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Landscape character assessment and sustainable planning strategies for coastal lagoons in Türkiye: A case study approach

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Abstract
Coastal lagoons, straddling the interface between terrestrial and aquatic ecosystems, represent critical biodiversity hotspots and are significant for ecological stability and socio- economic sustenance. This study investigates the ecological and cultural landscape values of selected coastal lagoons in Türkiye— Balık, Büyükçekmece, Köyceğiz, and Paradeniz Lagoons— employing the Landscape Character Assessment (LCA) methodology. Positioned uniquely along various seas (Black Sea, Marmara Sea, Aegean Sea, and Mediterranean Sea), these lagoons undergo dynamic environmental and anthropogenic pressures. Türkiye's substantial legislative framework aimed at coastal conservation, including national laws and international conventions, provides a backdrop against which the effectiveness and implementation of environmental protections are evaluated. The research integrates Geographical Information Systems (GIS) mapping and administrative data analysis to illuminate the geographical, legal, and ecological nuances influencing lagoon management. This study's multi-dimensional approach reveals significant disparities in protective measures and planning, underscoring the need for refined, location- specific environmental management strategies. By highlighting the interaction between human activities and natural settings, the research advocates for a balanced approach to coastal lagoon usage and conservation, aiming to enhance ecological integrity while accommodating socio- economic realities. The findings call for a comprehensive, integrated management strategy that synergizes LCA with robust legal and planning frameworks to ensure the sustainable future of these vital ecological zones.

1. Introduction

Since the early years of human history, people have accepted coastal areas as attractive due to ecological, social, and cultural reasons. These unique areas are dynamic and sensitive transitional zones where the interface between the land and aquatic ecosystems (Beatly et al., 2002; Zhou et al., 2022; Gong et al., 2023). This paper examines the role of coastal lagoons within the landscape ecology framework, primarily through the application of Landscape Character Assessment (LCA) in selected coastal settings in Türkiye. Furthermore, it integrates sustainable planning strategies to support the conservation and effective management of these fragile ecosystems.

As one of the essential parts of coastal areas, a coastal lagoon is a shallow water body between the land and the sea that contains brackish water. It is often surrounded by a barrier island, sandbank, or coral reef and is affected by both tidal and freshwater inflows (Kjerfve, 1994; Pérez-Ruzafa et al., 2019; Dalrymple & Rivers, 2023). Considering their geographical and water dynamics characteristics, coastal lagoons are critically important due to their biological diversity and ecological richness.

Ecotones indicate the transitions between ecosystems along environmental gradients and are pivotal interfaces within coastal areas where multiple biological populations converge. These transition zones between freshwater and marine environments improve connectivity between biodiversity and functions of the ecosystems. These vital zones change due to biotic and abiotic effects (Jobe & Gedan, 2021; Grey et al., 2023).

The increased environmental degradation has also positively affected socio-economic development in recent times. However, this situation negatively pressures natural and ecologically characteristic areas such as coastal zones. It is vital to integrate sustainable development strategies to reduce the effects of these global environmental changes and protect the ecological integrity of coastal areas (Celliers, 2015; Popova & РудеНко, 2021).

The need for water policy frameworks and stringent sustainable conservation strategies to limit negative impacts on land and water ecosystems and coastal lagoons, where the human element meets the landscape, has come to the fore in recent decades. These are crucial for sustaining wetland ecosystems and enhancing the resilience of coastal areas (Pérez-Ruzafa et al., 2019; Widowati, 2022). The European Environment Agency (EEA) created the Corine Land Cover (CLC) database to describe and track European Landscapes. This database also includes data for Türkiye. These data provide practical and valuable information for different years for managing and pro-

Figure 1. *Location of Türkiye and selected coastal lagoons in Türkiye.*

tecting the sustainability of land and water bodies (Marthe et al., 2015; EEA, 2023).

Landscape character, defined as 'the totality of elements that distinguish a landscape from others', provides essential data in the decision-making process for sustainability regarding an area's landscape (Uzun, 2018). LCA is one of the most critical methods in mapping and detailing landscape identities (NatureScot, 2019; Gülçin & Yılmaz, 2020; Wang et al., 2023). Türkiye has signed the European Landscape Convention (2003), which undertakes the implementation of regulations for defining, protecting, and managing landscape quality targets. According to this agreement, LCA is an approach that should be used in studies to be conducted on an area's characteristics (Uzun, 2018; Machar, 2020).

LCA studies at different scales in various Turkish fields have been discussed until today. These studies have generally been conducted out on a macroscale and have guided numerous academic issues (Atik & Ortaçeşme, 2010; Uzun, 2011; Atabeyoğlu & Bulut, 2013; Görmüş & Oğuz, 2013; Şahin et al., 2014; Atik et al., 2018; Baylan, 2018; Koç & Yılmaz, 2020; Görmüş et al., 2021; Şengür & Nurlu, 2021). However, on a micro-scale, LCA has not previously been conducted for any coastal lagoon other than Titreyen Gol (Atik & Ortaçeşme, 2010).

With its location and geographical features, Türkiye is one of the critical ecological transition zones in the east-west (Asia-Europe) and north-south directions (Black Sea-Mediterranean Sea). The country has a long coastline and different coastal morphologies. An aspect of the vulnerable environment along Türkiye's coastline is coastal lagoons that always need targeted care and safeguarding to maintain sustainability. Within the research carried out on coastal lagoons in Türkiye until today, issues such as general conditions of lagoons, socioeconomic structures, populations and growth parameters of fish caught, pollution of the waters, and physicochemical parameters have been emphasized (Inandik, 1965; Kabdaşlı et al., 1996; Kırdağlı, 1999; Şeker et al., 2002; Balkis et al., 2011; Altınsaçlı et al., 2015; Kaleli, 2019; Mertol et al., 2019; Reis & Ateş, 2020; Altas, 2021; Dervişoğlu, 2022; Saygu, 2022; Köker et al., 2023).

Bayrak's (2013) study is the most comprehensive study to employ aerial photographs and Türkiye's topographic maps, integrated with GIS techniques, to map and analyze Türkiye's coastal lagoons' geomorphology and spatial distribution. This research identified key challenges facing these ecosystems and offered targeted short-term management strategies, although these fall beyond the scope of traditional LCA methodologies.

This study focuses on coastal lagoons, encompassing a diverse landscape shaped by natural features, ecosystems, and land use patterns. Effective management of coastal lagoons within the balance of conservation and utilization requires their evaluation within Türkiye's administrative framework.

The primary objective of this paper is to define and assess the ecological and land use attributes of coastal lagoons in Türkiye while concurrently developing sustainable landscape planning strategies tailored to their specific conditions. The coastal lagoons examined in this study include Balık, Büyükçekmece, Köyceğiz, and Paradeniz, each situated along different seas— namely the Black Sea, Marmara Sea, Aegean Sea, and the Mediterranean Sea (Figure 1). Their selection is based not only on their representation of four distinct marine environments but also on their diverse urban dynamics, encompassing urban, rural, and rural-urban fringe areas, as well as their varying spatial characteristics. This carefully curated selection enables a comprehensive exploration of sustainable landscape planning strategies, integrating distinct environmental variables and governance frameworks specific to each coastal lagoon.

Since 1937, Türkiye has enacted more than 20 national laws, regulations, and international agreements aimed at managing coastal lagoons and their ecosystems, including the Coastal Law (1990), the Ramsar Convention on Wetlands (1994), the European Landscape Convention (2003),

and the Regulation on the Protection of Wetlands (2014). However, current legislation only covers some coastal lagoons in Türkiye. The numerous and different regulatory categories reflect that some coastal lagoons fall under local government jurisdiction, others have drinking water basin status, and some are protected under different protection statuses. For this reason, the legislation regarding coastal lagoons in Türkiye needs to create a more precise and comprehensive protection status.

The interaction between coastal lagoons and human activities highlights the need for strategic conservation management to reduce anthropogenic pressures, such as construction and water quality degradation, that threaten the ecological integrity of these areas. Although Türkiye has adopted an almost entirely protectionist paradigm for its coasts through international conventions and legal documents, it still needs a more comprehensive protection status for its coastal lagoons.

This study investigates four selected coastal lagoons to develop sustainable landscape planning strategies that balance ecological protection with practical use, aiming to ensure the long-term preservation of these critical ecosystems.

2. Materials and method
The study focuses on four coastal lagoons in Türkiye: Balık, Büyükçekmece, Köyceğiz, and Paradeniz. The selected coastal lagoons represent various dynamics (urban, rural, rural-urban), spatial sizes, and representativeness for Türkiye's various coastal regions. Therefore, samples determined by comprehensive analysis cover many different changes.

The study involves six phases of research. Its first step is the selective search for coastal lagoons to study. In the subsequent phase, GIS-based mapping and database techniques are used for in-depth mapping research to generate a complete visual depiction of these coastal lagoons used to assess spatio-temporal changes, including a progressive buffer zone analysis ranging from 0.25 km to 5 km and associated risk assessment procedures.

The first stage of the spatiotemporal analysis handles land cover/use alterations within the buffer areas of coastal lagoons with a radius of 250 meters from the coastline. 1990 and 2018, CLC datasets were used for this stage. The horizontal region between the lagoon and the adjacent land has a rich texture regarding ecological importance and biodiversity (Tavares & Siciliano, 2013). Thus, changes in buffer areas at 1 km, 2 km, 3 km, 4 km, and 5 km were also analyzed to address indirect impacts on coastal lagoons. These buffer zones were determined by adapting 2017 dated Regulation on the Protection of Drinking-Use Water Basins data (Ministry of Forestry and Water Affairs, 2017).

In addition, the three-level hierarchical system that forms the CLC database formed the basis of this research. The spatiotemporal analysis employed Level 1 classifications, encompassing five primary land cover categories: artificial surfaces, agricultural fields, forest and semi-natural areas, wetlands, and water bodies. The comprehensive nature of this dataset allows for a de-
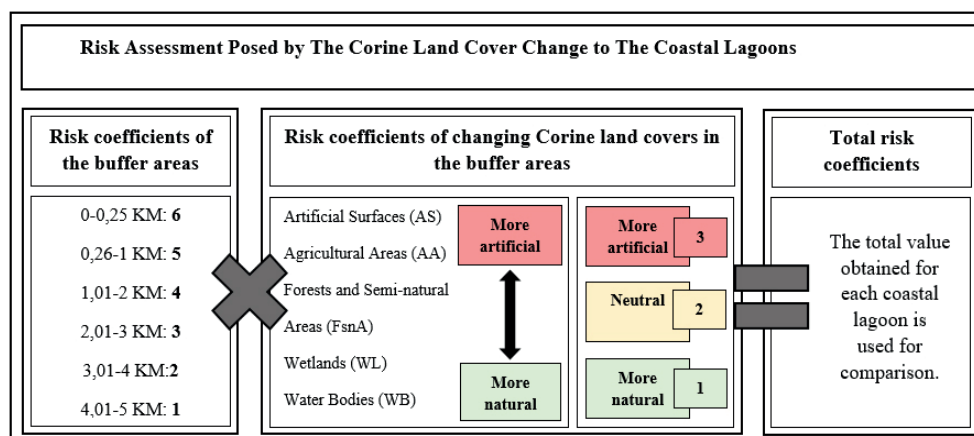

Figure 2. *Risk assessment posed by the Corine Land Cover change to the coastal lagoons.*

tailed examination of the spatiotemporal dynamics of landscape changes within the coastal lagoon environment. The analysis highlights that transitions between land use patterns and ecologically driven changes are ongoing within this sensitive coastal interface zone (Figure 2).

The dynamic nature of land use changes in coastal lagoons creates varying levels of ecological risk. However, not all land cover changes impose an immediate or equivalent threat to the coastal lagoon ecosystem. To systematically evaluate these risks, the study meticulously categorized and tabulated each land cover change detected within the buffer areas surrounding the coastal lagoons based on its nature and impact on the ecosystem. It used a structured risk assessment framework.

The study applied a dual-coefficient system to quantify the level of risk associated with land cover changes. The first coefficient represented the type of land cover transition according to the Corine Level 1 classification and ranged from 1 to 3. A coefficient of 1 indicated a transition to the same land cover category, signifying relative stability and minimal ecological disruption. A coefficient of 2 reflected a shift toward a more natural category, suggesting potential ecological improvement. A coefficient of 3 represented a transition toward a more artificial category, signaling increased ecological degradation and heightened vulnerability.

In addition to the land cover change coefficients, the study assigned a separate risk coefficient to the buffer areas surrounding the coastal lagoons, ranging from 6 to 1. This coefficient was inversely proportional to the distance from the lagoon, with areas closer to the lagoon facing greater vulnerability to ecological disturbance. A coefficient of 6 corresponded to changes occurring closest to the coastal lagoon, reflecting higher ecological sensitivity and greater vulnerability to disturbance. In contrast, the study assigned a coefficient of 1 to changes occurring at the farthest boundary of the buffer area, reflecting lower direct ecological impact and reduced vulnerability.

The final risk value for each lagoon was calculated by multiplying the land cover change coefficient and the buffer area coefficient. This approach provided a weighted measure of the ecological risk posed by land cover changes, effectively capturing both the type of transition and its spatial proximity to the coastal lagoon. Total risk values were computed for four distinct periods: 1990, 2000, 2006, and 2018.

The risk assessment employed an ordinal measurement scale, where risk levels were categorized into three levels (Good, Fair, and Bad) based on a structured risk scoring system. Ecological changes were defined based on land cover transitions influencing natural habitats and biodiversity, while cultural changes were identified through land use transitions reflecting human interventions, such as urbanization, agricultural expansion, and infrastructure development. The map legend reflects the three-tier classification of total risk scores: Good (1–4), Fair (5–9), and Bad (≥10), capturing both the type of transition and its spatial proximity to the lagoon.

To facilitate interpretation, the resulting values were systematically classified into three categories. Total risk values between 1 and 4 were categorized as Good, indicating minimal ecological disturbance and relative stability. Values between 5 and 9 were classified as Fair, reflecting moderate ecological disturbance or partial recovery. Values of 10 or higher were assigned to the Bad category, representing significant ecological degradation and heightened vulnerability.

This classification framework offers a more nuanced understanding of the ecological changes affecting coastal lagoons over time. The weighted-criteria method used in this analysis ensures that both the type of land cover transition and its spatial proximity to the lagoon are integrated into the risk assessment. This approach enhances the accuracy and comprehensiveness of the ecological vulnerability evaluation, providing valuable insights into the underlying drivers of landscape change and their potential ecological consequences within coastal lagoon ecosystems.

In the third phase, the study evaluates the intrinsic qualities of the land-

scape, likely employing qualitative and quantitative methods. Explore the interplay between the quantitative and qualitative aspects of the principles of LCA. A LCA was undertaken to identify the unique characteristics of each selected coastal lagoon. These steps include identifying and classifying key landscape features, assessing ecological value, and understanding the cultural meaning.

LCA revealed the unique features of each coastal lagoon and its sustainability against environmental pressures.

LCA and Land Cover Classification (LCC) represent different methodologies in landscape analysis. LCA is a comprehensive approach that identifies natural, aesthetic, cultural, and historical dimensions to delineate the unique landscape characteristics of an area and supports management and conservation strategies for the targeted purpose. On the other hand, LCC quantitatively evaluates temporal and spatial changes in vegetation and land cover to facilitate ecological impact assessment and sustainable policies for the area's landscape. Although both methods aim to guide land use planning, LCA emphasizes more subjective valuation while LCC focuses on objective data analysis.

The fourth phase, 'Administrative Framework Analysis,' examines the complexities and policy synchronization within administrative structures, leading to an evaluation of existing policies and their alignment with comprehensive plans.

In the next phase, 'Overlaying Mapping and Administrative Studies,' suggests a comparative analysis between spatial data and administrative guidelines. Türkiye's institutional framework for coastal lagoons is complex and pluralistic, with different institutions participating in spatial planning. Effective implementation requires coordination between plan-making institutions such as municipalities, governorships, and ministries. However, the environment is constantly in flux due to ever-changing and disconnected plans, policies, and strategies, making it complex to track long-term outcomes continually. In order to understand the lands, the administration needs to evaluate the laws and regulations comprehensively. This is supported by a survey of national and international legislative documents covering selected lagoons, looking at the scope of protection.

This study uses GIS technology to map selected coastal lagoons utilizing the ArcGIS 10.3.1 software, the Universal Transverse Mercator (UTM) 3 Degree coordinate system, and the European Datum 1950. GIS technology overlapped the results of mapping studies with the administrative framework analysis. Such an integration made it possible to pinpoint where ecological importance and administrative measures overlap, finding areas of potential gaps or conflicts.

The final phase, 'Development of Sustainable Landscape Strategies,' indicates formulating strategies to promote sustainable landscape management
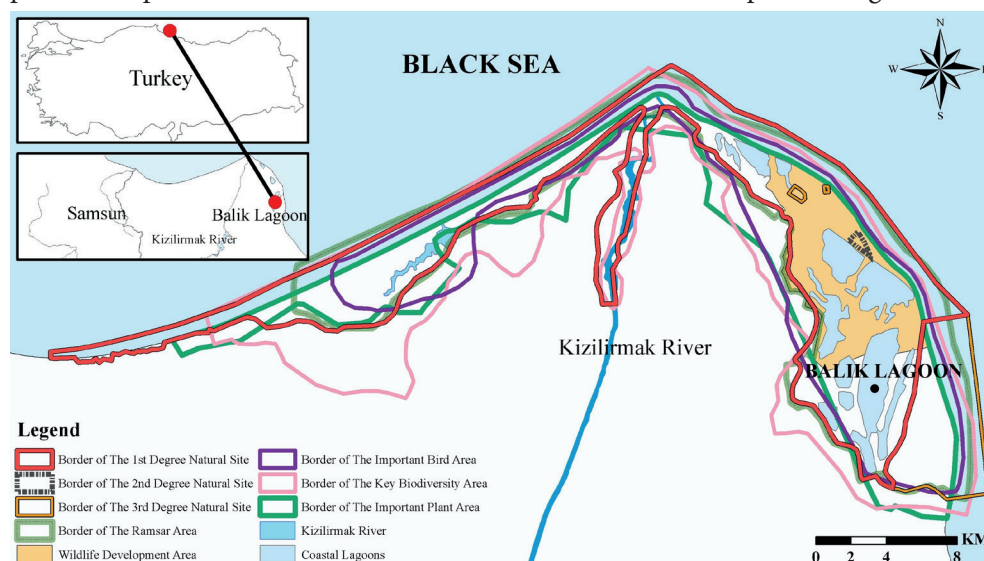

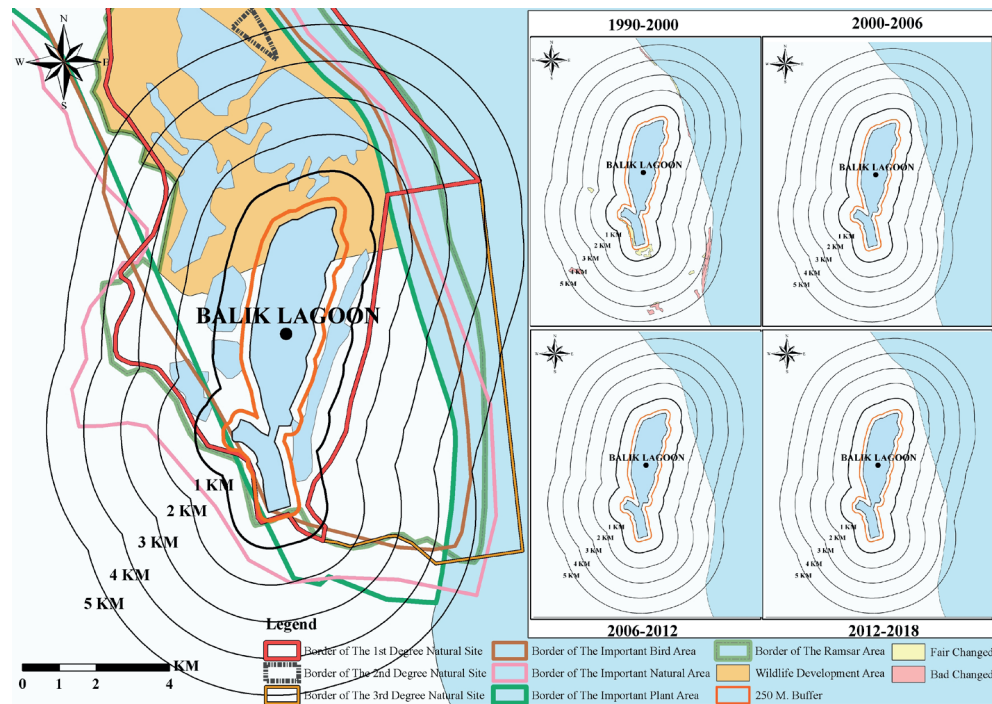**Figure 3.** *Location of Balık Lagoon and boundaries of protection areas.*

Figure 4. *Risk Assessment of Balık Lagoon.*

and development that allow the protection and sensitivity management of these ecologically, socially, and culturally valuable ecosystems.

2.1. Case studies

Coastal lagoons have undergone various land use alterations, both direct and indirect, over the years. This study section details the different land cover changes and landscape features in the chosen coastal lagoons and their surrounding areas.

2.1.1. Balık Lagoon

Balık Lagoon, a unique ecosystem, is surrounded by alluvial areas and marshes in a predominantly flat terrain (Figure 3). The Corine Land cover data reveals coastal lagoon buffer zone changes between 1990 and 2000, but no significant changes were observed in the buffer zones between 2000 and 2006, 2006 and 2012, and 2012 and 2018 (Figure 4).

The 250-meter buffer zone from the lagoon shoreline, the most critical buffer zone, has seen agricultural areas transform into similar agricultural areas. The second buffer area, between 250 and 1000 meters, has also witnessed changes only between agricultural areas. Balık Lagoon, situated in a rural area with dry and flooded meadows, reed beds, and mud flats extension

fields, is a hub of various socioeconomic activities such as agriculture, animal husbandry, fishing, and tourism.

The Kizilirmak Delta has various protection statuses that draw different boundaries to protect wildlife and habitats (Figure 3). These definitions include Natural Protected Areas, Wildlife Development Areas, Ramsar Site statuses, and qualified natural protection areas, and a significant part of the delta is declared as a Natural Protected Site, Grade I and partly Grade III (Dervişoğlu, 2022). Balık Lagoon and its immediate surroundings are located within the borders of the Ramsar Site (1998) and Natural Protected Area (2020) (Ministry of Agriculture and Forestry, n.d.). With this situation, a commitment has been made at the international level to protect the ecological character of the area thoroughly (Gül, 2020).

The Kizilirmak Delta meets almost all the criteria that define wetlands of international importance. Delta is on the 2016 UNESCO World Heritage Tentative List. The delta is home to numerous bird species, plants, fish, mammals, invertebrates, reptiles, and amphibians. Due to all this richness, the area is also an Important Bird Area (IBA), Important Plant Area (IPA), and Key Biodiversity Area (KBA). In the 1/100,000 scale Environmental

Plan, wetland protection zones (absolute protection zone, ecological impact zone, buffer zone) were determined (MEUCC, 2022). These regions are structured to regulate the principles of protection and use, considering the relevant ecosystems and habitats.

Significant planning decisions have been made for each buffer area, demonstrating the region's active management and planning efforts. The Kizilirmak Basin Drought Management Plan (2022), Samsun Kizilirmak Basin Natural Protected Areas, Wetland and Bird Sanctuary Management Plan (2019–2023), and Kizilirmak–Basin Protection Action Plan are among the programs that address the region's management and planning.

2.1.2 Büyükçekmece Lagoon

Büyükçekmece Lagoon, located on the Marmara Sea coast of Istanbul, is an important water source that meets approximately 6% of the city's water needs (Figure 5) (Yarar & Magnin, 1997; ISWA, n.d.). It is vital for water supply and an important ecological corridor for the urban ecosystem. However, its surroundings consist mainly of non-irrigated arable land amidst various land covers, including urban fabrics, industrial areas, transportation networks, and agricultural areas.

The region's biodiversity, including the presence of endemic and rare species, indicates the ecological balance and is crucial for gauging habitat quality and the impacts of environmental stressors. The human footprint through recreational, urban, and industrial activities further exacerbates the pressure on this natural habitat. Notably, shoreline construction and nearby industrial processes substantially compromise water quality. Environmental impact assessments and sustainable management plans are essential to mitigate these impacts and preserve the natural and cultural integrity of the area (Eken et al., 2006).

The lagoon and its surroundings, known as a drinking water basin and a 3rd Degree Archaeological Site, are not just essential due to their historical ruins but also for their unique ecological value. The lagoon, a designated IBA, provides crucial habitat support for water birds and is a key point on their migration routes. It and its surrounding area have also been designated a KBA because of its exceptional ecological values (Figure 5) (Yarar & Magnin, 1997; Eken et al., 2006).

Although many laws and regulations protect it, the lagoon is under increasing pressure from urbanization (Ministry of Justice, n.d.). There are in-
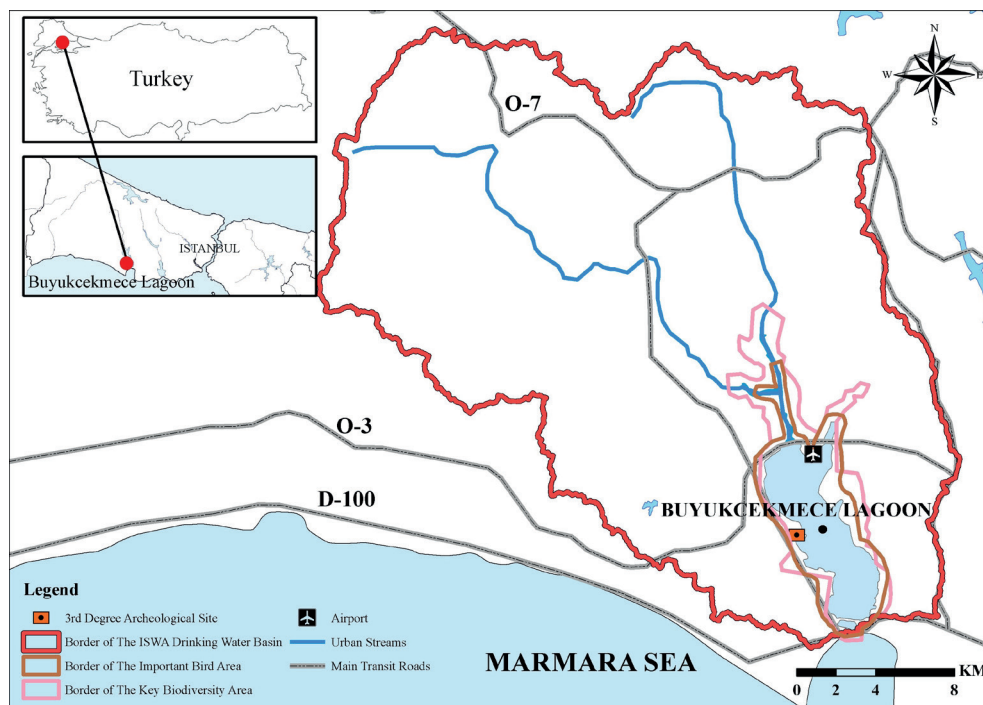

Figure 5. Location of Büyükçekmece Lagoon and boundaries of protection areas.

dustrial facilities within the collection area, and it has been converted into a waste storage pool. The city's critical transportation infrastructure also threatens it. The Istanbul Environmental Plan (2009) (under revision) and the Büyükçekmece Dam Lake Basin Protection Plan are the two upper-scale plans for the region also (Ministry of Justice, n.d.a.).

Such urban pressure profoundly affected land cover in the region between 1990 and 2018. From 1990 to the present, urban sprawl has intensified, in many cases, with shifts from artificial landscapes to agricultural, natural areas, and water bodies. Later periods saw the transformation of traditional agricultural land into artificial surfaces, showing how the lagoon environment has changed with urbanization (Sofu, 2009).

The increase in urban pressures significantly changed land cover between 1990 and 2018. Intensive urban sprawl from 1990 to 2000 converted agricultural areas, such as forests and semi-natural areas, into artificial areas and water bodies into artificial areas (Figure 6).

Another period in which these changes are most observed in terms of diversity is between 2006 and 2012. The period when the minor change was observed in the Büyükçekmece

Lagoon buffer areas was between 2000 and 2006. It is vital for the sustainability of the coastal lagoon that no direct change is observed during this period, especially in the first 1 kilometer.

2.1.3. Köyceğiz Lagoon

Köyceğiz Lagoon, nestled within the Muğla District, is a marvel of nature. This expansive lagoon, approximately 55 km², is a tapestry of diverse ecosystems (Figure 7). From the 4.5 km long coastal dune, Iztuzu Beach, to the reed beds, marshes, and wetlands vital for numerous species, the lagoon is a haven of biodiversity. Alagol and Sulungur Lake, flanking Iztuzu Beach, are globally renowned for their ecological significance (MEUCC, 2007).

Freshwater lakes, reed areas, dunes, forests of Liquidamber orientalis and Cupressus sempervirens, and various vegetation surround Köyceğiz Lagoon. The region, which hosts two endemic plant species, has the status of an IPA and an IBA that supports the breeding and wintering of water birds. Iztuzu Beach is also essential for breeding endangered Mediterranean monk seals and sea turtles (classified as a KBA) (MEUCC, n.d.a).

Although the region's dominant land use is coniferous forest, diverse landscapes such as broadleaf for-
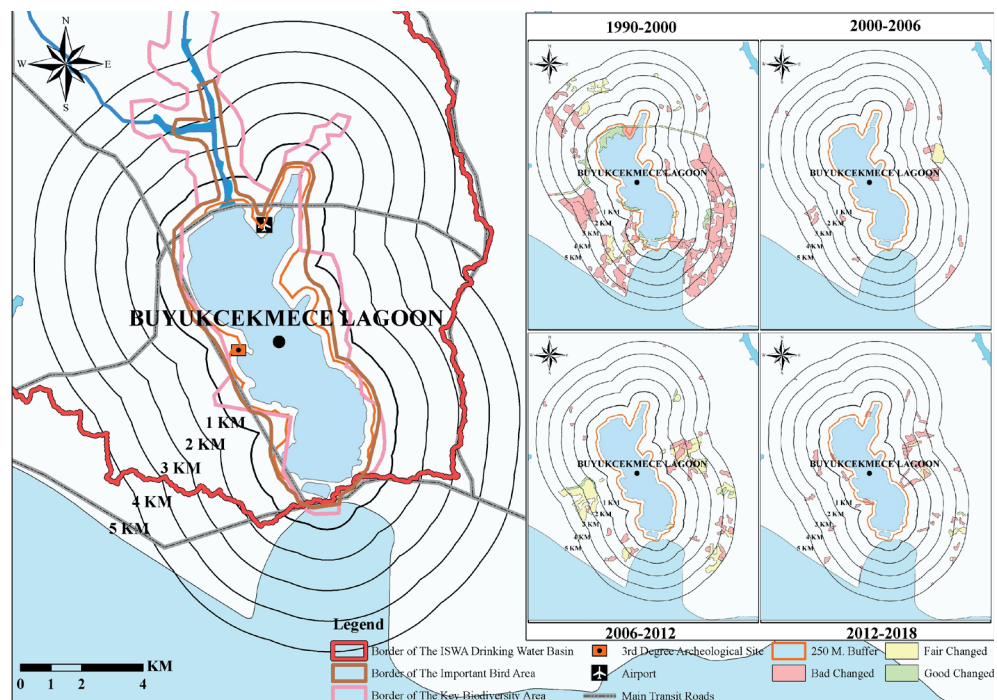

Figure 6. *Risk Assessment of Büyükçekmece Lagoon.*

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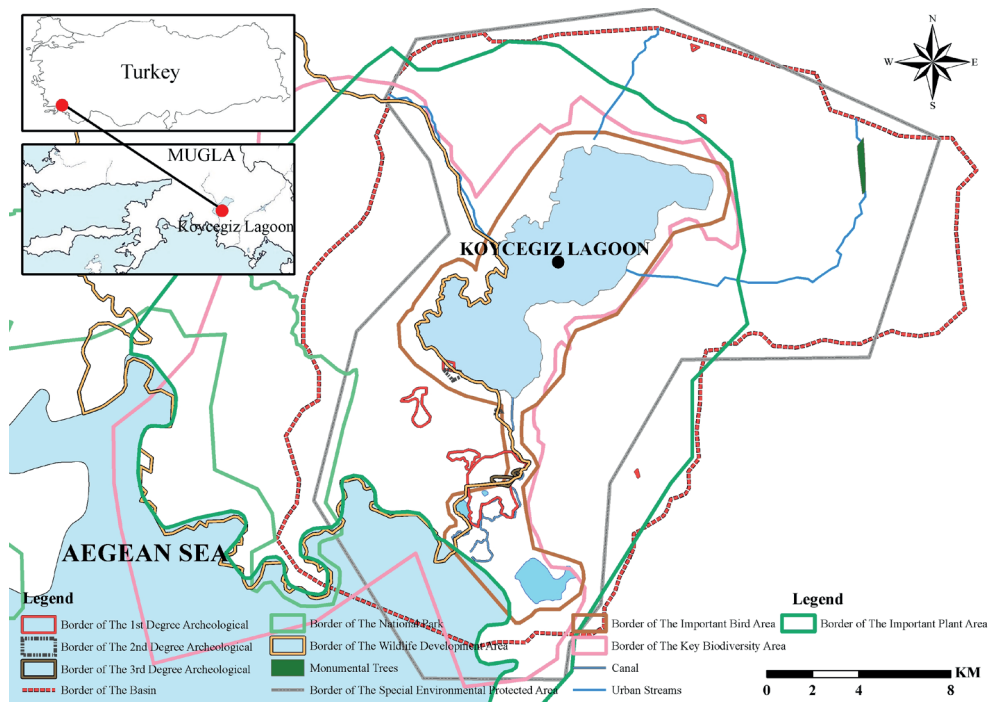
Figure 7. *Location of Köyceğiz Lagoon and boundaries of protection areas.*

ests, agricultural fields, beaches, and marshes exist. In order to protect this area, various definitions have been made, including 1st Degree Archaeological Site, Special Environmental Protection Area (SEPA), Marmaris National Park, and Wildlife Development Area (Alptekin, 2022).

Moreover, the area is protected by many laws and regulations. The MEUCC prepared the Biodiversty Management Plan of Köyceğiz-Dalyan SEPA in 2007, Integrated Coastal Areas Plan (2018), and Environmental Plan (2011) (MAF, 2007; MEUCC, n.d.a).

According to CLC data, the 250-meter buffer zone of Köyceğiz Lagoon changed only between 1990 and 2000 (Figure 8). This change occurred within the forests and semi-natural areas themselves. Additionally, this period is the only period in which change occurs in each buffer area. No changes were detected in the first 2 kilometers of buffer areas between 2000 and 2006, 2006 and 2012, and 2012 and 2018. It has been determined that the changes in other buffer areas during these periods also occurred within the forests and semi-natural areas.

Despite the commendable protective measures, Köyceğiz Lagoon is not immune to threats. Uncontrolled tourism activities pose a significant risk between May and October when Caretta Carettas give birth to their young at Iztuzu Beach. The unregulated transformation of land from forests and swamps to agricultural lands, waste pollution, and disturbances caused by motorboat traffic further jeopardize the integrity of this precious ecosystem. While efforts to combat these threats are underway at national and local levels, the current outcomes still need to be sufficient (Alptekin, 2022).

2.1.4. Paradeniz Lagoon
Paradeniz Lagoon on the Mediterranean coast of Mersin is a large and untouched coastal lagoon (Figure 9). It was formed by sediment transport at the Goksu River and the Mediterranean junction. As a result, it has very low salinity, and its maximum depth is only one and a half meters (MEUCC, n.d.b). Although the vegetation within the lagoon is sparse, the untouched dunes have been designated as a 1st Degree Natural Protected Area to be protected (Meriç & Kavruk, 2007). Other ecosystems near the Paradeniz Lagoon include rice fields, natural grasslands, beaches, and dunes. The chemical composition of salt marshes on lakes such as Akgol,
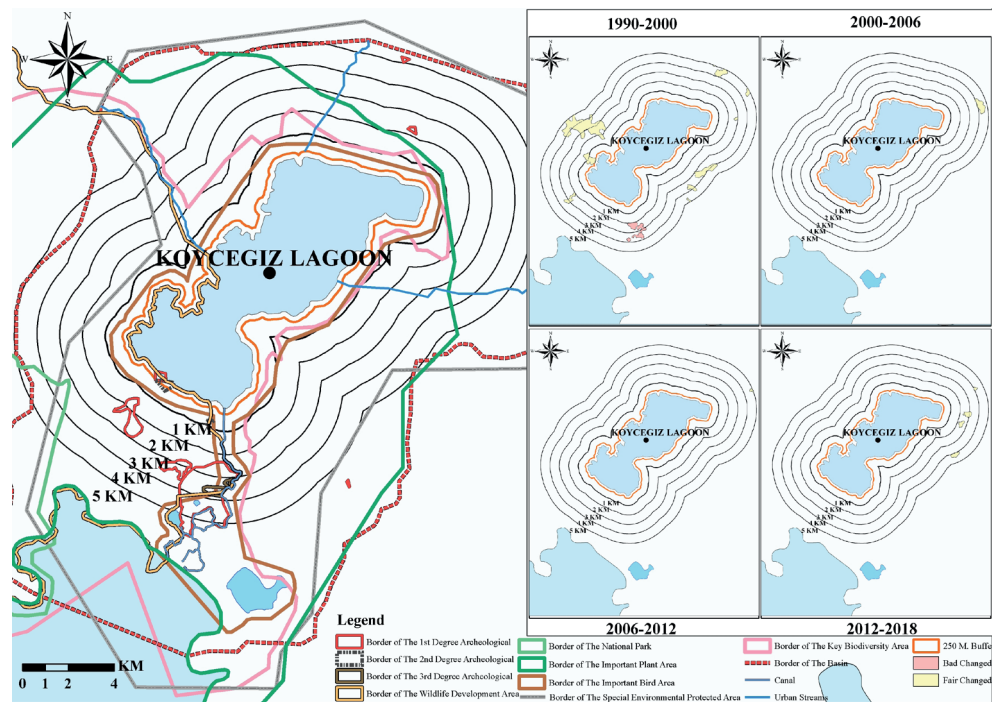
Figure 8. *Risk Assessment of Köyceğiz Lagoon.*

Kugu Lake, and Arapalani lagoons changes yearly due to mud. The activities in the surrounding regions include irrigated agriculture, animal husbandry, fishing (coastal and offshore), and limited eco-tourism initiatives (Yarar & Magnin, 1997).

Paradeniz Lagoon serves as an essential habitat for various species, such as the Mediterranean Monk Seal (Monachus monachus), the Sea Turtle (Caretta caretta), and the Green Sea Turtle (Chelonia mydas). The lagoon was recognized as a SEPA in 1990 and was designated a Ramsar site in 1994 due to its extraordinary diversity of flora and fauna. Paradeniz Lagoon holds additional designations as an IBA, a KBA, and an IPA (Yarar & Magnin, 1997; Eken et al., 2006). It was declared a 1st Degree Natural Protected Area in 2007 to protect its ecological integrity (Meriç & Kavruk, 2007). It was accepted as an INA in 2016. Also, it was classified as a Sensitive Area in 2020 (Republic of Türkiye Official Gazette, 2020).

Between 1990 and 2018, no direct change in land cover was detected in the 250-meter buffer zone of the Paradeniz Lagoon (Figure 10). Between 1990 and 2000, there was an exchange between agricultural areas in the buffer areas between 250-3000 meters. In the period between 2000 and 2006, it was determined that most of the changes that occurred in the buffer areas between 3 and 5 kilometers were in the form of the transformation of wetlands into agricultural areas or forests and semi-natural areas. The only change between 2006 and 2012 was 4-5 kilometers within the agricultural areas. Between 2012 and 2018, the change between 1-2 kilometers and 4-5 kilometers occurred again among agricultural areas. Management plans, including the Goksu Delta SEPA Management Plan in 1990 and the Ramsar Site Management Plan in 1999, were created (MEUCC, [date unknown]b; Dıvrak et al., 2008). However, these plans remained the same. Current plans such as the Integrated Coastal Areas Plan (2015), Goksu Delta SEPA Environmental Plan (2017), and Environmental Plan (2013) aim to ensure the sustainability of the region (MEUCC, 2015; MEUCC, 2020). In addition, the area is protected under the Coastal Law (1990).

However, despite all these preventive measures, the lagoon still faces many threats. The Kayraktepe Dam and Hydroelectric Power Plant, which are planned to be constructed, pose the most significant threat as they will restrict sediment flow with their operation. The structure predicted to cause
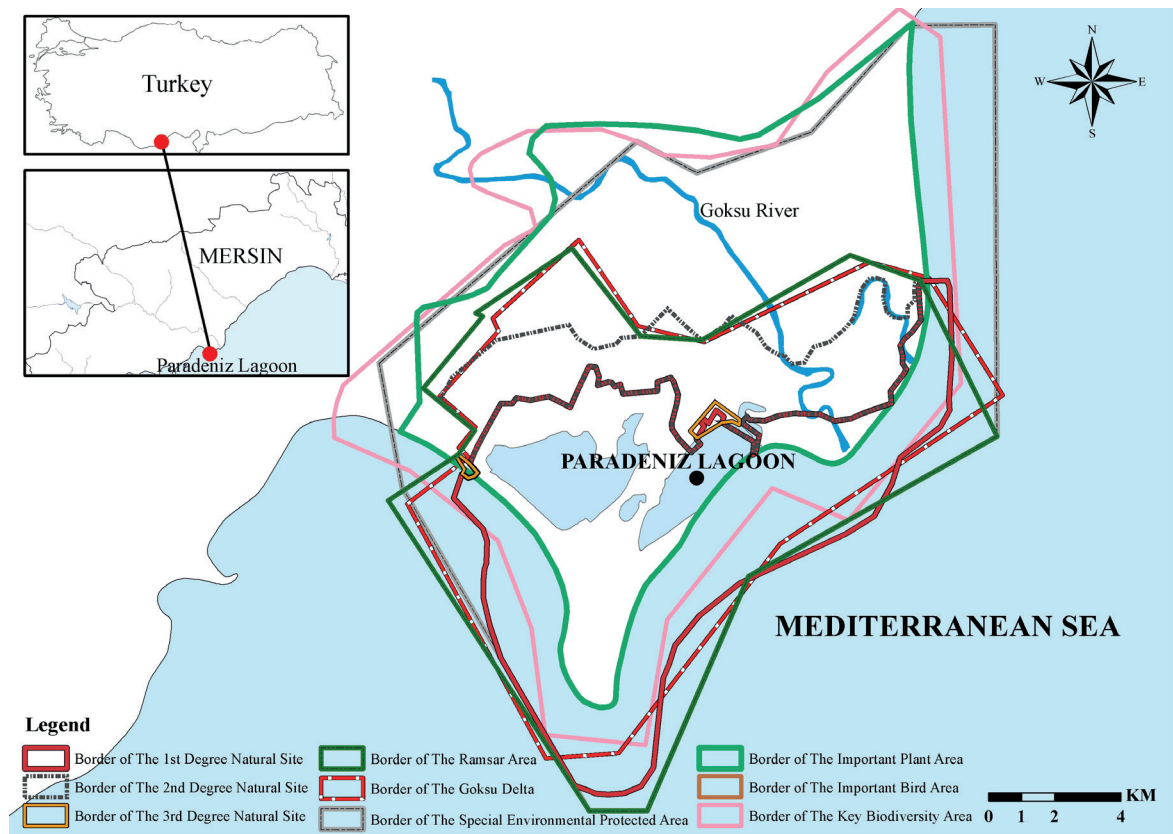
Figure 9. *Location of Paradeniz Lagoon and boundaries of protection areas.*

coastal erosion in the first place is also expected to threaten agricultural and fishing activities. Moreover, construction activities, uncontrolled grazing, agricultural subsidies (especially rice farming), construction, and unmanaged grazing contradict environmental protection principles. General Directorate for the Protection of Natural Assets and Silifke Special Environmental Protection Directorate carry out various studies to reduce these risks (Yarar & Magnin, 1997; Gürbüz, 2000).

3. Results and discussions

Coastal lagoons, straddling terrestrial and marine ecosystems, exhibit unique ecological and biological characteristics. These shallow bodies of water are pivotal centers of global primary productivity. These areas' ecological richness and hydrochemical attributes fluctuate with temporal and spatial variables.

3.1. Environmental pressures and urban influences on coastal lagoons

Regional analysis of selected coastal lagoons reveals distinct distribution patterns of urban influence. Paradeniz Lagoon remains largely natural, shielded from direct urban encroachments. Conversely, Balık Lagoon faces minimal impact, primarily from unregulated fishing activities. Köyceğiz Lagoon, subject to high tourism and dense population, experiences intense boating, construction near Iztuzu Beach a critical nesting site for caretta carettas and unmanaged exploitation in adjacent Dalyan, leading to diminished habitat quality and heightened environmental degradation compared to Paradeniz and Balık Lagoons.

Büyükçekmece Lagoon, situated at the interface of urban and rural expanses, endures more severe impacts due to Istanbul's rapid urban sprawl, haphazard development, and unsustainable resource utilization. These alterations affect both water quality and quantity. These alterations contribute to significant landscape changes and disrupt ecological linkages, impacting its role as a crucial water reservoir for Istanbul and its ecological sensitivity.

Although the coastal lagoons selected from four different coastlines of Türkiye differ in geographical location, they have some similar features.
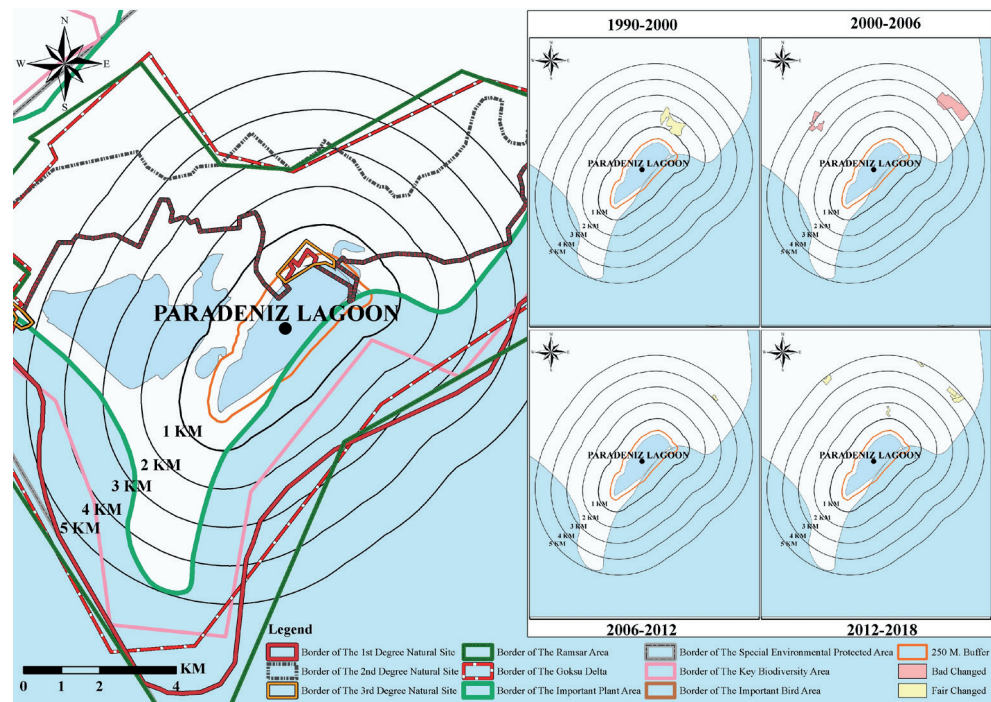
Figure 10. *Risk Assessment of Paradeniz Lagoon.*

The most striking situation is that each coastal lagoon gradually loses its natural characteristics and enters semi-natural characteristics. In addition, if sustainable, long-term strategies are not developed for the coastal lagoons in Türkiye, considering the balance of protection and use against urban pressures, their natural features, especially Büyükçekmece Lagoon, will be lost entirely.

3.2. Legal frameworks and challenges in safeguarding coastal lagoons

This analysis examines the effectiveness of legal frameworks in protecting coastal lagoons, highlighting the adverse impacts observed in selected lagoons and their surroundings. Protecting selected coastal lagoons, which are ecologically extremely valuable productive areas, requires a combination of management plans, statutes, legal regulations, and international agreements.

Among the coastal lagoons examined, the Balık Lagoon benefits from a comprehensive legal scope. The Coastal Law, two management plans (Kizilirmak Basin Drought Management Plan and Wetland and Bird Sanctuary Management Plan), and multiple protective statuses, such as recognition as a Ramsar Site, all contribute to the lagoon's protection. This comprehensive legal framework reflects a concerted effort to protect the ecological integrity of the Balık Lagoon, instilling confidence in the effectiveness of these measures.

On the other hand, since there are no unique management plans for Büyükçekmece Lagoon and its surroundings, there are apparent legal deficiencies. Although the Istanbul Environmental Plan has comprehensive decisions regarding the area, this plan is still in the revision phase. This dependence highlights critical gaps in its legal protections, underscoring the need for tailored legal measures to avert ecological degradation.

Due to its existence as a SEPA and a National Park, Köyceğiz Lagoon is supported by both a Master Plan and a Biodiversity Management Plan. Special environmental protection areas refer to land, water, and sea areas that have ecological importance on a national and global scale and are sensitive to environmental pollution and degradation in cases where it is necessary to protect and ensure the sustainability of biological diversity, natural resources, and their associated cultural resource values (Ministry of Justice, n.d.b). However, this decision also allows some construction to support tourism in these protected areas.

Ranging from international to national protection statutes, Paradeniz Lagoon standing inside the Gok-

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su Delta Special Protection Area, is comprehensively protected and supported by multi- scale plans. However, all examined lagoons need help with enforcement and implementation, compounded by a disjointed legal landscape in Türkiye characterized by inconsistencies and lenient penalties for infractions.

In summary, while existing legal frameworks are crucial for lagoon conservation, they require clarity, enforcement, and scope enhancements to strengthen these ecosystems' resilience and sustainability, promoting a unified conservation approach.

3.3. Ecological fragility and human impact: Threats to riparian zones and coastal lagoons

This section assesses land cover changes within 250-meter buffer zones around selected coastal lagoons, highlighting the relationship between human activity and these ecologically sensitive areas. From 1990 to 2018, Paradeniz Lagoon showed substantial ecological stability, with minimal human disturbances in its immediate surroundings.

In contrast, Köyceğiz and Balık lagoons have experienced significant transformations over the latter part of the 20th century. Adjacent agricultural areas near Balık Lagoon have transitioned into various land cover types (Figure 4), and the forests and semi-natural terrains around Köyceğiz Lagoon have undergone considerable alterations, reflecting the complex nature of human impacts on these ecosystems (Figure 8).

Between 1990 and 2000, Büyükçekmece Lagoon's buffer zone was markedly affected by significant infrastructural developments, including highway construction and extensive urban expansion (Figure 6). This period underscores the urgent need for societal efforts to mitigate environmental degradation and sustain the lagoon's ecological health.

While direct land cover changes in the buffer zones around Balık Lagoon from 2000 to 2018 were not observed, indirect modifications nearby indicate ongoing anthropogenic pressures.

Comparative data show that Paradeniz and Balık lagoons were least affected by direct and indirect human activities, whereas Büyükçekmece Lagoon demonstrated increased vulnerability during each analyzed period (Figure 10).

These findings underscore the critical importance of preserving the ecological integrity of buffer zones to ensure the health and sustainability of coastal lagoons. Enhanced regulatory and strategic planning measures, including extending protections up to five kilometers, are essential to counteract the challenges of urbanization and land use changes and protect these vital ecosystems from escalating environmental pressures.

4. Conclusion

This study thoroughly investigates the strategic importance of LCA in supporting sustainable landscape planning and management of Türkiye's coastal lagoons. The results highlight the lagoons' significant ecological, social, and cultural significance. These areas serve as essential barriers against ecological deterioration and hotspots for biodiversity. The study outlines how combining LCA with other environmental management strategies might improve these coastal ecotones' sustainability and resilience, especially in the face of growing human demands.

Although there are many legislative documents and plan types regarding the management of coastal lagoons in Türkiye, they reveal that existing management tools should be specific, comprehensive, and applicable to each lagoon, taking into account the local realities of the lagoons. This inadequacy underscores the urgent and critical need for a more tailored strategy that considers each lagoon's unique ecological and socioeconomic conditions. The value of landscape character is not solely determined by the characteristics of the land but also by its mutual relationship with the local people living there. Their participation and understanding of the legal and administrative situation are crucial for the sustainable management of the lagoons.

By incorporating LCA, coastal lagoon management can more effectively capture and evaluate the unique and complex landscape values of these regions. This integration holds immense potential, as LCA can revolutionize coastal lagoon management with comprehensive, up-to-date environmental data and a governance structure that supports integrated, cross-sectoral planning and management techniques. This approach not only promotes sustainable development but also helps maintain ecological integrity, offering a promising path forward for the management of these crucial ecosystems.

The study concludes by emphasizing the necessity of holistic, integrated management strategies to protect selected coastal lagoons that synergize with Türkiye's dynamic legislative and planning frameworks. This study highlights the vitality of inserting LCA based studies inside the management system. By strengthening legal protections, improving enforcement mechanisms, and encouraging local community participation and interdisciplinary collaboration, it is possible to ensure sustainable management of these vital ecological assets. Going forward, policymakers, researchers, and practitioners should collaborate to develop and implement strategies that protect and sustainably use the unique landscape values of coastal lagoons for future generations.

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