 2010; Erkaya, 2020). An adult may consume up to 7 or 8 times its own weight and wound 10 PPM larvae, consuming up to 7 wounded preys daily. Over its 3-4 year lifespan, a *C. sycophanta* adult can consume between 840 and 1120 PPM larvae (Kanat and Mol, 2008). This predator's mass production and release into forested areas were prompted by its exceptional hunting proficiency and reproductive capacity (Ünal and Yaman, 2018). In laboratory conditions, adults collected from the forests in late February and early March are fed with PPM larvae for 75 days and supplied with eggs in a specially prepared soil environment (Onaran and Katı, 2010; Ünal and Yaman, 2018).

The newly hatched larvae of *C. sycophantha* are placed individually in seed pots filled with soil. To pupate in their natural habitat, the last-stage larvae should be buried in moist soil at a depth of 30 to 50 centimeters.

If adults are released in areas with significant damage or if damage becomes apparent during the pupal stage, burial should be implemented promptly (Ünal and Yaman, 2018).

Phryxe caudata **Rond. (Diptera: Tachinidae)**

PPM and *Phryxe caudata* Rond. (Dip., Tachinidae) have a mutually beneficial relationship (Grenier, 2012; Ünal and Yaman, 2018) (Figure 4). In Türkiye, *T. pityocampa*, *T. wilkinsoni*, and *T. ispartaensis* are hosts of *P. caudata* (Aytar et al., 2018; Erkaya, 2020). To facilitate the return of parasitoids and their predators, particularly the parasitoid *P. caudata*, to the forest, caterpillar nests are located on small islands surrounded by water (Figure 5). Furthermore, the nests are placed in cages covered with wire on both sides to ensure the development and return of the parasitoids to the forest (Oğurlu and Pekel, 2000; Anonymous, 2016). Therefore, this parasitoid is reared and released against *T. pityocampa* and *T. wilkinsoni* through an island, a water chamber wire cage technique (Laz, 2020; Aytar et al., 2021).

Figure 4. *Phryxe caudata* Rond. (Diptera: Tachinidae) adult (Anonymous 2016)

Figure 5. Pine processionary moth caterpillar nests located on islets for the safe return of the parasitoids back to the forest area. (Şimşek et al., 2017)

P.caudata has two generations. Mated parasitoids lay 200-250 eggs individually on pine trees. Once hatched, the parasitoid larvae penetrate the PPM caterpillar's integument, consume its internal organs, and cause its death. The emerging parasitic larvae pass through the nest or within the islet for a second time. After the mating parasitoids mature, they lay their eggs on PPM caterpillars that are about to land in the soil. During the pupation of the infected PPM larva, *P. caudata* feeds on the internal organs, causing pupal death. As a result, an adult parasitoid can cause the death of approximately two hundred PPM caterpillars in the first generation and prevent about 200 PPM pupae from becoming adults by consuming their internal organs (Ünal and Yaman, 2018). *P. caudata* pupates at the nests of the PPM, making it vulnerable to attacks by hyperparasitoids (Oğurlu and Pekel, 2000).

***Ooencyrtus pityocampae* Mercet (Hymenoptera: Encyrtidae)**

Ooencyrtus pityocampae Mercet (Hym., Encyrtidae) (Figure 6) is a common parasitoid of PPM eggs. This egg parasitoid is a polyphagous, solitary, and thelytokous egg parasitoid of more than 50 species of Lepidoptera and Heteroptera (Saab et al., 2023). Their main hosts are PPM eggs in pine forests (Saab et al. 2023).

Many studies are in the literature on alternative hosts of *O.pityocampae* and its cultivation under laboratory conditions. Successful breeding studies include *Nezara virudula* (L.) (Masutti et al., 1993; Tunca et al. 2019b, Tabone et al., 2020), *Pizodorus lituratus* (F.*) Halyomorpha halys* (Roversi et al., 2018; Tunca et al., 2019a, b; Tabone et al., 2020) *Graphosoma lineatum* L. (Roversi et al., 2018; Saab et al., 2023) (Het., Pentatomidae), *Rhinocoris icacundus* (Poda) (Het., Reduviidae), *Dendrolimus pini* (L.) (Lep., Lasiocampidae) (Masutti et al., 1993), *Nephele hespera* (F.) (Danarun and Bumroonsook, 2017), *Philosoma ricini* (Donovan) (Tunca et al.), 2019b; Tabone et al., 2020) (Lep., Sphingidae), *Leptoglossus occidentalis* Heidemann (Het., Coreidae) (Tunca Cosic et al., 2022) are among the host species. In recent years, *O. pityocampae* has also been reported to be a native parasitoid of *Leptoglossus occidentalis* Heidemann (Hem., Coreidae), which feeds on the sap of the seeds of coniferous trees (Binazzi et al., 2013; Oğuzoğlu and Avcı, 2020; Lesieur). and Farinha, 2021; Ponce-Herrero et al., 2022; Tunca Cosic et al., 2022; Saab et al., 2023). Mass production of this parasitoid may aid biological control of the invasive *L.occidentalis*.

Figure 6. *Ooencyrtus pityocampae* (Mercet) (Hymenoptera: Encyrtidae) female (Saab et al., 2023)

There are two generations of *O. pityocampae.* The first generation of adults emerges between May and June. During this time, they parasitize eggs of alternative hosts, such as heteropteran and lepidopteran species, as PPM egg batches are not yet present. The second generation of adults emerges between August and September when PPM egg batches are present (Saab et al., 2023).

The literature reports the mass rearing of *O. pityocampae* under laboratory conditions using different hosts (Battisti et al., 1990, 1998; Halperin, 1990; Masutti et al., 1993; Tiberi et al., 1991, 1993, 1994; Zhang et al., 2005; Binazzi et al., 2015; Samra et al., 2015a,b, 2018; Federico et al., 2016; Tunca et al., 2019b). Adult *O. pityocampae* can be collected from the remaining PPM eggs after the larvae have hatched in October (Figure 7). The unhatched egg batches are placed in glass tubes. After confirming that the emerged parasitoid adult is *O. pityocampae*, one parasitoid adult and the alternative host egg batch should be placed in another glass tube for 48 hours. As *O. pityocampae* is a thelytokous parasitoid, mating is not necessary, and all adults are females. The mouth of the glass tube should be sealed with muslin or cotton. A 1:1 honey-water solution should also be given as food. After a 48-hour parasitization period, the host eggs can be examined for egg-stalks using a stereomicroscope. New parasitoid adults emerge 15 days later (Saab et al., 2023).

Figure 7. A pine processionary moth egg batch with parasitized eggs (Şimşek et al., 2017)

Also, the islet method (as mentioned in *P.caudata*) enables egg parasitoids to emerge and return to the pine forest (Şimşek et al., 2017).

- **Red Wood Ants [*Formica rufa* L. (Hymenoptera: Formicidae)] Agents Against Various Forest Pests**

Formica rufa L. (Hym., Formicidae) (Figure 8), are known as red wood ants and are common in the northern hemisphere. *F.rufa* adults construct their nests as mounds using needles, branches, resin, and herbaceous species (Çakır, 2021). *F.rufa* inhabits colonies within coniferous and mixed forests found at altitudes ranging from 1000 to 2500 meters (Ünal and Yaman, 2018). The length of *F.rufa* adults vary between 4-9 mm. Since their environments are forests, their food sources are mostly harmful forest pests (Kaygın, 2003).

Figure 8. *Formica rufa* L. (Hymenoptera: Formicidae) adult (Kaygın and Yıldız, 2006)

F.rufa builds nests on the edges of clearings in forests. It is helpful in controlling certain insect pests, such as *T. pityocampa*, *T.* wilkinsoni, *Acleris undulana*, *Diprion pini*, *Neodiprion sertifer*, *L. dispar*, *E. chrysorrhoea*, *I.*

sexdentatus, *I. typographus*, *I.acuminatus*, *D. micans*, *O. erosus*, and *Pristiphora abietina*. *F.rufa* consumes larvae and pupae of insect pests, preventing their reproduction. A colony of *F.rufa* consumes approximately 24 kg of food. However, *F.rufa* may also attack beneficial insects, such as honeybees (*Apis mellifera* L.) and Pompilidae (Hymenoptera) members.

Studies on transplanting *F. rufa* nests are conducted in regions where pests exist but there is no existing *F. rufa* population. To ensure successful transplantation, site conditions should be similar. The nest pits should measure 50x50x50 cm. Dry needles should be inserted into the bottom of the pit, and the crates should be poured into a new nest in the original order. After successful transplantation, the biological control rates in new forest areas may reach up to 80% (Ünal and Yaman, 2018).

Insects can cause significant damage to coniferous forests in Türkiye. This damage is even greater than that caused by forest fires. Common pests found in these forests include bark beetles and pine processionary caterpillars. These insects make the forests more susceptible to degradation from both biotic and abiotic factors. Additionally, negative impacts from biotic and abiotic factors can reduce the resistance of trees to insect attacks, such as those from bark beetles.

Furthermore, coniferous forests are negatively impacted by climate change. To ensure the sustainability of forests, it is important to promote environmentally friendly methods for controlling insect damage. Using the appropriate biological control agents against forest pests, implementing necessary silvicultural measures to preserve the life and diversity of natural enemies, and conducting further research on biological control agents are crucial for achieving sustainable forest management.

A number of natural enemies are used in the biological control of harmful insects in the coniferous forests of Türkiye. It is necessary to continue the research and implementation of biological control methods to determine their effectiveness in order to ensure the healthy preservation of coniferous forests and successful control of pests.

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Chapter 11

Prioritization Of Occupational Health And Safety Hazard Classes In The Context Of Sustainable Forestry

Ersin GÜNGÖR[1]

Abstract: In the study, extension forestry activities within the scope of sustainable forestry were evaluated in terms of OHS risks and hazard classes. According to the legislation in force, sustainable forestry is carried out in three hazard classes: "very dangerous-dangerous-less dangerous" in 12 activity branches. However, for a forestry activity where OHS studies and accident statistics are taken into account, there is a need to re-evaluate the hazard classes and adapt them to today's conditions. The study includes a four-stage model for re-evaluating hazard classes for forestry activities. In the relevant model, AHP and SAW methods, which are multi-criteria decision-making techniques and Discriminant Analysis, were used together. In the first stage, Turkey's forestry activities, which were divided into 3 classes based on hazard class, were adapted to the current conditions for the Ulus OİM application area.

The "Risk Assessment Control Checklist for Forestry," developed by the Ministry of Family, Labor, and Social Services (CSGB) for the identification of dangers and risks, takes into account the obligations of the "Occupational Health and Safety Risk Assessment Regulation." Thus, five risk criteria have been established within the scope of the work. The second phase consists of 20 of the pieces Risk Assessment Team Members examined and weighted within the scope of the AHP. In the third stage, Ulus OİM forestry activities were brightened with SAW according to durations. In the fourth stage, the results compared with the hazard classes in the legislation and the classes found as a result of the calculations using Discriminant Analysis were interpreted. Taking research into account in forestry activity branches contributes to the certainty of sustainable forestry.

Keywords: OHS Hazardous Classes in Sustainable Forestry Activities, Multi-Criteria Decision Making, Risk Prioritization, AHP, SAW, Discriminant Analysis.

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Sustainable Forestry and Occupational Health and Safety (OHS)

The industrial revolution, which emerged because of the classical development approach, causes environmental pollution because of excessive use of natural resources. Risks and dangers, which were not taken into consideration sufficiently before, have become important today, as the number of accidents arising from adverse workplace conditions and irregular behavior of employees has increased and led to fatal consequences. Likewise, the cost of workplace accidents is quite high. Action was taken on an international scale to stop this negative progress; Instead of the classical development approach, the sustainable development approach, also called green economy, has begun to be implemented in the world. For this reason, the phenomenon of trouble-free operation has gained importance today and it has become essential for both the workplace and the employee to comply with occupational health and safety measures.

The adoption of the concept of sustainable development in the world has not actually been enough to eliminate the negativities that employees are exposed to. For this reason, measures have begun to be taken at international levels regarding OHS. In the United Nations Environment Program report, one of the three globally accepted main goals of the green economy is explained as "revitalizing the global economy, preventing job losses, creating new job opportunities, and contributing to the protection of vulnerable segments of society" (Yalçın, 2016). Another of these initiatives is that one of the European Union (EU) Sustainable Development Indicators (EUROSTAT, 2011) is the "resource efficiency" indicator with the theme of "sustainable consumption and production" (Aksu, 2011). In these two initiatives, OHS-related issues such as reducing job losses, protecting vulnerable segments of society, and resource efficiency are emphasized (Elbir, 2019).

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The concept of Occupational Health and Safety (OHS) has been taken into consideration in many countries of the world in terms of its definition, legal dimension and legislation. In this direction, OHS, It can be expressed as a set of rules consisting of ways, methods and obligations developed to eliminate or reduce the dangers that employees may encounter in the work environment (Akyüz, 1980). Work accidents and occupational diseases, which are a part of this definition, refer to the situation related to the dangers that a person encounters due to his work (Arıcı, 1999). Türkiye enacted the Occupational Health and Safety Law No. 6331 in 2012. In the relevant law, a work accident is defined as an event that occurs in the workplace or due to the execution of work, causing death or damaging the integrity of the body mentally or physically. Occupational disease is defined as a disease that occurs because of exposure to occupational risks (ÇSGB, 2012a).

The main purpose of OHS is to protect employees from work accidents and occupational diseases and to ensure that they work in a more trouble-free environment. Another aim of OHS is to increase productivity in the workplace by ensuring operational and production safety. The general purpose of OHS is to reduce liabilities towards employees, their families, the workplace and responsible authorities, and to reduce losses in the country's economy due to problems arising from productivity losses, work accidents and occupational diseases, thanks to the OHS culture.

OHS in Forestry

OHS activities are important in forestry, which is one of the hazardous and very dangerous sectors. Likewise, it is aimed to increase operational efficiency by ensuring production and operational safety in forestry. Forestry, which is open to nature and in harmony with nature, is carried out under the influence of many biotic and abiotic risks. For example, considering the physical conditions of

Turkey's forests, most of the forestry activities are carried out in high slope areas. Especially tree cutting, grading, skidding, transportation and stacking activities are the areas where accidents occur most frequently. When we look at the issue in terms of risks, adverse weather conditions, non-ergonomic working environment, food and beverage problems, equipment that is not suitable for working and problematic tools and equipment negatively affect forestry activities. For this reason, it can be stated that forest conditions are quite difficult for workers. Varying temperatures, vegetation and different terrain conditions negatively affect employees. Because of this situation, diseases that affect employees in different ways may occur. Workers are at risk due to many health problems such as skin diseases and chemical irritation, sunstroke, carcinogenic substances, musculoskeletal disorders and poisoning. Thus, forestry activities also pose risks in terms of occupational diseases.

On the other hand, harsh working conditions, ignorance of their legal and social rights, poor housing conditions, and unrecorded near misses and accidents cause employees to experience more OHS problems. In addition, forestry work still relies on labor rather than machine power, which puts a strain on employees in terms of OHS. In summary, it can be said that there are many OHS problems for those working in forestry activities in Turkey.

The process, which begins with the preparation of forestry management plans, continues with the creation of cutting plans and cutting, skidding and transportation activities. The process ends with the preparation and sale of logs in forest warehouses. In this process, forestry activities are the activities that pose the greatest dangers and risks within the scope of OHS. Especially the works and operations carried out in forest areas are among the main tasks that need to be taken into consideration within the scope of OHS. Therefore, in order to evaluate the OHS structure in Turkish forestry, each hazard and risk in forestry activities should be examined in detail and solutions should be determined.

OHS Hazard Classes and Forestry Activities

Today, the basis of Turkey’s OHS system is based on the hazard levels of workplaces in terms of OHS, it is classified as "*Very Dangerous*", "*Dangerous*" and "*Less Dangerous*". The division of workplaces into hazard classes directly or indirectly affects the legal obligations of workplaces regarding OHS and, accordingly, their efforts to protect the health and safety of employees in workplaces in many areas. When looking at the hazard classes of workplaces in terms of legal obligations regarding OHS, it is seen that there are significant differences between a workplace in the "Very Hazardous" class and a workplace in the "Dangerous" class, and between a workplace in the "Dangerous" class and a workplace in the "Less Hazardous" class.

The Communiqué on OHS Workplace Hazard Classes published in the Official Gazette dated 26.12.2012 and numbered 28509 means that the classification of workplaces in terms of OHS is made according to the current NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) Rev.2 "Six Economic Activity Classes". Accordingly, in determining the hazard class of a workplace, the hazard class of the actual work carried out in that workplace is taken into account. If there is any hesitation in assigning the actual job, the purpose of establishment of the workplace is taken into consideration. If more than one activity is carried out in accordance with the main job description in the workplace, the job with a higher hazard class is taken as basis.

However, many objections have been made to the Workplace Hazard Classes Communiqué regarding workplace hazard classes since its publication. Actually, the "Hazard Classes List" in the annex of the relevant communiqué has been amended many times since its first publication date of 26.12.2012. At the meeting of the commission, which is responsible for determining workplace hazard classes regarding occupational health and safety, held on 12-13 March 2014, the "Procedure for Evaluation of Objections to Workplace Hazard Class" was signed in order to ensure that the commission's work can continue quickly, effectively and efficiently. The procedure in question is still in force, and the procedures regarding the determination of hazard classes of workplaces or the evaluation of objections made by workplaces to hazard classes must be carried out in accordance with the said procedure (Ceylan and Başhelvacı, 2011).

Based on what has been explained, the Hazard Class List created for Turkey's forestry activities needs to be updated in accordance with current conditions. Today, T.R. According to the OSH Workplace Hazard Classes Communiqué published by the Ministry of Labor and Social Security (ÇSGB), Turkey's forestry activities are defined in 12 activity branches. The hazard class and NACE code of each activity line is shown in Table 1.

Table 1. List of Hazard Classes for Forestry Activities (Works) (ÇSGB, 2012b).

NACE Code	NACE Definition	Danger Class
02.10.01	Cultivation of forests operated as coppices (including those for paper and fuel wood production)	Dangerous
02.10.02	Production of saplings and seeds for growing forests	Less Dangerous
02.10.03	Cultivation of forest trees (except cultivation of coppice forests)	Less Dangerous
02.20.01	Industrial and fuel wood production (including charcoal production by traditional methods)	Dangerous
02.30.01	Collection of wild products other than trees (cork oak bark, roots, cones, balsam, lac and resin, acorns, horse chestnuts, moss and lichens, wild flowers, wild fruits, edible mushrooms, etc.)	Less Dangerous
02.40.01	Cutting down trees in the forest, cleaning them from their branches, peeling them, etc. supporting activities	Dangerous
02.40.02	Transport, stacking and loading activities of cut and cleaned trees in the forest	Dangerous
02.40.03	Silvicultural service activities in the forest (thinning, pruning, etc.)	Dangerous
02.40.04	Activities to protect the forest against pests (insects and diseases)	Very Dangerous
02.40.05	Activities to protect the forest against fire and illegal cutting (unauthorized cutting)	Dangerous
02.40.06	Forest road construction and maintenance activities for forest protection and maintenance	Dangerous
02.40.07	Other forestry service activities (forestry inventories, forest management, forest management consultancy services, research and development regarding forests (maintenance, productivity, etc.)	Less Dangerous

Turkish forestry is the synthesis of forestry activities with many aspects (Sayın et al., 2014). Each forestry activity conducted within a complex system is a matter that needs to be carefully addressed and worked on from the perspective of Occupational Health and Safety (OHS). The identified hazard classes for forestry activities in Turkey (Table 1) define the conditions of the country's forestry and prove to be insufficient in resolving OHS issues encountered in practices. Indeed, the first stage in effective OHS planning involves accurately identifying hazards.

The "Occupational Health and Safety Workplace Hazard Classes Communiqué," which determines the hazard classes for each forestry activity in Turkey, proves to be insufficient in this regard. Moreover, individuals and cooperatives carry out most forestry activities with fewer than 50 employees, who are not insured according to Law No. 6831. Consequently, this unfavorable structure reduces the likelihood of accidents during forestry activities being included in Turkey's accident statistics. Therefore, it is necessary to comprehensively identify OHS risks for each forestry activity and, accordingly, redefine hazard classes.

Ulus Forest Management Directorate and OHS

Within the scope of the study, forestry activities of the Ulus Forest Management Directorate (FDM), affiliated with the Zonguldak Regional Directorate of Forestry (ZOBM), which is among the leading regions in Turkey in terms of timber raw material production, have been considered. The study involves the identification, classification, and prioritization of OHS hazards and risks related to forestry activities for the mentioned directorate. The Ulus FDM was established in 1965 and covers Ulus District in Bartın Province. It includes 10 Forest Management Offices. Ulus FDM is located in the Western Black Sea Region. The rural population rate in Ulus District, where 95% are forest villagers, is above the averages of Bartın Province and Turkey, with rates of 86%, 74%, and 25%, respectively (TURKSTAT, 2022). Ulus FDM, located within the boundaries of Bartın and Karabük provinces, has a total area of 86,398.6 hectares, of which 58,747.8 hectares (68%) are forested, 882.8 hectares (1%) are non-forested land, and 26,768 hectares (31%) are agricultural and settlement areas (Figure 1). Due to the favorable edaphic and climatic conditions in the region, forestry activities in the area exceed the national average (UOIM, 2022).

Figure 1. Ulus FDM Area.

The study incorporates general information related to the study area, including geographical location, topography, climate, geological and geomorphological structure, soil, flora, fauna, current land use, population, and economy. To identify OHS hazards in forestry activities in the region, records from Ulus FDM, along with numerous articles, books, and internet sources, were utilized (Wind and Saaty, 1980; Keleş and Tunca, 2015; Kılıçoğulları et al., 2009; Şevkli, 2010; Östberg, 1980; Zander, 1980; Poschen, 1993; CSGB, 1993; 2017; 2018; Ringdahl, 2001; Geray et al., 2007; Camkurt, 2007; Güngör, 2010; Gümüş and Türk, 2012; OGM, 2012; 2019; Calay, 2015). The gathered information was compiled to present the current situation and OHS hazards related to the study area.

Study Data and Evaluation Methods

In the study, a model consisting of four stages was developed for the reevaluation of hazard classes for forestry activities. The model incorporates Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods, along with Discriminant Analysis, which are multi-criteria decision-making techniques.

In the first stage of the study, the existing hazard classes for Ulus FDM forestry activities were examined. In practice, forestry activities were categorized into hazard classes based on the NACE code. To effectively establish hazard classes for forestry activities, the current situation was analyzed first. Risks that could be encountered in Ulus OIM forestry activities were researched, and potential risks and sub-risks were identified. The "Risk Assessment Control Checklist for Forestry" (CSGB, 2018) developed by the Ministry of Family, Labor, and Social Services and the obligations of the "Occupational Health and Safety Risk Assessment Regulation" (considering working conditions, employer-employee relationship, nature of the work, and responsibility) were taken into account for risk identification. As a result, risks were summarized under five risk criteria.

In the second stage, these risks were examined by a Risk Assessment Team (RAT) consisting of 20 members, and the weights of risk criteria were determined using the AHP method.

In the third stage, Ulus OIM forestry activities were prioritized using the SAW method based on the established criteria. As a result of this stage, forestry activities were reassigned to "Hazard Classes."

In the fourth stage, the "Hazard Classes" defined in the existing regulation for forestry activities were compared and interpreted with the "Hazard Classes" calculated within the scope of the study using Discriminant Analysis.

MCDM Techniques taken into consideration within the scope of the study are presented below.

Analytical Hierarchy Process (AHP) Method

Analytic Hierarchy Process (AHP) was developed by Thomas L. Saaty in 1977. AHP provides a structured approach to determining multiple criteria and importance levels. AHP is an easy method used in the decision-making process. When applying the AHP method to a decision problem, the following 4 steps are followed: (1) Transforming the decision problem into a hierarchical structure, (2) obtaining the pairwise comparisons matrix, (3) calculating the consistency of the criterion weights and comparison matrices, (4) determining the final priority value. Selecting alternatives accordingly. In the AHP method, all factors affecting the decision-making process are determined by taking the opinions of experts or because of surveys conducted on the subject (Schomoldt et al., 1995.). Because of these determined factors, if there are alternatives and criteria, a hierarchical structure is created with sub-criteria. After the structure formed by determining the alternatives and criteria, data is collected using the pairwise comparisons scale in Table 2 and thus the pairwise comparisons matrix is obtained (Saaty, 1980).

Table 2. Paired Comparisons Scale (Saaty, 1990).

Importance Degree	Value Definitions	Description
1	Equality	Both activities contribute equally to the goal.
3	Less Important (Less advantage)	As a result of experience and evaluations, one activity is slightly preferred over the other.
5	Quite Importance (Too much superiority)	As a result of experience and evaluations, one activity is much preferred over the other.
7	Very important (Very Superlative)	One activity is very strongly preferred over another.
9	Highly important (Sharp Superiority)	One activity is preferred over another to the highest degree possible.
2,4,6,8	Intermediate Values (Consensus Values)	If words are insufficient to make an evaluation, a value in the middle of the numerical values is given.

When calculating criterion weights, the decision matrix is normalized by dividing each column value by the total of its column. The total value of each column in the normalized decision matrix is 1. Afterwards, eigenvectors are calculated by finding the average of the values in the row (Saaty, 2008).

The following formulas are used to calculate the consistency ratio (CR). In Equation 1, CI is the consistency index, λmax is the largest value in the matrix, and n is the number of elements in each matrix.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (1)$$

After the consistency index is determined, the consistency ratio (CR) is obtained by dividing the consistency index to the random index corresponding to the matrix of the same size (Equation 2) (Saaty, 1980).

CR = CI / RI (2)

In Equation 2, RI shows the random consistency index rates, and the random consistency index table is given in Table 3.

Table 3. Stochastic Consistency Index (Saaty, 2008).

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
RI	0,0	0,0	0,52	0,89	1,11	1,25	1,35	1,40	1,45	1,49	1,52	1,54	1,56	1,58	1,59

In order for pairwise comparisons to be consistent, the consistency ratio is required to be below 0.10. In the last step, the alternative with the highest final priority values is selected.

SAW Method

The Simple Additive Weighting (SAW) method was introduced to the literature by Churchman and Ackoff (1954) by applying it to the portfolio selection problem. SAW is one of the most used techniques in MCDM literature due to its mathematical simplicity. In SAW, an index is created by the sum of the contributions of each criterion. Since different units cannot be collected, the data are first normalized in SAW calculations. Then, the total score for each alternative is obtained by multiplying the weights of the criteria with the normalized values of that alternative in various criteria, that is, its dimensionless evaluations, and finally adding them all together. In the SAW method, since the contribution of each criterion to the total score is independent of the others, the decision maker's preference requires that the value of a criterion not be affected by the values of other criteria for any reason. SAW obtains the final value by multiplying and adding the criterion weights to the criterion values for each alternative (Tzeng and Huang, 2011). The SAW method consists of two steps (Yeh, 2003; Janic and Reggiani, 2002):

Step I: Normalizing the Decision Matrix: In the first stage of the SAW method, the type of criteria is determined. Then, if the type of criterion is maximization, Equation 3 for the benefit criterion is used. Here, "max rij" is obtained by dividing each criterion value to the largest value in that row. If the type of criterion is minimization, Equation 4 for the cost criterion is used. “min rij” is obtained by dividing the smallest value in the row to each criterion value. In Equations 3 and 4; m refers to the number of alternatives, n refers to the number of criteria, i refers to row and j column (Tzeng and Huang, 2011).

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{\max x_{ij}} \quad i = 1, \dots, m; \;\; j = 1, \dots, n \text{ for benefit criterion} & (3) \\ \dfrac{\min x_{ij}}{x_{ij}} \quad i = 1, \dots, m; \;\; j = 1, \dots, n \text{ for benefit criterion} & (4) \end{cases}$$

All calculated criterion values must be positive. Otherwise, negative values should be converted to positive values. The conversion formula is given in Equation 5.

$$r_{ij} = r_{ij} + \left| \min r_{ij} \right| + 1 \tag{5}$$

II. Step: Calculating the Preference Values of the Alternatives: The total preference values of each alternative are found by multiplying the weight of each criterion by the previously calculated values (Equation 6).

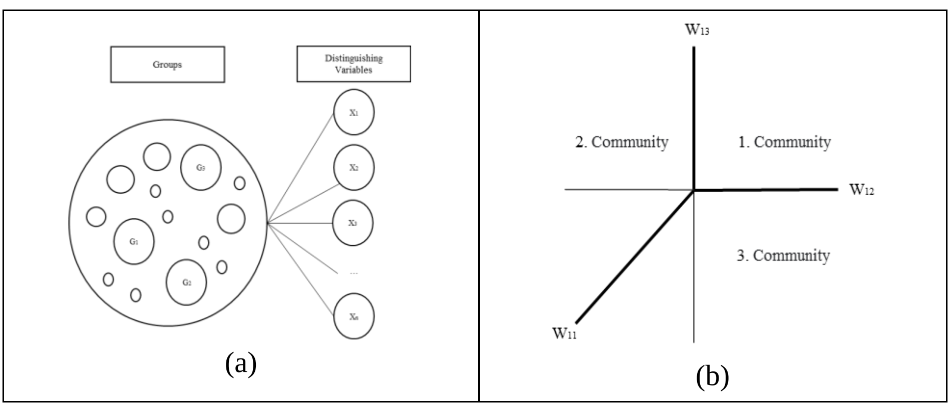
$$S_j = \sum_{j=1}^{m} w_j \, r_{ij} \qquad i = 1, \dots, m \;, \tag{6}$$

Equation 6 shows the weight of criterion "j" and the alternative preference value. Calculated alternative preference values must be greater than zero, less than one and equal to one. A higher value means that the alternative will be more preferred. Relative values, that is, average alternative preference values, are found by proportioning each value to the total alternative value. The alternative with the highest value is ranked first (Equation 7).

$$S_j^{\%} = \frac{S_j}{\sum_{j=1}^{n} S_j} \tag{7}$$

Discriminant Analysis

Discriminant Analysis (DA) is a multivariate analysis that allows X individuals or units to be divided into two or more groups according to many (n) characteristics and provides related functions. A large number of individuals, according to their numerous characteristics, are represented as points in a multidimensional space formed by these characteristics. Some of the many individuals sometimes have similar characteristics to each other. In this case, individuals shown as points in multidimensional space may group together due to their similar characteristics, or move away from each other due to their dissimilar characteristics, and eventually group again. The questions of whether groups of individuals grouping in multidimensional space can be distinguished from each other, how many groups can be distinguished, which individuals will be in each group, and what features will be effective in distinguishing them into groups are answered by DA (Daşdemir, 1987). It is a broad concept that encompasses several closely related statistical approaches (Klecka, 1980). According to DA analysis, individuals are divided into two or more groups based on the dependent variable. In DA, it is determined whether such a grouping can be made by taking into account many variables and whether the groups are different from each other (DA for identification purposes). Likewise, it can be determined which group a newly measured individual will fall into (DA for decision-making purposes) (Daşdemir and Güngör, 2002). Comparing the classification made as a result of the analysis with the original group memberships allows testing whether the known function is sufficient (Erçetin, 1993; Pohekar and Ramachandran, 2004). DA focuses on two important elements: groups and distinctive variables. The relationship between groups and discriminant variables in DA is given in Figure 2a and the classification of regions for k=3 and p≥2 in DA is given in Figure 2b.



(a) (b)

Figure 2. Relationship between groups and discriminant variables in DA (a), classification of regions for k=3 and p≥2 in DA (b).

Findings

In this study; Forestry activities carried out within Ulus OİM were evaluated with AHP and SAW methods, which are among the MCDM methods, and Discriminant Analysis, which is a statistical analysis. The criteria used in the study were examined and evaluated by a RAT of 20 people, consisting of representatives of public institutions operating in the forestry sector and forestry workers. The findings obtained are given below.

AHP Calculations: Prioritization of Risk Criteria in Forestry Activities

In order to prioritize forestry activities, the weights of the risk criteria defined for forestry were determined by AHP. In AHP calculations, five risk criteria (OHS Training, General Risks, Health Safety and Ergonomics) developed by the ÇSGB were taken into account (Table 4).

Table 4. Risk Criteria for Forestry Activities (ÇSGB, 2018).

Risk Codes	Risk Criteria	Criterion Abbreviation
K1	OHS Training, Information, Personal Protective Equipment (PPE) and Auxiliaries	OHS Training
K2	General Risks (Climate, Ground, Slope, etc.), Weather Conditions, Emergencies, Hazardous Materials	General Risks
K3	Health Surveillance, Hygiene, Biological Factors Psycho-Social Factors	Health
K4	Safety Behaviors, Techniques and Safety Equipment in Unloading, Loading and Stacking.	Security
K5	Manual Lifting, Overflow, Ergonomics and Monotonous Operation	Ergonomics

RAT members prioritized the criteria given in Table 4. For this purpose, forms that allow the application of the AHP method have been answered. In the survey forms, each forestry activity branch was evaluated by pairwise comparisons in line with the determined risk criteria (K1, K2, K3, K4, and K5) and combined by taking the geometric averages of the RAT members. In this way, a common opinion was obtained. The weights of the risk criteria obtained because of AHP calculations are shown in Figure 3.

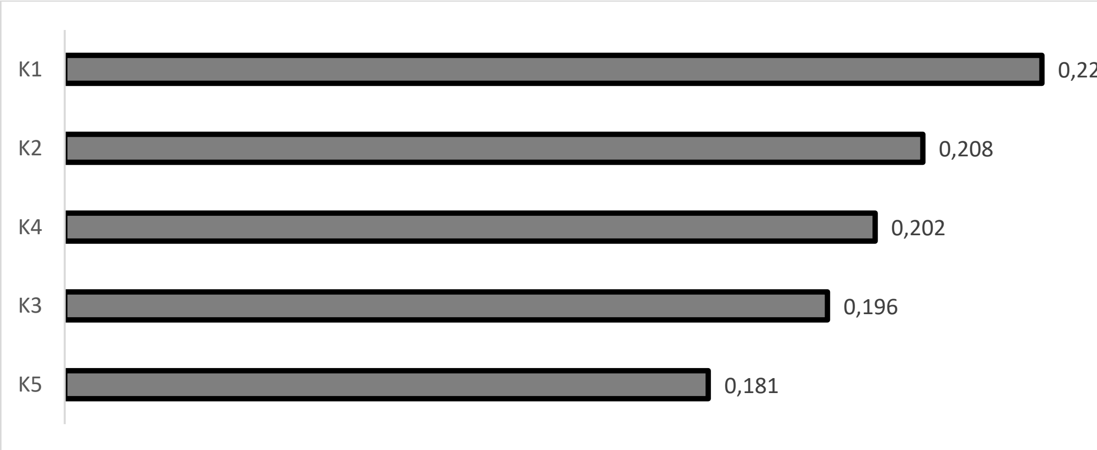


Figure 3. Criterion weights obtained as a result of AHP calculations.

As a result of AHP, it is seen that the most important risk criterion is "OHS Training" with 22.3%, and the least important risk criterion is "Ergonomics" with 18.1%. However, it should not be forgotten that all five risk criteria included in the calculations have close values to each other. Considering the risk priorities for forestry activities, the relevant manager should take the risks into account in this order within the scope of both resource and budget constraints. Likewise, in the Risk Analysis and Emergency Action Plans to be prepared for each forestry activity branch, it is thought that paying careful attention to hazard priorities will minimize possible near misses, accidents and material/moral losses resulting from these accidents.

SAW Calculations: Prioritization of Forestry Activities

At this stage, the “Hazard Classes” defined in the current communiqué for forestry activities were compared with the “Hazard Classes” calculated within the scope of SAW. In the list of hazard classes (Table 1) in the current communiqué on forestry activities (works), there are more than ten forestry activity branches (decision elements), one of which is in the “Very Hazardous” class, seven in the “Dangerous” class and four in the “Least Hazardous” class is taking. The forestry activities listed in Table 1 have been redesigned to enable SAW applications (Table 5). In the decision matrix given in Table 5, 12 Forestry Activities are defined as decision elements from A1 to A12.

Table 5. Decision elements and decision codes for SAW calculations.

Decision Element	**Decision Code**	**Hazard Class**	**NACE Definition**
A1	Coppice	Dangerous	Cultivation of forests operated as coppices (including those for paper and fuel wood production)
A2	Sapling Production	Less dangerous	Production of saplings and seeds for growing forests
A3	Afforestation	Less dangerous	Cultivation of forest trees (except cultivation of coppice forests)
A4	Wood Production	Dangerous	Industrial and fuel wood production (including charcoal production by traditional methods)
A5	NWFP Collection	Less dangerous	Collection of wild products other than trees (cork oak bark, roots, cones, balsam, lac and resin, acorns, horse chestnuts, moss and lichens, wild flowers, wild fruits, edible mushrooms, etc.)
A6	Tree Cutting	Dangerous	Cutting down trees in the forest, cleaning them from their branches, peeling them, etc. supporting activities
A7	Transport	Dangerous	Transport, stacking and loading activities of cut and cleaned trees in the forest
A8	Silviculture	Dangerous	Silvicultural service activities in the forest (thinning, pruning, repikage, etc.)
A9	Insect Protection	Very dangerous	Activities to protect the forest against pests (insects and diseases)
A10	Fire Protection	Dangerous	Activities to protect the forest against fire and illegal cutting (unauthorized cutting)
A11	Road construction	Dangerous	Forest road construction and maintenance activities for forest protection and maintenance
A12	Forestry Management	Less dangerous	Other forestry service activities (forestry inventories, forest management, forest management consultancy services, research and development regarding forests (maintenance, productivity, etc.)

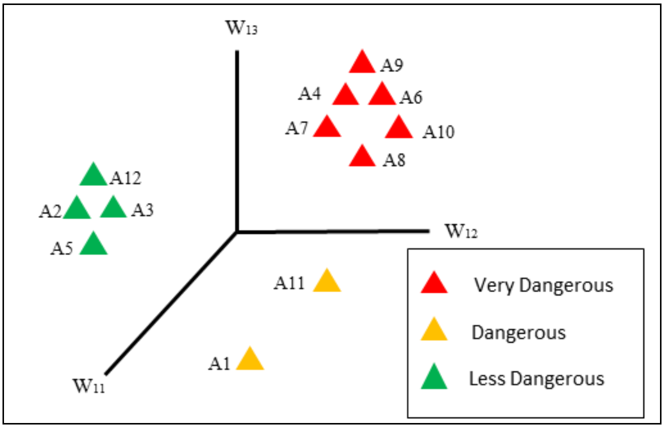
A summary of the results of SAW calculations is given in Table 6.

Table 6. Normalized Decision Matrix and Normalized Values of Forestry Activities.

RISK CRITERIA	WEIGHT	ALTERNATIVES (FORESTRY ACTIVITIES)											
		A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
OHS Training (K1)	0,223	3,742	3,895	3,777	4,000	3,748	3,901	3,912	3,980	3,984	3,647	3,554	3,752
General Risks (K2)	0,208	3,642	4,000	3,555	3,624	3,445	3,642	3,912	3,940	3,647	3,651	3,774	3,858
Health (K3)	0,196	3,844	3,748	3,587	3,414	3,678	4,000	3,775	3,852	3,842	3,952	3,947	3,985
Security (K4)	0,196	3,997	3,991	3,645	3,675	4,000	3,941	3,917	3,621	3,774	3,774	3,777	3,824
Ergonomics (K5)	0,181	3,423	3,645	3,512	3,991	3,748	3,441	4,000	3,741	3,744	3,841	3,852	3,912
	NORMALIZATION OF FORESTRY ACTIVITIES												
		0,9752	0,9732	0,9622	0,9845	0,9745	0,9722	0,9741	0,9633	0,9844	0,9754	0,9822	0,9884
		0,0805	0,0730	0,0722	0,092	0,0928	0,0861	0,0858	0,0832	0,0959	0,0836	0,0817	0,0732
Rank		**8**	**10**	**12**	**2**	**11**	**3**	**4**	**6**	**1**	**5**	**7**	**9**
		A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**

Discriminant Calculations: Assignment of Forestry Activities to Hazard Classes

In the study, forestry activities were grouped according to Discriminant Analysis (DA) results. Accordingly, in the study, 3 groups (clusters) were created (very dangerous-dangerous-less dangerous). Since there were few variables in the groups (n<30), the groups were tested whether they were different at the 95% confidence level with the Kruskal Wallis H Test, one of the non-parametric multiple comparison tests. The results were found to be significant. DA results are shown graphically in Figure 4.



Şekil 4. Discriminant Analizi sonuçları grafiği.

Current Situation (Legislation) - Proposal Model (AHP-SAW-Discriminant) Comparison

At this stage, the current legislation on forestry activities and the recommended model (AHP-SAW- Discriminant Analysis) values were compared (Table 7).

Table 7. Comparison of Current Legislation-SAW

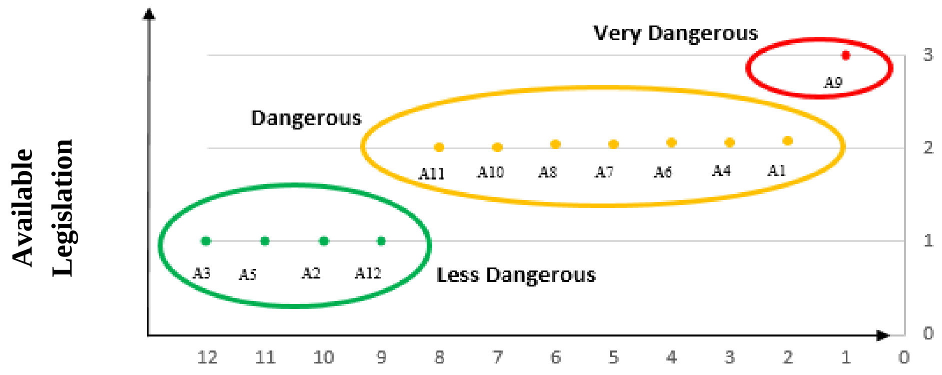
Related Models	Forestry Activities		
	Less Dangerous	Dangerous	Very Dangerous
	Cluster-1	Cluster-2	Cluster-3
Available Legislation	A2 (Seedling Production) A3 (Afforestation) A5 (ODOÜ Collection) A12 (Forestry Management)	A1 (Copic) A4 (Wood Production) A6 (Tree Cutting) A7 (Carriage) A8 (Silviculture) A10 (Fire Protection) A11 (Road Construction)	A9 (Insect Protection)
Suggestion Model (AHP-SAW-DA)	A12 (Forestry Management) A2 (Seedling Production) A3 (ODOÜ Collection) A5 (Afforestation)	A11 (Road Construction) A1 (Copic)	A9 (Insect Protection) A4 (Wood Production) A6 (Tree Cutting) A7 (Carriage) A10 (Fire Protection) A8 (Silviculture)

When Table 7 is examined, the Hazard classes found as a result of the current legislation and calculations differ from each other. The results found with the legislation, especially for the Very Hazardous class, differ (Table 8).

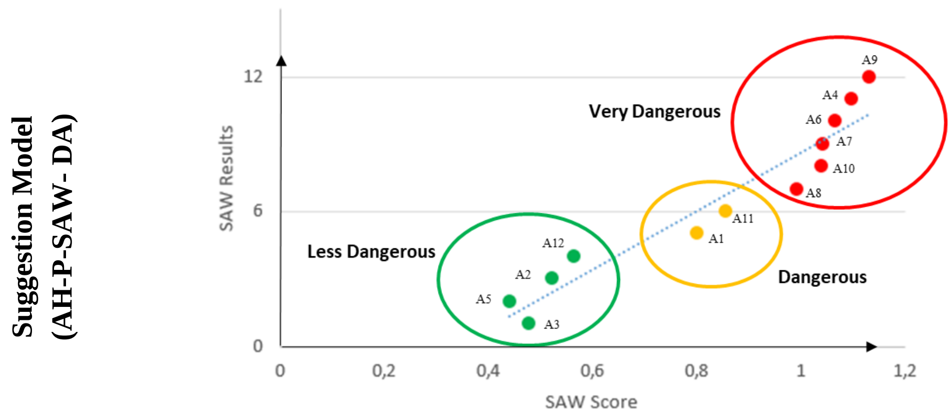
Table 8. Prioritization of Forestry Activities.

Decision Element	Decision Code	Legislation Arrangement	Danger Class	Suggestion Model Arrangement	Danger Class
A9	Insect Protection	1	Very Dangerous	1	Very Dangerous
A4	Wood Production	2	Dangerous	2	
A6	Tree Cutting	3		3	
A7	Transport	4		4	
A10	Fire Protection	5		5	
A8	Silviculture	6		6	
A11	Road construction	7		7	Dangerous
A1	Coppice	8		8	
A2	Sapling Production	10	Less Dangerous	10	Less Dangerous
A12	Forestry Management	9		9	
A5	NWFP Collection	11		12	
A3	Afforestation	12		11	

The hazard classes of forestry activities in the legislation are shown in Figure 5a, and the assignment of these activities to new hazard classes as a result of the proposal model is shown in Figure 5b.



(a)



(b)

Figure 5. Hazard Classes of Forestry Activities in the Legislation (a). Hazard Classes Found as a result of the Recommendation Model (b)

Results

Within the scope of the study, a study was carried out to re-define the OHS hazard classes defined for each forestry activity, but containing inadequacies. In the research, AHP (Analytic Hierarchy Process-AHP), SAW (Simple Additive Weighting) methods and Discriminant Analysis, which are multi-criteria decision making (MCDM) methods that take into account many different criteria simultaneously, were used together within the scope of a model. In this model, the OHS hazard criteria given primarily for forestry activities are weighted by the AHP method. Then, calculations to recreate the hazard classes determined for forestry activities in practice were carried out using the SAW method. Finally, the hazard class of each forestry activity in the current communiqué was compared and interpreted with the hazard classes found as a result of Discriminant calculations.

In Turkey, many problems have been encountered in the relevant process since 2003, when the practice of dividing activity lines first into risk groups and then into hazard classes in terms of OHS began, until today. This classification system, which directly or indirectly affects the OHS-related obligations of employers and, accordingly, the health and safety of employees in workplaces in many areas, is not based on concrete and fair classification criteria that can be understood by all parties. Instead, the determination of hazard classes is based on subjective opinions.

In the Turkish forestry sector, the OSH concept has not been fully adopted and OHS practices have not been developed at a sufficient level. Therefore, special importance should be given to OHS practices in the country's forestry as a requirement of international legislation. In the report of the OGM (OGM, 2012), it was reported that forestry, one of the 59 sectors contributing to the Turkish economy, is a labor-intensive sector (employment multiplier 0.291) and provides an average of 15 million person-days of employment annually. This report also stated that forestry jobs could offer employment opportunities to all parts of the country for a largely unqualified workforce without requiring advanced training (Ministry of Development, 2014). Therefore, forestry activities are activities that are open to all kinds of natural conditions, are considered to have a heavy workload and a high risk of accidents, and are carried out in different ways such as afforestation, cultural care, production, construction, maintenance and repair of forest roads (Acar at al., 2002). . In addition, forestry labor requires the presence of skilled employees in all activities carried out within forestry production activities (Tunay and Emir, 2015). In forestry, working under harsh conditions in terms of OHS, having to work in large and rugged areas, being away from social environments and requiring accommodation in the workplace, cause the risk of accidents to be high since working in open air conditions.

Within the scope of sustainable forestry, in order to establish an OHS culture in Turkish forestry, to reduce accident statistics and to be successful in OHS activities, it is necessary to effectively identify very hazardous-hazardous-less hazardous business lines. For this reason, within the scope of the study, hazard classes for forestry activities were re-determined with the "Recommendation Model" developed within the scope of the study and compared with the current situation in practice.

As a result of AHP, the most important risk criterion for Ulus OİM was found to be "OHS Training". The least important risk criterion was "Ergonomics". On the other hand, the five risk criteria included in the calculations had values close to each other. In OHS planning for forestry activities, the relevant manager should take into account hazard and risk prevention strategies in line with this order, within the scope of both resource and budget constraints. Likewise, it is thought that paying careful attention to hazard priorities in the Risk Analysis and Emergency Action Plans to be prepared for each forestry activity will minimize possible near misses, accidents and material/moral losses resulting from these accidents.

For the success of Risk Analysis, the data obtained for each risk must be sufficient and reliable. Additionally, it has been understood that decisions are made subjectively in assigning Turkey's forestry activities to hazard classes. Therefore, qualified research is needed to obtain comprehensive and accurate data on relevant risks in the country's forestry. Therefore, it is necessary to create inventory records for OSH risks in Turkish forestry.

It is important to implement the current hazard classes determined within the scope of the study. For forestry activities, this model developed for the Ulus OİM forest area and similar ones should be expanded for the entire country's forestry. Since the OSH concept is in the development process in our country, the training of employees and especially practitioners in the forestry organization is important. Considering research findings in forestry activity branches will also ensure sustainable forestry.

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