



Ecotourism-Based Sustainable Landscape Planning for Giresun Island: A Carrying Capacity Approach ^[*]

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Abstract: Giresun Island (Aretias), a second-degree archaeological and natural protected area located in the Black Sea, possesses significant ecological, historical, and cultural values that contribute to its unique identity. However, increasing tourism demand combined with mounting environmental pressures threatens the island's ecological integrity, cultural heritage, and long-term sustainability. This study aims to develop an integrated and sustainable tourism strategy for Giresun Island, grounded in ecotourism principles and landscape conservation. To this end, a mixed-methods approach was adopted, incorporating field observations, a comprehensive literature review, and semi-structured expert interviews. The island's carrying capacity was assessed based on the three-tier model proposed by Cifuentes (1992), which incorporates Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). The findings reveal that while the PCC theoretically allows up to 2,250 visitors per day, environmental, infrastructural, and managerial constraints significantly reduce this number to approximately 578 visitors per day under RCC and further to 332 visitors per day under ECC. The analysis highlights the importance of strategic planning interventions, such as seasonal zoning to distribute visitor loads more evenly, the development of infrastructure that respects ecological thresholds, and the active participation of local stakeholders in planning and decision-making processes. These recommendations seek to achieve a delicate balance between promoting sustainable tourism development and preserving the island's fragile ecosystem. As a case study, Giresun Island provides a valuable and replicable framework for integrating ecotourism-based landscape planning and sustainable visitor management in culturally and ecologically sensitive areas.

Keywords: Carrying capacity, ecotourism, Giresun island, landscape management, natural landscape, sustainable development.

Giresun Adası İçin Ekoturizm Temelli Sürdürülebilir Peyzaj Planlaması: Taşıma Kapasitesi Yaklaşımı

Öz: Karadeniz'de yer alan Giresun Adası (Aretias), ikinci derece arkeolojik ve doğal sit alanı olarak koruma altına alınmış; ekolojik, tarihi ve kültürel değerleriyle özgün bir kimliğe sahiptir. Ancak, artan turizm talebi ve çevresel baskılar, adanın ekolojik bütünlüğünü, kültürel mirasını ve uzun vadeli sürdürülebilirliğini tehdit etmektedir. Bu çalışma, Giresun Adası için ekoturizm ilkeleri ve peyzaj koruma yaklaşımı temelinde bütüncül ve sürdürülebilir bir turizm stratejisi geliştirmeyi amaçlamaktadır. Bu amaç doğrultusunda; saha gözlemleri, kapsamlı literatür taraması ve yarı yapılandırılmış uzman görüşmeleri içeren karma yöntemli bir yaklaşım benimsenmiştir. Adanın taşıma kapasitesi, Cifuentes (1992) tarafından önerilen üç aşamalı model çerçevesinde değerlendirilmiş; Fiziksel Taşıma Kapasitesi (PCC), Gerçek Taşıma Kapasitesi (RCC) ve Etkin Taşıma Kapasitesi (ECC) hesaplanmıştır. Bulgular, PCC'nin teorik olarak günlük 2.250 ziyaretçiyi mümkün kılabilirdiğini, ancak çevresel, altyapısal ve yönetsel kısıtlamalar nedeniyle bu sayının RCC'de yaklaşık 578'e ve ECC'de ise 332'ye önemli ölçüde düştüğünü göstermektedir. Analiz, ziyaretçi yükünü daha dengeli dağıtmak için mevsimsel bölgeleme, ekolojik eşiklere uygun altyapı geliştirme ve yerel paydaşların planlama ve karar alma süreçlerine aktif katılımı gibi stratejik planlama müdahalelerinin önemini vurgulamaktadır. Bu öneriler, sürdürülebilir turizm gelişimi ile adanın kırılğan ekosisteminin korunması arasında hassas bir denge kurmayı amaçlamaktadır. Bir örnek olay olarak Giresun Adası, kültürel ve ekolojik olarak hassas alanlarda ekoturizm temelli peyzaj planlaması ve sürdürülebilir ziyaretçi yönetimi için değerli ve çoğaltılabilir bir çerçeve sunmaktadır.

Anahtar Kelimeler: Doğal peyzaj, ekoturizm, Giresun Adası, peyzaj yönetimi, sürdürülebilir kalkınma, taşıma kapasitesi.

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INTRODUCTION

Giresun Island (Aretias) is located in the Black Sea, off the coast of Giresun (at 40°55'44"N, 38°26'10"E), and is one of the most ecologically and culturally valuable natural areas of the region (Figure 1). Located in the Turkish Black Sea region, Giresun Island holds a distinctive place in both natural heritage and historical narratives. It has been legally protected since 1991 as a second-degree natural and archaeological site and was further designated as an "Ören Yeri" (official archaeological site) by the Turkish Ministry of Culture and Tourism in 2022.

Giresun Island is renowned for its historical layers, with archaeological remains from the Roman and Byzantine periods, including defensive walls, cisterns, watchtowers, a chapel, and a monastery complex (Doksanaltı, Arslan, & Mimiroğlu, 2010)(Figure 1). The island is also home to the Hamza Stone; a notable fertility symbol rooted in ancient mythologies. These cultural elements, combined with rich folklore-such as associations with the Amazons and the Argonauts-make the island a significant mytho-historical landscape (Vıcıl et al., 2008). Also, ecologically, the island is home to diverse flora and fauna and plays a crucial role as a natural habitat in the Black Sea region.



Figure 1. Giresun Island (Ak, 2022)

Tourism development in small and ecologically sensitive island ecosystems poses complex challenges for sustainable landscape management. As visitor numbers increase, pressures on fragile natural and cultural resources intensify-often exceeding the ecological and managerial limits of the area. In the absence of clear regulatory frameworks and systematic visitor monitoring, such destinations become vulnerable to environmental degradation, infrastructure strain, and loss of cultural authenticity. Giresun Island, located in the eastern Black Sea and legally designated as a protected natural and archaeological site, is currently facing these very challenges.

In recent years, the island's accessibility has increased due to growing tourism demand, particularly during the summer season. Although only limited infrastructure exists on the island-such as a pier and a now-

defunct archaeological excavation building-rising visitor numbers have triggered concerns regarding the environmental sustainability of tourism activities. However, despite this growing interest, a lack of consistent and publicly available data on annual visitor numbers has posed challenges in assessing the full impact of tourism on the island's fragile ecosystem. Official visitor statistics specific to Giresun Island are currently unavailable from institutions such as TÜİK or the Ministry of Culture and Tourism. This lack of data is primarily due to the fact that, although the island is not officially open to public visitation, it remains accessible through private tours or individual marine vessels. As a result, visitor entries are not systematically recorded, leading to a gap in reliable data. Nevertheless, local authorities have projected that annual visitation could reach between 300,000 and 400,000 under new tourism development initiatives (Giresun Governorship, 2025). These conditions underscore the need for data-driven strategies to ensure long-term tourism sustainability.

Similar concerns have been documented in other island destinations. According to Coccossis (2002), rapid tourism growth in Mediterranean islands has led to environmental degradation, infrastructural overload, and ecological imbalances, underscoring the importance of carrying capacity-based planning and diversified tourism approaches. These projections and parallels emphasize the urgency of implementing sustainable tourism strategies grounded in systematic visitor monitoring.

Ecotourism, broadly defined as responsible travel to natural areas that conserves the environment, sustains the well-being of local people, and fosters environmental awareness among visitors, offers a strategic alternative for destinations with sensitive ecological and cultural values (TIES, 1990; Global Sustainable Tourism Council, 2022). In this context, Giresun Island represents a significant opportunity for the development of ecotourism practices that balance conservation and visitor engagement. The integration of ecotourism principles-such as minimal environmental impact, local community benefit, and educational value-into tourism planning is essential to preserve the island's integrity while supporting sustainable development goals.

The purpose of this study is to develop a comprehensive ecotourism-based sustainable landscape planning approach for Giresun Island, guided by science-based thresholds for visitor management. Specifically, the study aims to assess the island's ecotourism potential by considering its ecological richness and cultural heritage; identify the impacts of tourism activities on the natural landscape and archaeological assets; and apply the three-tier carrying capacity model developed by Cifuentes (1992) to determine acceptable visitor thresholds based on spatial, environmental, and managerial factors. In line with these

goals, the study also proposes adaptive planning strategies that integrate conservation principles, ecotourism practices, and participatory management approaches.

Giresun Island's Ecological and Cultural Values:

Giresun Island, also known as Aretias, is a unique ecological and cultural heritage site in the Black Sea, distinguished by its rich biodiversity and historical significance. The island's ecological and cultural values are integral to its identity and offer substantial potential for sustainable ecotourism development.

Giresun Island possesses unique vegetation shaped by the influence of the Black Sea climate. The island's limited surface area, topographic characteristics, and long-term relative isolation from human settlement have formed a distinct micro-ecosystem. Owing to its humid and mild

climatic conditions, the island provides a suitable environment for the development of broad-leaved woody species, shrub formations, and certain natural herbaceous plants. With its rich biodiversity, Giresun Island is also an important natural habitat. Seventy-one plant species have been identified on the island (Giresun Provincial Directorate of Culture and Tourism, 2024). *Laurus nobilis* (Bay laurel) stands out as an endemic species specific to the island. *Robinia pseudoacacia* (black locust) is also one of the most common species alongside *Laurus nobilis* (Figure 2). The species identified in the study conducted by Küçük in 1990, the research carried out by Vıçıl et al., in 2008, and the plant species we observed on the island are listed in the table below.

Table 1. Giresun Island plant species (Vıçıl et al., 2008) (Küçük, 1990).

Trees		Climbers	
Latin Name	English Name	Latin Name	English Name
<i>Aesculus hippocastanum</i> L.	Horse chestnut	<i>Calystegia sepium</i> (L.) R.Br.	Hedge bindweed
<i>Castanea sativa</i> Mill.	Chestnut	<i>Clematis vitalba</i> L.	Old man's beard
<i>Celtis australis</i> L.	European nettle tree	<i>Hedera helix</i> L.	Common ivy
<i>Cornus mas</i> L.	Cornelian cherry	<i>Parthenocissus quinquefolia</i> (L.) Planch.	Virginia creeper
<i>Corylus avellana</i> L.	Hazelnut	<i>Vitis vinifera</i> subsp. <i>sylvestris</i> (C.C.Gmel.) Hegi	Wild grapevine
<i>Crataegus monogyna</i> Jacq.	Hawthorn	Shrubs and herbaceous	
<i>Cydonia oblonga</i> Mill.	Quince	<i>Allium</i> spp.	Wild onion
<i>Diospyros lotus</i> L.	Date-plum	<i>Amaranthus retroflexus</i> L.	Redroot pigweed
<i>Ficus carica</i> L.	Fig	<i>Asphodelus aestivus</i> Brot.	Summer asphodel
<i>Fraxinus excelsior</i> L.	European ash	<i>Borago officinalis</i> L.	Borage
<i>Juglans regia</i> L.	Walnut	<i>Capsella bursa-pastoris</i> (L.) Medik.	Shepherd's purse
<i>Laurus nobilis</i>	Bay laurel	<i>Euphorbia</i> spp.	Spurge
<i>Magnolia grandiflora</i> L.	Magnolia	<i>Foeniculum vulgare</i> Mill.	Fennel
<i>Malus domestica</i> Borkh.	Apple	<i>Galium aparine</i> L.	Cleavers
<i>Malus sylvestris</i> Mill.	Wild apple	<i>Lamium purpureum</i> L.	Red dead-nettle
<i>Mespilus germanica</i> L.	Medlar	<i>Medicago lupulina</i> L.	Black medick
<i>Pinus brutia</i> Ten.	Turkish pine	<i>Melissa officinalis</i> L.	Lemon balm
<i>Pinus pinea</i> L.	Stone pine	<i>Pteridium aquilinum</i> (L.) Kuhn	Bracken fern
<i>Pistacia vera</i> L.	Pistachio	<i>Rosa canina</i> L.	Dog rose
<i>Platanus orientalis</i> L.	Oriental plane	<i>Rubus</i> spp.	Blackberry
<i>Prunus avium</i> L.	Wild cherry	<i>Rumex crispus</i> L.	Curly dock
<i>Prunus cerasus</i> L.	Sour cherry	<i>Sambucus ebulus</i> L.	Dwarf elder
<i>Prunus laurocerasus</i> L.	Cherry laurel	<i>Urtica dioica</i> L.	Stinging nettle
<i>Prunus spinosa</i> L.	Blackthorn	<i>Valeriana officinalis</i> L.	Valerian
<i>Punica granatum</i> L.	Pomegranate	<i>Verbascum thapsus</i> L.	Common mullein
<i>Pyrus communis</i> L.	Pear		
<i>Robinia pseudoacacia</i> L.	False acacia		

It is believed that some plant species, particularly fruit trees (*Malus domestica*, *Pyrus communis*, *Prunus cerasus*, *Juglans regia*), were introduced to Giresun Island by humans. Additionally, certain species (*Punica granatum*, *Pistacia vera*, *Cydonia oblonga*) not naturally found within the Black Sea climate and native vegetation are also thought to have been brought to the island through human activity. On the other hand, given that the island serves as an important breeding and resting site for migratory birds, it is also possible that some plant species (*Rubus* spp., *Ficus carica*, *Rosa canina*) arrived on the island through natural dispersal mediated by birds.

Furthermore, the island serves as a shelter and breeding ground for many bird species. The most commonly observed birds include the crested cormorant, great cormorant, shag, herring gull, and little gull (Vıçıl et al., 2008). The bird breeding season generally occurs between May and July, with a particular concentration in the island's

northern part. In addition to these key species, a diverse avian community has been recorded, including blackbirds, hooded crows, yellow-legged gulls, and black-headed gulls, as well as migratory waterfowl such as tufted ducks and crested pochards (Vıçıl et al., 2008). The island also supports a variety of invertebrate fauna—such as ladybirds, European garden spiders, slugs, centipedes, and Mediterranean mussels—and vertebrates including common frogs, European green toads, rock lizards, and slow worms (İncekara, 2017). This biodiversity highlights the ecological importance of the island as both a breeding habitat and a migratory stopover site within the eastern Black Sea ecosystem.

Giresun Island stands out not only for its natural features but also for its historical and cultural heritage. Historical sources reveal that the island was referred to by various names in antiquity, such as Aretias, Ares Nesos, Puga, and Khalkeritis, during the Roman period (Doksanalı,

Arslan, & Mimiroğlu, 2010; Sezer, 2019). The island has been associated with figures such as the Amazons and Heracles, and it is considered one of the stops in the Argonauts' quest for the Golden Fleece (İltar and Temür 2018). It is documented that a temple dedicated to Ares was established on the island, further enhancing its sacred status (Sezer, 2019). Known as Aretias in ancient sources, the island also served as a significant military and commercial base during the Kingdom of Pontus. With the dominance of the Roman Empire in the region, the island continued to function as a religious and cultural centre and later became a sacred site with churches and monasteries during the Byzantine period (Giresun İl Kültür ve Turizm Müdürlüğü, 2025). Thanks to its rich historical background and mythological associations, Giresun Island has become a valuable attraction for cultural tourism today.



Figure 2. A- *Laurus nobilis* and B- *Robinia pseudoacacia* (Ak 2023)

Giresun Island and its surroundings have hosted numerous civilizations throughout history. Archaeological evidence suggests that settlements in the region date back to the 2000s BCE, with encounters with the Azzians in the 15th century BCE, the Milesians and Cimmerian-Scythians in the 7th century BCE, and the Persians in the 6th century BCE. Later, the region came under the rule of the Kingdom of Pontus in 183 BCE, the Roman Empire in 172 BCE, the Byzantine Empire in 395 CE, and subsequently the Empire of Trebizond, the Chepni Turks, the Mongols, and the Ottoman Empire in 1461 CE (Özmenli, 2013). The Hellenistic (330–30 BCE), Roman (100 BCE–400 CE), and Byzantine (400–1461 CE) periods are considered the most significant eras when the island experienced intense settlement and cultural activity.

During the Roman and Byzantine periods, Giresun Island preserved its religious importance and primarily functioned as a sacred site (İltar & Temür, 2018). Archaeological excavations launched in 2011 have uncovered remarkable findings that shed light on the island's multilayered history. These discoveries include remnants of a Roman-era temple later converted into a Byzantine church,

human skeletal remains, Byzantine and Ottoman coins, ceramic fragments, terracotta lids, architectural pieces, and mosaics dating to the Roman period (Giresun Provincial Directorate of Culture and Tourism, 2024). It is noted in the salnames (official Ottoman yearbooks) that Giresun Island, part of the Trabzon Province in the second half of the 9th century, was uninhabited and housed a castle (Doksanaltı, Arslan, & Mimiroğlu, 2010). Correspondences and political developments of the period were analysed based on archival sources by Örenç (2009). In 1890, Vital Cuinet mentioned a small church, a lighthouse (from the Ottoman period), and fortifications (Doksanaltı, Arslan, & Mimiroğlu, 2010). However, the lighthouse has not survived to the present day. During excavations in 2012, more human skeletal remains were uncovered, and in 2015, a chapel known as the "Monastery" and associated burial areas were discovered. Furthermore, numerous amphorae, ceramic vessels, glass artefacts, coins, pithoi, and metal ornaments representing various historical periods were found (Giresun Provincial Directorate of Culture and Tourism, 2024).

Protection Status and Legal Regulations of Giresun Island: The state-owned island has been allocated to the Ministry of Culture and Tourism. It was declared a second-degree natural and archaeological protected site by the Trabzon Regional Board for the Conservation of Cultural and Natural Assets with decision No. 1029 dated 17.05.1991 (Vııl et al., 2008). Later, the conservation status of Giresun (Aretias) Island was changed to "Qualified Natural Site Area" by decision No. 882 dated 19.04.2018 of the Trabzon Regional Board for the Conservation of Cultural Heritage and Ministerial Approval No. 249044 dated 23.10.2019 (Çevre Şehircilik ve İklim Değişikliği Bakanlığı, 2019).

Giresun Island is a significant cultural and natural heritage site due to its historical and ecological richness. Dating back to the 3rd century BC, the island contains remnants from the Roman and Byzantine periods, including fortification walls, watchtowers, a monastery, a chapel, cisterns, wells, an inner castle, and ample storage containers (pithos) (Figure 3). Cultural elements such as the Hamza Stone are also located on the island (Figure 4).

The island currently contains a pier that needs renovation, a small structure, and a serender (traditional storage building) that requires restoration. The structure was initially constructed to be used as an excavation house during archaeological digs but is no longer in use. Apart from the existing facilities, no additional modern structures have been built on the island.

With its historical and ecological values, Giresun Island also has significant tourism potential. Today, boats access the island using a concrete platform on the southern coast.

In 2022, the island was granted the status of "Ören yeri" (applicable archaeological site or visitable

archaeological site), and environmental planning projects were completed by the General Directorate for Cultural Heritage and Museums of the Ministry of Culture and Tourism. The Trabzon Regional Board approved these projects for the Conservation of Cultural Heritage, and implementation works on the island have commenced. The island's designation as an Ören Yeri marks an important step in protecting its ecological, cultural, and touristic values for future generations. The initiation of implementation efforts following the approval of the environmental planning projects is a critical development toward introducing the island to tourism through ecotourism principles.

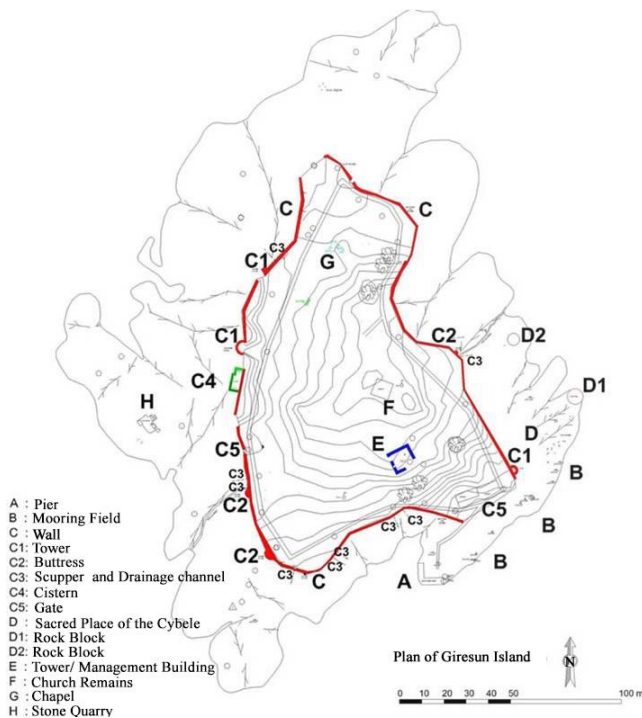


Figure 3. Plan of Giresun Island (Republic of Turkey Ministry of Culture and Tourism, 2010).



Figure 4. Hamza stone and Tower- Management building (Ak, 2023)

MATERIAL AND METHOD

Study Area: The research was conducted on Giresun Island, located in the eastern Black Sea approximately 1.6 km off the coast of Giresun Province, Türkiye (40°55'44" N, 38°26'10" E) (Figure 5). The island spans about 4 hectares (46.8 decares) and is designated as a

second-degree archaeological and natural protected site by the Turkish Ministry of Culture and Tourism.

Giresun Island is situated within the Black Sea climatic zone, which is characterized by year-round precipitation, relatively cool summers, and mild winters along the coast, while higher elevations experience cold and snowy conditions (MGM, 2025). Water scarcity is not observed in the region. According to the 1991-2020 climate normal published by the Turkish State Meteorological Service, the annual average temperature in Giresun Province is approximately 14.7 °C. Monthly averages range from 7.2 °C in February-the coldest month-to 23.4 °C in August-the warmest month. The annual average precipitation is 1,291.6 mm (MGM, 2025). Rainfall is distributed evenly throughout the year, contributing to the region's humid character. Relative humidity typically ranges between 70% and 80% (Çevre Şehircilik ve İklim Değişikliği Bakanlığı, 2005; Apaydın, 2024). These climatic conditions support dense vegetation and a high diversity of flora and fauna on the island.

The highest point of the island is approximately 24 metres above sea level. The island features a predominantly sloping terrain, with some areas-particularly between the pier and the former excavation shelter-having gradients steeper than 25 %. The island is surrounded by rocky shores, which contribute to its natural coastal morphology and limit access to specific landing points.

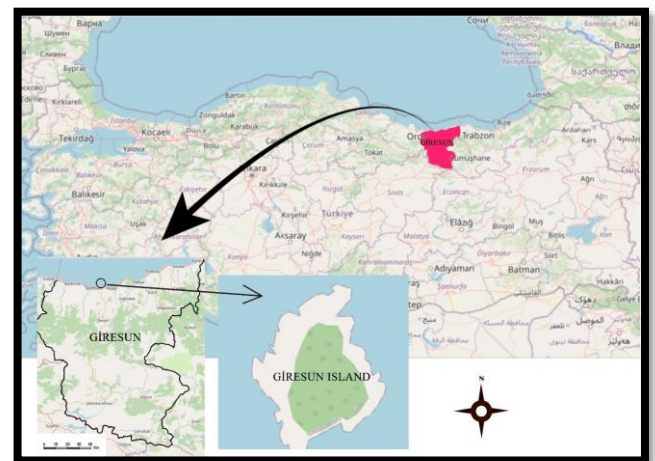


Figure 5. Geographic location of Giresun Island (the base map was obtained from QGIS).

Data Collection Methods

The data collection process in this study was conducted through a multi-method approach, combining both primary and secondary sources to evaluate the ecological, cultural, and managerial context of Giresun Island. The process included the following stages:

- **Literature review:** Academic publications, government reports, and archival documents related to Giresun Island's ecological and historical

significance were examined. Key sources included documents from the Ministry of Culture and Tourism, the Ministry of Environment, Urbanisation and Climate Change, and relevant peer-reviewed literature.

- **Field Observations:** On-site observations were carried out during two separate field campaigns—August 2022 and January 2023. These field visits enabled researchers to document vegetation types, faunal activity (especially bird species), archaeological structures, infrastructure condition, and general accessibility under differing climatic conditions. The collected data also informed the estimation of correction factors used in the carrying capacity analysis.
- **Expert interviews:** Semi-structured interviews were conducted with a total of nine experts selected through purposive sampling, based on their direct involvement with Giresun Island or their expertise in relevant disciplines. The expert panel included:
 - 3 archaeologists (including the head of the island's archaeological excavation team),
 - 2 architects (one of whom specialises in restoration),
 - 1 environmental engineer,
 - 1 landscape architect,
 - 1 civil engineer, and
 - 1 mechanical engineer.
- Mechanical and civil engineers were included to assess the technical feasibility of proposed infrastructure improvements such as pathways, signage, waste systems, and pier accessibility. The interviews focused on issues such as conservation restrictions, visitor infrastructure needs, archaeological site sensitivity, and administrative limitations.
- Face-to-face interviews were conducted during the field visits in August 2022 and January 2023, while the remaining interviews were held online. Interview transcripts were thematically analysed to extract key patterns related to ecological and archaeological protection priorities, tourism infrastructure requirements, and institutional management capacity. The insights gained were used to inform:
 - the identification of environmental and cultural correction factors in the RCC calculation,
 - the determination of the management coefficient for ECC, and
 - the development of practical and stakeholder-informed strategic recommendations for sustainable ecotourism planning on the island.

- **Cartographic and Spatial Analysis:** Spatial analyses were conducted using QGIS v3.28, based on AutoCAD-based current condition maps provided by the Ministry of Culture and Tourism. The maps were georeferenced and analysed to calculate the usable area for tourism activities and to support the Physical Carrying Capacity (PCC) assessment through basic area and slope evaluations.

Data Analysis Methods: The collected data were analysed using a combination of qualitative interpretation and quantitative modelling techniques, as follows:

- **Carrying Capacity Calculation:** Visitor thresholds were calculated using the Cifuentes (1992) three-tier model, which includes Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). Spatial measurements, ecological sensitivities (e.g., bird breeding periods), and operational factors were incorporated as correction coefficients.
- **Management Capacity Assessment:** The island's current and planned operational readiness was evaluated using a structured scoring system consisting of eight management indicators (e.g., staffing, waste management, visitor monitoring). The resulting management coefficient was used to determine the ECC.
- **Ecological and Cultural Inventory Assessment:** Observed plant species, bird habitats, and archaeological structures were catalogued to evaluate ecological sensitivity and cultural value. These findings supported the interpretation of constraints in the RCC stage and informed strategic recommendations for sustainable tourism development.
- **Legal and Institutional Context Evaluation:** The site's conservation status and legal protection history were analysed to understand policy frameworks governing visitor access, permissible development, and cultural preservation. This analysis supported recommendations for adaptive planning and stakeholder integration.

Carrying Capacity: The Recreational Carrying Capacity (RCC) of Giresun Island was calculated using the carrying capacity assessment method developed by the Cifuentes (1992). This method assesses three levels of capacity: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). The carrying capacity model developed by Cifuentes (1992) was selected for this study due to its structured, multi-tiered approach that enables a progressive refinement from theoretical capacity (PCC) to operational capacity (ECC). Unlike alternative frameworks such as Limits of Acceptable

Change (LAC) (Stankey et al., 1985), Visitor Experience and Resource Protection (VERP) (US National Park Service, 1997), or the Tourism Optimization Management Model (TOMM) (Manidis Roberts Consultants, 1997), which focus predominantly on qualitative indicators and visitor perceptions, the Cifuentes model provides a quantifiable and replicable method particularly suited for small, ecologically sensitive sites with limited data availability. Given the current lack of continuous visitor monitoring, survey-based perception data, and long-term management benchmarks on Giresun Island, the Cifuentes model offers a pragmatic and scalable tool for estimating sustainable visitor thresholds. Nevertheless, the integration of alternative models in future studies-particularly those incorporating social and perceptual indicators-would enhance the robustness and multidimensionality of carrying capacity analyses.

Based on these methods, ecotourism-oriented landscape management and tourism planning strategies were developed for the sustainable development of Giresun Island (Table 2).

These multi-layered capacity analyses have been implemented in island contexts such as Goa (India), Vis (Croatia), Mykonos (Greece), and Mauritius, where tourism pressure, environmental sensitivity, and infrastructural limitations have been integrated into sustainable tourism planning frameworks, resulting in successful scenarios (Coccossis, 2002). Similarly, in Türkiye, carrying capacity-based studies have been conducted in areas such as Beyşehir Lake National Park (Göktaş & Arpa, 2016), Termessos (Sayan & Atik, 2011), Pamukkale Hierapolis (Erdemir, 2018), and Bozcaada (Doğan & Gümüş, 2014).

Table 2. Carrying Capacity Assessment framework.

Level	Concept	Formula	Description	Giresun Island Application
PCC Physical Carrying Capacity	The maximum number of visitors an area can accommodate physically	$PCC = A / U_a \times R_f$	Considers only the physical space available without environmental limitations	- Total area: 3000 m² - Required space per person: 4 m² - Rotation factor: 3 - Result: 2,250 visitors/day
RCC Real Carrying Capacity	PCC adjusted for environmental and infrastructural limitations	$RCC = PCC \times (1 - C_{f1}) \times (1 - C_{f2}) \times \dots \times (1 - C_{fn})$	Correction factors (Cf) include environmental, infrastructural, and cultural constraints	- C_{f1} = Bird breeding season (0.25) - C_{f2} = Lack of infrastructure (0.20) - C_{f3} = Archaeological sensitivity (0.15) - C_{f4} = Waste management issue (0.10) - C_{f5} = Rainy days (0.44) - Result: ~578 visitors/day
ECC Effective Carrying Capacity	RCC adjusted based on management capacity	$ECC = RCC \times M$	Considers actual operational capacity (staffing, monitoring, education, facilities)	- Management score: 23/40 - Management coefficient (M): 0.575 - Result: ~332 visitors/day

Note: A = Total area available (m²); U_a = Space per visitor (m²); R_f = Rotation factor; C_f = Correction factor; M = Management coefficient.

FINDINGS

Effective visitor management in sensitive natural and archaeological sites like Giresun Island requires a systematic approach that balances conservation with controlled use. One of the most widely accepted frameworks for this purpose is the carrying capacity assessment method developed by Cifuentes (1992), which categorizes capacity into three progressive levels: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). This model has been successfully applied in numerous protected areas, including national parks and heritage landscapes. In this study, this method was employed to assess the suitability of ecotourism development on Giresun Island, beginning with an analysis of the Physical Carrying Capacity. When evaluating tourism capacity in the context of archaeological and natural protected areas, the concept should not only be understood as the ability to meet current visitor demands and ensure their satisfaction, but also as a threshold that defines the limits of development without jeopardizing the sustainability of natural systems. Capacity represents a flexible framework that can expand or contract depending on environmental conditions. Capacity is

defined here as the maximum number of visitors that a destination can accommodate while maintaining environmental balance and avoiding overexploitation of resources, all while optimizing visitor satisfaction. Moreover, external factors such as climate, infrastructure availability, and management practices are considered as key determinants in defining this threshold.

Physical Carrying Capacity (PCC): Physical Carrying Capacity (PCC) refers to the maximum number of visitors that a site can physically accommodate within a specific time frame, without causing congestion or compromising the basic functionality and safety of the area. The calculation of tourism carrying capacity relies on the Cifuentes (1992) framework, which provides a structured methodology for progressively refining theoretical capacity into operational thresholds. It represents the theoretical maximum number of visitors that the site can host, disregarding environmental or managerial constraints.

On Giresun Island, the total area available for visitor use is approximately 3000 m². According to spatial analysis, an average of 4 m² per person is required to ensure that each visitor can move comfortably, observe the surroundings without causing harm, and that basic safety

conditions are maintained (Cifuentes, 1992; UNEP & WTO, 2005). This figure is widely adopted in the planning of nature trails and cultural heritage sites to avoid overcrowding and to support conservation-oriented tourism management. With visiting hours from 09:00 to 17:00, it is assumed that each tour group spends approximately two hours on the island. Consequently, a maximum of three separate tour groups can be accommodated daily. Based on these parameters, the Physical Carrying Capacity (PCC) of Giresun Island has been calculated using the following formula: $PCC = A/UaxRf$

Where:

- A = Total available area for tourism use (m²)
- Ua = Area required per user (m²/person)
- Rf = Daily rotation factor (how many groups per day can use the space)

$$PCC = 3000/4 \times 3 = 750 \times 3 = 2250 \text{ visitors/day}$$

Real Carrying Capacity (RCC): While the Physical Carrying Capacity (PCC) represents the maximum number of visitors an area can accommodate under ideal physical conditions, it does not take into account environmental, ecological, infrastructural, or cultural constraints that may limit actual usability. The Real Carrying Capacity (RCC) refines this estimate by incorporating a series of correction factors that reflect the real-world limitations of the site, such as sensitive wildlife habitats, lack of permanent facilities, or risks to archaeological assets. Following the method proposed by Cifuentes (1992), RCC is calculated by applying these correction coefficients to the PCC value, yielding a more realistic and sustainable threshold for visitor management in protected or fragile environments like Giresun Island. The Real Carrying Capacity (RCC) of Giresun Island has been calculated using the following formula: $RCC = PCC \times (1 - Cf_1) \times (1 - Cf_2) \times (1 - Cf_3) \times \dots \times (1 - Cf_n)$

- **RCC** = Real Carrying Capacity (adjusted number of visitors per day)
- **PCC** = Physical Carrying Capacity (calculated maximum without limitations)
- **Cf₁, Cf₂, ..., Cf_n** = Correction factors (expressed as decimals), representing limiting conditions such as:

Cf₁ = Environmental restrictions (e.g., bird breeding seasons)

Cf₂ = Infrastructure limitations (e.g., lack of water supply or waste management)

Cf₃ = Cultural sensitivity (e.g., presence of archaeological remains) etc.

Each correction factor reduces the initial PCC to reflect real-world constraints, giving a more realistic estimate of sustainable visitation.

Based on your input about the conditions on Giresun Island:

- Bird breeding season (restricted use during 3 out of 12 months → 25% limitation): $Cf_1 = 0.25$
- Lack of permanent infrastructure (e.g., electricity via generator, water via tanks, no sewage system): $Cf_2 = 0.20$
- Presence of sensitive archaeological and natural features (risk of damage): $Cf_3 = 0.15$
- No integrated waste infrastructure (waste to be transported by boat): $Cf_4 = 0.10$

- The average annual number of rainy days in Giresun is approximately 161.1 days, indicating that about 44.1% of the year experiences rainfall (MGM, 2025). Accordingly, a correction factor for rainy days can be calculated as: $Cf_5 = 161.1 / 365 \approx 0.44$

$$RCC = 2250 \times (1 - 0.25) \times (1 - 0.20) \times (1 - 0.15) \times (1 - 0.10) \times (1 - 0.44)$$

$$RCC = 2250 \times 0.75 \times 0.80 \times 0.85 \times 0.90 \times 0.56 \approx 578$$

$$RCC = 2250 \times 0.75 \times 0.80 \times 0.85 \times 0.90 \times 0.56 \approx 578$$

Real Carrying Capacity (RCC) = ~578 visitors/day

Effective Carrying Capacity (ECC)

Even after environmental and infrastructural limitations are considered through the Real Carrying Capacity (RCC), a further refinement is required to account for the site's actual operational and managerial capacity. The Effective Carrying Capacity (ECC) refers to the number of visitors that can be realistically managed on a daily basis, considering the availability of personnel, monitoring systems, emergency protocols, visitor education programs, and supporting infrastructure. This value is obtained by multiplying the RCC by a management capacity coefficient (M)—a normalised score derived from qualitative or quantitative assessments of on-site management capabilities. As such, ECC provides the most accurate and applicable figure for sustainable tourism planning, especially in sensitive areas like Giresun Island where ecological and cultural values require active protection. This figure reflects the maximum number of visitors that can be effectively managed given the current infrastructure and operational capacity. The Effective Carrying Capacity (ECC) for Giresun Island was calculated using the formula:

$$ECC = RCC \times M$$

Where:

- **ECC** = Effective Carrying Capacity (maximum number of visitors that can be effectively managed)
- **RCC** = Real Carrying Capacity = 578 visitors/day
- **M** = Management capacity coefficient (a decimal score from 0 to 1)

The management capacity assessment for Giresun Island was developed based on consultations with experts from the Turkish Ministry of Culture and Tourism (Table 3). In this context, existing and planned site management elements were evaluated using a scoring system ranging from 0 to 5, with a maximum total score of 40. According to this method, each management criterion received 5 points if fully implemented, 1–4 points if partially implemented, and 0 points if absent. This quantitative evaluation provides a structured basis for determining how effectively the site can support sustainable tourism activities (Cifuentes, 1992; UNEP & WTO, 2005).

Table 3. Management Capacity Evaluation for Giresun Island.

Criteria	Current/Planned Situation	Score (0–5)
Sufficient staff availability	Partially available personnel (based on ministry consultation)	4
Monitoring systems (cameras, sensors)	Planned camera system installation	3
Informational signage and wayfinding	Signage and guidance planned	4
Waste management infrastructure	No fixed infrastructure, waste will be transported	1
Visitor entry/exit control	Visitor flow will be controlled	4
Emergency response plans	No emergency response system yet	1
Visitor guidance and education programs	Guided visitor tours planned	3
Ecotourism-friendly infrastructure	Viewing platforms, trails, solar energy and water tanks planned	3

Total Score: 23 out of 40
Management Coefficient (M): 0.575
Real Carrying Capacity (RCC): 578 visitors/day
 $ECC=578\times0.575= \sim 332$ visitors/day

DISCUSSION

The application of the recreation carrying capacity framework on Giresun Island offers critical insights into the challenges of managing tourism in fragile insular environments. Rather than focusing solely on numerical thresholds, this study underscores how physical, ecological, and managerial variables interact to shape the island’s capacity for sustainable tourism. The Cifuentes (1992) methodology proved particularly effective in structuring a tiered approach-highlighting the importance of distinguishing between theoretical limits and real-world applicability. By examining infrastructure constraints, seasonal environmental sensitivities, and institutional preparedness, this discussion aims to contextualize the carrying capacity findings within broader debates on sustainable tourism planning in protected coastal and island landscapes.

This pattern is consistent with findings from other protected areas, such as Termessos National Park, where Sayan and Atik (2011) found that theoretical visitor capacities were rarely achievable due to real-world limitations including trail erosion, inadequate infrastructure, and unregulated visitor behaviour. Similarly, Gül and Akten (2005) emphasize that recreational carrying capacity should not be considered a fixed number but rather a flexible tool incorporating physical, social, and ecological dimensions, especially in vulnerable ecosystems.

Giresun Island, with its protected natural and archaeological features, faces seasonal overcrowding during peak summer months. As Göktuğ and Kurkut (2016) underscore, visitor management in protected areas must be informed by sustainable strategies that account for ecological limits and management capacities. The island’s climatic conditions—high humidity levels and precipitation exceeding 1,200 mm annually (MGM, 2025)—further amplify the need for seasonal zoning, as also proposed by Yüksek et al. (2024) in ecotourism planning efforts in similar Black Sea landscapes.

In line with these observations, Yüksek, Cengiz, and Yüksek (2008) stress that effective planning in ecologically sensitive areas must be grounded in integrated assessments that account for ecological thresholds, user pressure, and administrative limitations.

Furthermore, this study supports the view that carrying capacity must be treated not as a static threshold but as a planning and management tool responsive to environmental feedback, managerial limitations, and visitor behaviour trends. This perspective aligns with the international ecotourism literature, where Ceballos-Lascuráin (1996) and Buckley (2009) advocate for conservation-first approaches that integrate legal protection, stakeholder participation, and low-impact infrastructure design. Similarly, Coccossis (2002) as well as McCool and Lime (2001) emphasize that carrying capacity should be understood as a multidimensional, dynamic framework that balances ecological resilience, visitor experience, and operational realities.

The lack of regulated access routes, comprehensive monitoring systems, and interpretive infrastructure limits the capacity for adaptive visitor management. As highlighted by Göktuğ and Kurkut (2016), Turkish protected areas frequently lack formal monitoring frameworks, which hinders real-time capacity regulation and long-term sustainability planning. At this point, the integration of spatial tools such as GIS and remote sensing technologies can enhance dynamic decision-support mechanisms, as suggested in the broader literature. In this context, Sayan and Atik (2011) emphasize the need for new monitoring and management systems that take site-specific administrative limitations into account.

Moreover, the social dimension of carrying capacity—such as visitor satisfaction, local community support, and crowding perceptions—plays a vital role in sustainable tourism development. The case of Nevşehir, analysed by Tabak and Özdemir (2020), shows how exceeding social carrying capacity thresholds can lead to negative visitor experiences and conflict with local stakeholders. On Giresun Island, the absence of visitor data collection mechanisms and local stakeholder engagement further limits sustainable tourism potential.

Legal and institutional frameworks must also support capacity-based tourism policies. As Çeti (2018) and Avcı (2007) argue, planning efforts should integrate carrying capacity indicators into tourism policies, ensuring that resource protection is prioritised over short-term economic gains. Similarly, the necessity for low-impact infrastructure, community participation, and enforcement mechanisms is repeatedly emphasised in both national and international literature.

Ultimately, the findings of this study reaffirm the conceptual view that carrying capacity should be treated not as a rigid limit but as a dynamic management tool that responds to environmental feedback and operational capacity. Giresun Island's current visitor numbers may not yet exceed its theoretical thresholds; however, the combination of seasonal overcrowding, sensitive ecosystems, and weak monitoring systems presents a clear risk. Without the institutionalization of carrying capacity indicators and strategic planning, the long-term sustainability of the island's ecological and cultural heritage may be compromised.

RECOMMENDATIONS

Ecotourism, which emphasizes responsible travel to natural areas that conserve the environment and enhance the well-being of local communities (TIES, 1990), provides a suitable framework for guiding sustainable tourism development on Giresun Island. The island's legal designation as a protected natural and archaeological site offers a firm foundation for low-impact tourism initiatives. However, realizing this potential requires clear planning, infrastructural investment, and conservation-based visitor management.

Giresun Island's rich biodiversity, endemic plant species, bird habitats, and mytho-historical landscape demand that tourism development be conducted within carefully defined environmental limits. The island's infrastructural constraints—such as the absence of a wastewater treatment system and reliance on alternative energy—necessitate low-intensity, small-scale visitation, which aligns with the core principles of ecotourism (Honey, 1999).

Strategic planning for the island must integrate ecological sensitivity with socio-economic benefits for surrounding communities. According to Weaver (2001), effective ecotourism planning involves zoning sensitive areas, implementing visitor capacity limits, and designing infrastructure in harmony with the natural landscape. For Giresun Island, such planning should include nature-compatible walking trails, controlled docking and entry systems, interpretive signage, and trained guides to ensure both conservation and education. Similarly, McElroy and de Albuquerque (2002) emphasize that sustainable tourism

in small islands must address external economic dependencies and environmental vulnerabilities through adaptive, locally integrated strategies.

Participatory planning is equally critical. As Wearing and Neil (1999) suggest, community involvement in tourism management strengthens local ownership, distributes economic benefits, and helps preserve cultural identity. Stakeholder consultations conducted during this study (e.g., Ministry of Culture and Tourism experts) revealed partial readiness in areas such as staff availability, monitoring infrastructure, and visitor services. These insights form the foundation for strategic actions to improve management capacity, including waste transport, emergency preparedness, and ecotourism infrastructure (Buckley, 2009; UNEP & WTO, 2005).

The carrying capacity assessment—based on the Cifuentes (1992) model—demonstrates the island's environmental and managerial limitations. The estimated thresholds for Physical Carrying Capacity (PCC: 2,250), Real Carrying Capacity (RCC: 578), and Effective Carrying Capacity (ECC: ~332) provide concrete reference points for regulating visitor numbers. As McCool and Lime (2001) emphasize, these thresholds should guide adaptive management that responds dynamically to environmental monitoring, seasonal variations, and infrastructure upgrades.

Similar challenges have been documented in other island contexts such as the Aeolian Islands, where environmental degradation, overcrowding, and water shortages have underscored the importance of integrated planning and diversification of tourism models. Lessons from these Mediterranean cases reinforce the urgency of promoting eco-compatible tourism that balances environmental conservation with socio-economic resilience. Informed by such insights, tailored strategies must be developed to meet Giresun Island's specific ecological and infrastructural conditions.

To operationalize sustainable tourism, the following strategic recommendations are proposed. These are organized into eight key thematic categories and are grounded in the carrying capacity analysis, expert consultations, and site-specific limitations. The goal is to support phased, adaptive, and participatory implementation of ecotourism on Giresun Island.

- **Environmental zoning and visitor regulation:** Legally enforce daily visitor limits based on the previously calculated thresholds and adjust them seasonally in response to bird breeding periods and climatic conditions. Apply seasonal and thematic zoning to protect sensitive habitats and cultural assets, including restricting access to northern nesting areas during May–July. Implement ticketing, reservation, and entry time-slot systems to manage flow and reduce peak-hour crowding.

- **Infrastructure and facilities (low-impact design):** Develop eco-compatible infrastructure such as: Solar-powered units, Composting toilets and mobile waste stations, Elevated walkways and viewing platforms built with natural materials. Prioritize small-scale, modular facilities to maintain the island's visual integrity and ecological function. Upgrade the existing pier and signage to improve access while limiting physical footprint.

- **Monitoring, technology, and data-driven planning:** Establish real-time monitoring systems (e.g., GIS, sensor-based counters, camera surveillance) to track visitor density and detect ecological stress indicators. Digitally integrate data into adaptive management systems that trigger seasonal or event-based restrictions when thresholds are approached. Explore mobile apps and digital visitor guides to reduce the need for physical signage and encourage self-guided, low-impact tourism.

- **Interpretation, education, and awareness:** For a destination as rich in natural and cultural assets as Giresun Island, the ecotourism principle emphasising the observation, study, and immersive experience of flora, fauna, and cultural heritage (Akat & Çakıroğlu, 2024) serves as a fundamental guide in structuring site-specific programmatic and experiential content. Design and install interpretive panels explaining the island's ecological and cultural significance at key points. Offer guided tours and educational programs focusing on endemic species, archaeological remains, and conservation ethics. Develop a visitor code of conduct and promote it through outreach campaigns, QR-coded media, and tour briefings.

- **Community participation and governance:** Actively involve local stakeholders in tourism operations, including guiding services, craft markets, and logistics. Establish a co-management structure among the Ministry of Culture and Tourism, local municipalities, and community-based organisations. Adopt revenue-sharing models that return a portion of tourism income to local conservation and education efforts.

- **Climate and Resilience-Oriented Measures:** Incorporate climate-responsive planning, including shoreline stabilization, rainwater harvesting, and native vegetation restoration to buffer against erosion and sea-level rise. Limit expansion of permanent structures, focusing instead on mobile, weather-resilient installations.

- **Institutional strengthening and capacity building:** Offer training programs for local guides, conservation officers, and municipal staff on ecotourism principles, biodiversity, and crisis response. Ensure ongoing institutional coordination between the Ministry of Environment, Ministry of Culture, and municipal agencies for integrated oversight. Pursue eco-

certification for tourism providers, setting standards for waste, water, energy, and interpretation practices.

- **International collaboration and funding:** Partnerships with international conservation agencies, EU-funded programs, and UNESCO initiatives can provide both technical expertise and financial support.

The implementation of ecotourism on Giresun Island presents a timely opportunity to protect its fragile ecosystem while supporting sustainable development goals. Realizing this vision requires coordinated governance, evidence-based planning, and conservation-oriented visitor management. If strategic actions are aligned with ecological thresholds and stakeholder input, Giresun Island can emerge as a leading example of low-impact tourism that preserves natural and cultural heritage for future generations.

CONCLUSION

With its exceptional ecological, cultural, and historical significance, Giresun Island offers a unique opportunity to implement sustainable ecotourism strategies. The findings of this study, which are grounded in the Carrying Capacity Assessment Model (Cifuentes, 1992), reveal that while the island's physical capacity may accommodate up to 2,250 visitors daily under ideal conditions, real-world environmental and infrastructural constraints reduce this figure to approximately 578 visitors/day (RCC). When considering the site's management capacity, the Effective Carrying Capacity (ECC) is refined to 332 visitors/day, highlighting the necessity for carefully managed and low-impact tourism policies.

This research demonstrates that strategic planning based on conservation, community involvement, and sustainable infrastructure is essential for maintaining the ecological balance of Giresun Island. The island's biodiversity, endemic flora, and role as a critical habitat for bird species require seasonal and spatial regulation of visitor flows, particularly during breeding seasons and periods of high rainfall. Investments in green infrastructure and renewable energy systems should be designed to preserve the island's natural character, and continuous environmental monitoring must support an adaptive management approach. Climate-resilient planning, eco-certification, digitalization, and international cooperation are essential complementary strategies supporting the island's long-term sustainability. These integrated approaches will make it possible to protect the ecological integrity of Giresun Island and promote a tourism model that is in harmony with nature.

In conclusion, Giresun Island represents Turkey's significant natural and cultural asset and a model site for ecotourism-driven landscape planning. The success of such

a model depends on adherence to scientific frameworks, inclusive governance, and a strong commitment to ecological integrity. Through integrated and adaptive management, Giresun Island can be preserved as a living laboratory of biodiversity and a sustainable tourism destination for future generations. To achieve this, a phased action framework is essential. In the short term, capacity-building initiatives such as training programs for local guides, ecotourism awareness campaigns, and visitor code of conduct enforcement should be prioritised to improve stakeholder readiness and enhance responsible tourist behaviour. In the medium term, investments in low-impact infrastructure-including solar-powered visitor facilities, ecological sanitation units, and controlled entry systems-will be critical to align tourism operations with ecological thresholds. In the long term, establishing partnerships with international conservation organisation, pursuing UNESCO Biosphere Reserve status, and implementing regional monitoring networks can institutionalize environmental stewardship and position Giresun Island as a globally recognised model for sustainable island tourism. These integrated strategies will preserve the island's ecological integrity while fostering inclusive and resilient tourism development.

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