

Environmental Sustainability and Land Use Decisions: Hürmetçi and KOIZ

Çevresel Sürdürülebilirlik ve Arazi Kullanım Kararları: Hürmetçi ve KOSB

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ABSTRACT

This study highlights the importance of considering long-term economic and environmental sustainability in selecting locations for Organized Industrial Zones (OIZs). However, land-use decisions often neglect ecological concerns, posing significant threats to sensitive areas. The research focuses on the environmental impacts of the Kayseri Organized Industrial Zone (KOIZ) on the nearby Hürmetçi Marsh Wetland, a biodiversity-rich ecological site. Using qualitative methods like literature reviews, field observations, and PESTLE analysis, the study reveals that KOIZ activities and potential expansions jeopardize the wetland's ecological health. The PESTLE framework identifies political, economic, social, technological, legal, and environmental factors influencing the interaction between industrial development and ecological stability. Based on these findings, the study proposes several sustainable management strategies. These include enforcing strict environmental regulations, adopting eco-friendly industrial practices, and creating buffer zones to protect sensitive areas. Wetland restoration projects, along with sustainable water and waste management systems, are recommended to mitigate environmental damage. Continuous monitoring and adaptive research are emphasized to refine conservation strategies over time. The study also underscores the importance of local community involvement through education and awareness initiatives. A participatory approach not only strengthens community ties to the environment but also ensures broader support for preservation efforts, fostering shared responsibility for sustainable development. These measures aim to balance industrial growth with the preservation of vital ecological areas like the Hürmetçi Marsh Wetland.

Keywords: Ecological Concerns, KOIZ, PESTLE, Wetland.

Öz

Bu çalışma, Organize Sanayi Bölgeleri (OSB) için yer seçerken uzun vadeli ekonomik ve çevresel sürdürülebilirliğin dikkate alınmasının önemini vurgulamaktadır. Ancak, arazi kullanım kararları genellikle ekolojik kaygıları göz ardı ederek hassas alanlar için önemli tehditler oluşturmaktadır. Araştırma, Kayseri Organize Sanayi Bölgesi'nin (KOSB) biyolojik çeşitlilik açısından zengin bir ekolojik alan olan yakındaki Hürmetçi Sazlığı Sulak Alanı üzerindeki çevresel etkilerine odaklanmaktadır. Literatür incelemeleri, saha gözlemleri ve PESTLE analizi gibi nitel yöntemler kullanılarak çalışma, KOSB faaliyetlerinin ve potansiyel genişlemelerinin sulak alanın ekolojik sağlığını tehlikeye attığını ortaya koymaktadır. PESTLE çerçevesi, endüstriyel gelişme ile ekolojik istikrar arasındaki etkileşimi etkileyen politik, ekonomik, sosyal, teknolojik, yasal ve çevresel faktörleri belirlemektedir. Bu bulgulara dayanarak, çalışma çeşitli sürdürülebilir yönetim stratejileri önermektedir. Bunlar arasında sıkı çevre düzenlemeleri uygulamak, çevre dostu endüstriyel uygulamaları benimsemek ve hassas alanları korumak için tampon bölgeler oluşturmak yer almaktadır. Çevresel hasarı azaltmak için sulak alan restorasyon projeleri, sürdürülebilir su ve atık yönetim sistemleri ile birlikte önerilmektedir. Zamanla koruma stratejilerini geliştirmek için sürekli izleme ve uyarlanabilir araştırmalar vurgulanmaktadır. Çalışma ayrıca eğitim ve farkındalık girişimleri aracılığıyla yerel topluluk katılımının önemini vurgular. Katılımcı bir yaklaşım yalnızca toplulukların çevreyle bağlarını güçlendirmekle kalmaz, aynı zamanda koruma çabaları için daha geniş bir desteği garanti ederek sürdürülebilir kalkınma için paylaşılan sorumluluğu teşvik eder. Bu önlemler, endüstriyel büyümeyi Hürmetçi Bataklık Sulak Alanı gibi hayati ekolojik alanların korunmasıyla dengelemeyi amaçlamaktadır.

Anahtar Kelimeler: Ekolojik Kaygılar, KOSB, PESTLE, Sulak Alan.

Introduction

The establishment of Organized Industrial Zones (OIZs) is integral to advancing economic development and fostering industrial growth by centralizing industrial operations and enhancing regional economies. However, the choice of location for these zones has significant implications for environmental sustainability and ecological health. While the economic advantages of OIZs are evident, ensuring their long-term success depends on a careful balance between industrial growth and the preservation of natural ecosystems. Increasingly, the integration of environmental concerns into land use planning is recognized as crucial; yet, critical ecological areas frequently suffer neglect during decision-making processes. This oversight can lead to severe environmental consequences, such as habitat destruction, biodiversity loss, and ecosystem imbalance, which undermine not only ecological sustainability but also the health and resilience of local communities (Sacrovic et al., 2019; Vasileva et al., 2020). Wetlands are crucial ecosystems that provide ecological, economic, and social benefits, including biodiversity, water quality, and climate mitigation. However, they are threatened by industrial zone expansion, with factories and waste operations introducing toxic metals and chemicals that pollute these areas. An ongoing interdisciplinary study seeks to identify pollution-affected zones and assess heavy metal concentrations in the wetlands to support sustainable resource management (Basnukaev et al., 2023). Beyond direct pollution, the growth of industrial zones can also disrupt the natural hydrology of wetlands, altering water flows and causing habitat fragmentation (Muwanga & Barifaijo, 2006; Sarwat Jahan & Singh, 2023). Additionally, the presence of industrial wastewaters can elevate levels of total dissolved solids and total suspended solids in nearby water bodies, further exacerbating the ecological stress on ecosystems and diminishing their capacity to support biodiversity and provide essential ecosystem services (Singare & Dhabarde, 2013). Industrial development can severely harm wetlands, leading to biodiversity loss and ecosystem degradation. Addressing these challenges requires collaboration between policymakers and industry leaders to create sustainable management strategies, such as improved wastewater treatment, green infrastructure, and circular economy practices that promote the reuse of industrial by-products (Inyinbor Adejumo, A., Adebisin Babatunde, Q., Oluyori Abimbola, P., Adelani-Akande Tabitha, A., Dada Adewumi, O., Oreofe Toyin, 2018). While industrialization has spurred economic growth, it has also caused significant environmental damage, including pollution and habitat destruction. To mitigate these effects, adopting sustainable practices such as eco-industrial networks and the 6Rs (reduce, reuse, recycle, recovery, redesign, rethink) is essential for balancing industrial progress with ecological protection (Patnaik, 2018).

The case of the Kayseri Organized Industrial Zone (KOIZ) and its proximity to the Hürmetçi Marsh Wetland highlights the delicate balance between industrial expansion and ecological conservation. The Hürmetçi Marsh Wetland is renowned for its ecological importance and biodiversity, serving as a key habitat that supports regional wildlife and contributes to the ecological stability of the area. This study investigates why KOIZ's proximity poses significant risks to the wetland and explores strategies to minimize these impacts. The research utilizes a comprehensive approach, including literature review, field observations, and PESTLE (Political, Economic, Social, Technological, Legal, and Environmental) analysis to evaluate the factors influencing this dynamic and the potential threats posed by industrial activities such as pollution and habitat encroachment. The study's findings emphasize the critical need for sustainable land use practices that

align industrial growth with environmental stewardship. By proposing solutions that incorporate regulatory frameworks, sustainable practices, and community engagement, this research aims to reorient industrial planning toward strategies that prioritize ecological sustainability. The integration of a PESTLE analysis further enriches the study by providing a holistic view of the external factors impacting the relationship between KOIZ and the Hürmetçi Marsh Wetland. The research advocates for re-evaluating current industrial practices and underscores the importance of embedding ecological priorities in planning processes to achieve a sustainable coexistence between industry and nature.

Wetlands

Wetlands are unique ecosystems that are inundated with water either permanently or seasonally. They are characterized by distinct soil types and vegetation adapted to wet conditions. Wetlands play crucial roles in water purification, flood control, carbon storage, and biodiversity support (Basnukaev et al., 2023). Wetland ecosystems, such as marshes, mangrove forests, and seagrass meadows, play a vital role in providing key ecosystem services, including fish nurseries, water purification, flood risk reduction, climate regulation, and nutrient cycling. Beyond these well-known benefits, they also offer diverse cultural ecosystem services, including recreation, aesthetic value, spiritual significance, cultural heritage, education, inspiration, social connection, scientific opportunities, and a sense of place, which are often overlooked in ecological analyses (Alikhani et al., 2021; Sutton-Grier & Sandifer, 2019).

There are several types of wetlands, classified based on factors such as water source, vegetation, and geographic location (Mitsch & Gosselink, 2000). Different types of wetlands include tidal wetlands, salt marshes, riparian wetlands, peatlands, and inland freshwater wetlands, each with unique characteristics influenced by factors like species composition, climate, geology, and landscape exposure. Understanding these ecosystems involves examining elements such as soil conditions, ecosystem services, hydrology, human activities, pollution, and biodiversity. However, wetlands face numerous threats from both human activities and natural events (Bhowmik, 2020). Generally, wetlands are divided into four main categories: **Bogs**: Bogs are distinguished by their peat-rich, nutrient-poor, and acidic soils, which result in low species diversity and limited primary production. The central areas of bogs receive water exclusively from rainfall. **Forested wetlands, Swamps**: Forested wetlands can be found across nearly all types of wetlands, except in areas with extremely wet or nutrient-poor conditions that prevent the establishment and growth of trees. **Mineral soil wetlands, Marshes**: Like mires, marshes and mineral-soil wetlands often contain significant amounts of organic matter in their surface layers. However, this organic matter does not accumulate quickly enough to form peat. Additionally, the water table levels in these wetlands fluctuate more than in peatlands. **Fens**: Fens and bogs share several similarities, such as the presence of peat soil and a water table that remains consistently close to the surface, often creating a landscape of hummocks, hollows, and pools. However, they differ significantly in vegetation composition and peat characteristics, largely due to the influence of water from terrestrial sources (Kellner, 2003).

The Ramsar Convention for the protection of wetlands is important and includes 9 criteria. The convention was adopted in Ramsar, Iran, in 1971 and entered into force in 1975. Since then, many countries from all geographical regions of the world have

become parties to the convention. Under the Convention, Contracting Parties are generally obligated to incorporate wetland conservation into national planning efforts and to promote research, data sharing, and the exchange of publications related to wetlands and their associated flora and fauna. There are 172 Contracting Parties to the Convention. The total number of designated wetlands is 2,518, covering a combined area of 257,289,352 hectares. Türkiye became a party to the Ramsar Convention in 1994. Türkiye has 14 Ramsar sites covering a total area of 184,487 hectares (Ramsar, n.d.).

At the national level in Türkiye, the "Regulation on the Protection of Wetlands" has been prepared based on the Environmental Law No. 2872 dated August 9, 1983, the Hunting Law No. 4915 dated July 1, 2003, the provisions of the Convention on Wetlands of International Importance especially as Waterfowl Habitat, approved by Law No. 3958 and published in the Official Gazette No. 21937 dated May 17, 1994, as well as Articles 410 and 420 of Presidential Decree No. 1 on the Presidential Organization, published in the Official Gazette No. 30474 dated July 10, 2018. The regulation addresses provisions aimed at the protection, management, and development of wetlands in Türkiye. It is designed to preserve the ecological character of wetlands, enhance biodiversity, and promote sustainable use. The regulation prohibits the filling, draining, and pollution of wetlands, and regulates activities such as water extraction and Marsh cutting within these areas. Additionally, it seeks to ensure cooperation and coordination among relevant institutions. In this regulation, registered wetlands are evaluated in 3 categories: "Ramsar Site", "Wetland of National Importance" and "Wetland of Local Importance" (Legislation Information System, 2014). There are 122 wetlands in Türkiye. 14 of these are Ramsar Sites, 59 are Wetlands of National Importance and 49 are Wetlands of Local Importance (Ministry of Agriculture and Forestry, n.d.).

Anthropogenic Impacts on Wetlands

Anthropogenic impacts on wetlands involve the harmful effects of human activities, such as agriculture, urban expansion, and industrial projects, on these delicate ecosystems. While wetlands offer vital ecological, economic, and social services like water purification, flood control, and biodiversity support, they face increasing threats from land conversion, urban development, and industrial activities. Converting wetlands into agricultural land destroys habitats and disrupts water systems, reducing biodiversity. Urban development diminishes wetland areas, increases flooding risks, and lowers groundwater recharge. Industrial activities, including mining and oil extraction, contribute to wetland degradation through pollution and altered water flows (Mitsch & Gosselink, 2000). Agricultural runoff and industrial discharge introduce nutrients, chemicals, and pollutants into wetlands, causing eutrophication, oxygen depletion, and reduced biodiversity. This contamination harms wildlife and poses risks to both the ecosystem and human health (Reddy et al., 2022).

The diversion of rivers and streams for agriculture, industry, or urban water supply can reduce the water flow into wetlands, leading to desiccation and loss of habitat. The construction of dams alters the natural flow of rivers, often reducing the amount of water reaching downstream wetlands. This can lead to changes in wetland vegetation and a decline in species that depend on

seasonal flooding. Excessive withdrawal of groundwater can lower water tables, drying out wetlands that rely on groundwater inputs, particularly in arid and semi-arid regions (Zhang et al., 2023). Human activities can introduce invasive species to wetlands, which can outcompete, prey on, or bring diseases to native species. Invasive plants can alter the structure of wetlands, changing the habitat and the species composition (Lázaro-Lobo & Ervin, 2021). Invasive species can disrupt the food webs in wetlands, leading to the decline or extinction of native species, which can have cascading effects on the entire ecosystem (Pegg et al., 2022). Rising global temperatures can alter the hydrology of wetlands, affecting species composition and the timing of biological processes. Warmer temperatures can also increase the frequency of algal blooms and other harmful ecological shifts. Coastal wetlands, such as mangroves and salt Marsh, are particularly vulnerable to sea-level rise, which can lead to submersion, increased salinity, and loss of habitat for species adapted to specific tidal ranges. Climate change can lead to altered precipitation patterns, causing either increased flooding or prolonged droughts in wetlands, both of which can be detrimental to the ecosystems (Salimi et al., 2021).

Overfishing and unsustainable hunting can lead to the depletion of key species in wetlands, disrupting the ecological balance and leading to a decline in biodiversity. The unsustainable harvesting of wetland resources such as Marsh, peat, and timber can degrade the ecosystem, reducing its capacity to provide essential services. High levels of tourism can lead to physical damage to wetland vegetation, soil compaction, and disturbance to wildlife. Littering and waste from recreational activities can also pollute the water and harm the ecosystem. Motorized boats can cause erosion of wetland banks, disturb sediment, and introduce pollutants such as oil and gasoline into the water, impacting water quality and aquatic life (Saadi et al., 2023; Xiong et al., 2023). As a result, the negative impacts of human activities on wetlands are summarized in Figure 1.

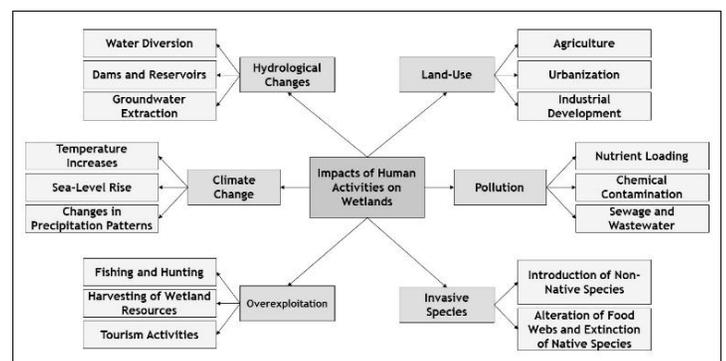


Figure 1. Impacts of Human Activities on Wetlands

The cumulative effects of these anthropogenic impacts can lead to the degradation, fragmentation, or complete loss of wetland ecosystems. Protecting wetlands requires the implementation of sustainable management practices, strict regulation of harmful activities, and restoration efforts to rehabilitate damaged wetlands. Several wetlands around the world have been significantly impacted by human activities. Table 1 shows some of these examples.

Table 1. Wetlands impacted by human activities	
Sundarban, India-Bangladesh	Afghanistan. An assessment of anthropogenic impacts and desertification reveals that human activities have a greater effect on the water cycle in this region than desertification, extreme heat, and related climate events. Despite existing uncertainties, it is essential for policymakers to understand how these activities and desertification influence the water cycle and water use in the Aral Sea Basin, as well as the variations in water levels of the Aral Sea, agroecosystem water yield, and crop water use efficiency (Kayiranga et al., 2024).
The Sundarban forest in southwest Bangladesh is one of the largest continuous mangrove forests globally, comprising over 200 islands interconnected by approximately 400 tidal rivers, creeks, and canals. Human activity has increasingly impacted mangroves over recent decades, leading to significant losses in forest cover, with many countries, including Bangladesh, experiencing declines of up to 73%. Common causes include clearing for aquaculture, coastal development, and urban expansion. The growth of industries near this UNESCO World Heritage site has further affected the mangrove ecosystem by introducing pollutants, waste, and wastewater. Industrial activities, agriculture, aquaculture, and population growth contribute to the discharge of harmful substances into the wetland. Additionally, pollution from oil spills, heavy metals, pesticides, and nutrient runoff has heightened the vulnerability of the Sundarbans, potentially altering its ecological balance and biogeochemistry (Rahman et al., 2009).	Mesopotamian Marsh, Iraq
Pantanal, Brazil	The Mesopotamian Marshes in Southern Iraq are among the world's most significant wetlands, supporting diverse plant life, including reeds and papyrus, and hosting numerous bird species. However, these marshlands have faced severe drying due to human activities, particularly the damming of rivers upstream and politically motivated drainage operations in the late 1980s and early 1990s. The construction of dams and canals disrupted the natural flow of the Tigris and Euphrates rivers, leading to an ecological disaster. This degradation resulted in a significant reduction of vegetated areas, transforming the marsh into arid land. These extensive drainage and hydrological changes are considered some of the most severe environmental disasters impacting wetlands worldwide (Albarakat et al., 2018).
The Pantanal, located at the heart of South America, is the world's largest freshwater wetland, known for its unique landscapes, ecosystems, and traditional cultural practices shaped by various natural and human interactions. Although it is relatively well-conserved, human activities in the broader catchment area are increasingly threatening its ecological balance. Key threats include deforestation, intensified agriculture, and the construction of hydropower plants, which also affect local communities' livelihoods. While the Pantanal itself lacks industrialization and high human population density, urbanization in surrounding areas exerts indirect pressure, negatively impacting this vital wetland ecosystem (Schulz et al., 2019).	Mekong Delta, Vietnam
Sumatra and Kalimantan, Indonesia	The Vietnamese Mekong Delta, vital for the food security of Southeast Asia and home to 18 million people, is highly vulnerable to both human activities (such as hydropower dam operations and sand mining) and global challenges like climate change-induced sea level rise. These factors have significantly impacted the delta's hydro- and morphodynamic processes, affecting local livelihoods. The findings indicate that current conditions already cause substantial erosion in the Tien River. In the future, hydropower development is expected to have the largest effect, further intensifying erosion, followed by sand mining and climate change-induced discharge changes. While sea level rise has a minimal impact on local morphodynamics, completely banning sand mining could slow erosion. If human activities are continued, it could result in an increase in riverbed incision and a rise in the imbalance between erosion and deposition (Jordan et al., 2020).
Peatlands, which cover about 13 million hectares in Sumatra and Kalimantan, have experienced rapid human-induced degradation over the past two decades. Activities such as logging, drainage, and conversion to plantations have led to the destruction of peatland ecosystems, making them vulnerable to fires and contributing to significant carbon emissions (Miettinen & Liew, 2010).	Lake Victoria Wetlands, Kenya-Tanzania-Uganda
Camargue, France	Lake Victoria, the largest of the African Great Lakes by surface area, is shared by Kenya, Uganda, and Tanzania. It supports the world's largest inland fishery, producing around 1 million tonnes of fish annually. However, this fishery is largely artisanal, dominated by silver cyprinid, Nile perch, and Nile tilapia. Over the past century, the lake's biophysical and ecological conditions have dramatically changed due to human activities such as overfishing, species introductions, and catchment processes. The fish population has also shifted, with native tilapias being replaced by introduced species. Fishing efforts have increased, affecting fish catches, particularly the Nile perch, which has only recently shown signs of overfishing. These impacts have caused a decline in native fish species, water pollution, and the loss of wetlands (Nyamweya et al., 2020).
Situated in the Rhône River delta, the Camargue is a large alluvial environment spanning around 140,000 hectares. It consists of an incredibly diverse mosaic of habitats. Camargue wetlands, which support a diverse range of breeding birds, have been significantly altered by human activities. Mostly in the 1960s and 1970s, the Camargue's natural wetland habitat area shrank by 39.8% to 50,000 hectares. The centre basin's Marsh are severely impacted by water pumping and diking. Enormous networks of lagoons surround the delta's southeast and southwest corners, which are used for the industrial manufacturing of salt (Nager et al., 2010).	Okavango Delta, Botswana
Anzali Wetland, Iran	The Okavango Delta in Botswana has faced significant environmental changes over the past 150 years due to natural factors like declining rainfall and reduced inflow from the Okavango River, leading to water scarcity and ecosystem degradation. Human activities, particularly unsustainable livestock farming and changing land use, have intensified these issues, increasing the demand for grazing land and further stressing natural resources. Research using historical data, satellite imagery, and GIS has shown the limited potential for natural recovery without adaptive strategies. Sustainable resource management is crucial for the long-term resilience of the Delta, necessitating further study of the interactions between environmental changes and human activities (Hamandawana et al., 2007).
The Anzali wetland, located in northern Iran and connected to the Caspian Sea, is renowned for its rich biodiversity, serving as a vital habitat for migratory birds and fulfilling essential ecological functions. It is recognized as a coastal waterbody under the Ramsar Convention and designated as an Important Bird and Biodiversity Area. However, the wetland is facing deterioration due to both natural and human-induced factors. Natural droughts and a decline in the Caspian Sea's average water level have reduced the wetland's surface area, while human activities in its watershed—such as land use changes and intensive farming—have further diminished water inflows and increased sedimentation, disrupting the hydrological balance (Mahdian et al., 2023).	Sudd, South Sudan
Everglades Wetland, USA	The Sudd Wetland in South Sudan, covering approximately 57,000 km ² , is a vital Ramsar site that supports diverse wildlife and local communities, including the Dinka, Nuer, and Shilluk. Valued at around \$3.3 billion in 2015 for its ecosystem services, the wetland faces threats from climate change, insecurity, and human land use changes, jeopardizing its ecological balance. To address these challenges, sustainable development in agriculture, ecotourism, and fishing is essential. Protecting the Sudd requires coordinated governance and strategies like climate finance to ensure its ecological and economic benefits for future generations (MoEF, 2022).
The Everglades is an expansive subtropical wetland that spans much of southern Florida and is well-known for its significant ecological value. However, due to human activities over the past century—including agricultural and urban development, nutrient pollution from stormwater runoff, alterations in hydrology, and the spread of invasive species—the biological integrity of the entire Everglades ecosystem is now at risk. These activities have led to habitat loss, decreased water quality, and a decline in native species and natural pattern (Chimney & Goforth, 2001).	
Aral Sea Wetlands, Kazakhstan-Uzbekistan	
The Aral Sea Basin, a transboundary water catchment in Central Asia, spans approximately 1.8 million km ² and includes six countries: Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan, and	

These examples illustrate human activities' widespread and varied impacts on wetlands worldwide, leading to the degradation of these vital ecosystems and the services they provide. Wetlands are critical for biodiversity, climate regulation, water purification, and supporting livelihoods. However, human-induced pressures like land-use changes, agricultural expansion, unsustainable resource extraction, and climate change are accelerating their degradation.

Martial and Methods

The methodology involved a qualitative approach, including a comprehensive literature review, field observation, and PESTLE analysis. The literature review assessed existing studies on industrial zones' impacts on wetlands, informing potential risks related to the KOIZ's proximity. Field analysis comprised on-site observations to identify environmental stress indicators, such as water quality changes and pollution. Additionally, the study mapped the location of industrial activities near sensitive wetland areas to understand possible impact pathways. This study also investigated the environmental impacts of the Kayseri Organized Industrial Zone (KOIZ) on the Hürmetçi Marsh Wetland using a PESTLE analysis, which considered Political, Economic, Social, Technological, Legal, and Environmental factors. Data obtained from literature reviews, field observations, and PESTLE analysis were cross-referenced to identify critical environmental threats posed by the KOIZ. Consequently, the study concluded with targeted recommendations and strategies developed according to PESTLE analysis for mitigating these risks. This study provided a robust assessment of the KOIZ's effects on the Hürmetçi Marsh Wetland and established a foundation for conservation efforts.

Kayseri Organized Industrial Zone (KOIZ)

Kayseri Organized Industrial Zone (KOIZ) is a significant industrial hub located in the Hacilar district of Kayseri. According to the Cabinet decision dated March 29, 1973, and numbered 7/6177, it was established in 1976 with the participation of the Provincial Special Administration, the Chamber of Industry, and the Industrialists' Association. The Kayseri OIZ continues its activities following the provisions of Law No. 4562. Kayseri OIZ is one of Türkiye's oldest organized industrial zones and it has expanded over the years into a comprehensive industrial centre. The zone hosts a variety of industrial sectors, including furniture, metal processing, machinery manufacturing, textiles, food, chemicals, and plastics (Figure 2). This diversity ensures a robust and varied economic structure. There are a total of 1,166 firms in Kayseri OIZ and 65 thousand people work there. The Figure 3 shows the distribution of industrial sectors in KOIZ (Kayseri Organized Industrial Zone Directorate, 2017).

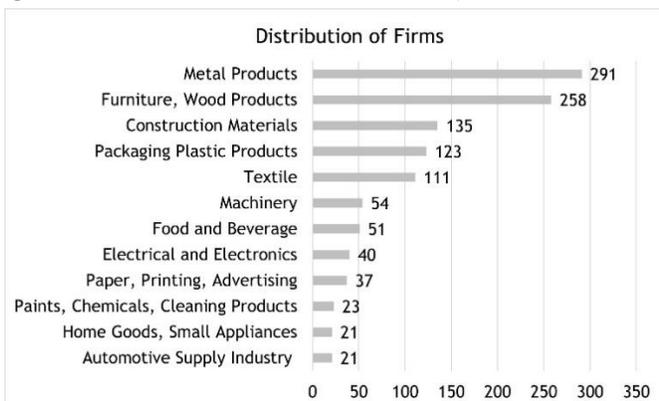


Figure 2. The Distribution of Firms in KOIZ

It also hosts a wide range of firms from various industrial sectors, contributing to economic diversity. Products manufactured are exported to international markets, boosting economic growth. KOIZ plays a crucial role in the region's economy and increase local employment opportunities. Figure 3 illustrates the layout of firms in KOIZ.

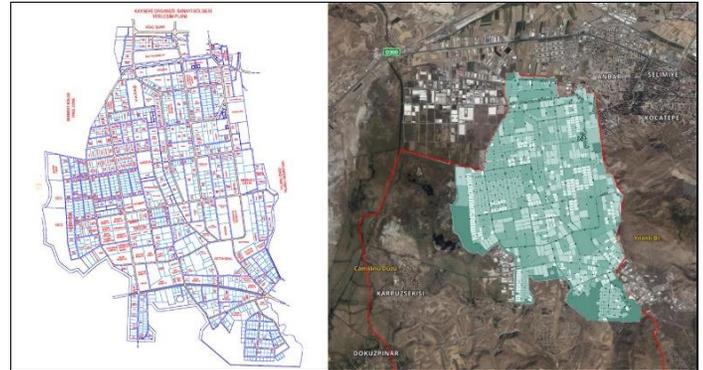


Figure 3. Layout of Firms in KOIZ (Kayseri Organized Industrial Zone Directorate, 2017).

KOIZ is approximately 15 kilometres from the city centre and covers about 22 million square meters. The zone benefits from easy access via road, air, and rail. Its proximity to Kayseri Airport and Kayseri Train Station provides significant logistical advantages. Equipped with modern infrastructure, KOIZ provides essential services such as electricity, water, natural gas, and telecommunications. It also has supporting facilities like wastewater treatment plants, fire stations, and security services (Kayseri Organized Industrial Zone Directorate, 2017).

Hürmetçi Marsh Wetland

Hürmetçi Marsh Wetland, is located 13 kilometres south of the central districts of Kayseri, within the boundaries of the Hacilar and İncesu districts. To the south of Hürmetçi Marsh Wetland lies Mount Erciyes. Figure 4 shows the location of Hürmetçi Marsh Wetland in Türkiye and Kayseri.

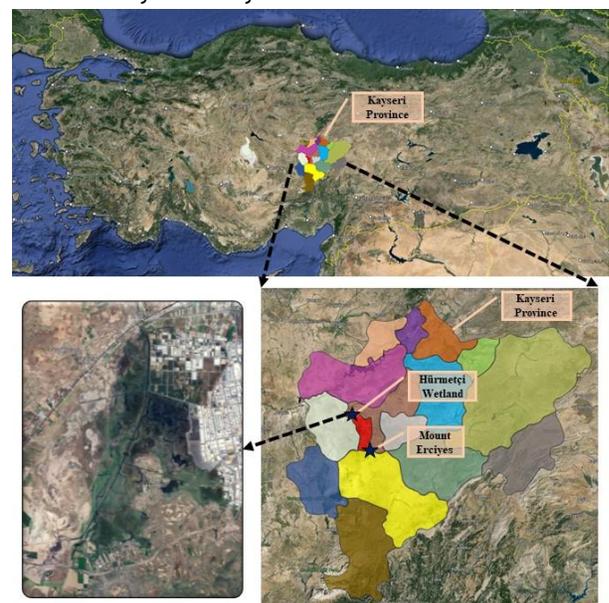


Figure 4. The Location of Hürmetçi Marsh Wetland in Türkiye and Kayseri

In Kayseri's arid climate, winters are snowy and cold, while summers are hot and dry. The high-altitude areas have a plateau climate. The annual average temperature is 10.7°C. The average annual total precipitation is 390.5 mm, and the average annual sunshine duration is 7 hours (Turkish State Meteorological Service, 2023). The soils of Kayseri Province are generally suitable for agriculture, where traditional farming methods are applied. The most commonly grown crops are barley, wheat, legumes, sunflower seeds, apples, potatoes, sugar beets, grapes, and forage crops (Governorship Republic of Türkiye Kayseri, n.d.). The melting snow from Mount Erciyes and seasonal precipitation are influential factors in filling the Hürmetçi Marsh Wetland. The area hosts a variety of species, contributing to its biological diversity: 234 bird species, 145 plant species, 26 mammal species, 13 reptile species, 4 fish species, and 4 amphibian species (General Directorate of Nature Conservation and National Parks, 2024). Figure 5 contains images of Hürmetçi Marsh Wetland.



Figure 5. Hürmetçi Marsh Wetland (Hacılar Municipality, n.d.).

Hürmetçi Marsh Wetland is categorized into two main habitats: terrestrial and wetland. The wetland ecosystem, which gives the region its biological and ecological significance, is formed by a shallow freshwater lake, wet meadows, and Marsh beds resulting from seasonal water expansion and contraction. Additionally, there are salty steppes known to have developed due to the receding water surface, which once covered a larger area. In the surrounding hills and nearby rural areas, wheat, barley, and other agricultural crops are predominantly cultivated.

Protection Status of Hürmetçi

Hürmetçi Marsh Wetland is a neighbourhood due to its location within the administrative borders of Hacılar Municipality. The Ministry of Agriculture and Forestry defined the area as a "Wetland of National Importance" on 20.06.2006 due to its compliance with Ramsar standards. The registered area size of the Hürmetçi Marsh, which has a wetland status, is 15,712 ha. The Hürmetçi Marsh are located in the Kızılırmak Basin and the wetland size is approximately 3,745 ha. (Ministry of Forestry and Water Affairs, 2017a). The region is administratively managed by the 7th Regional Directorate of the General Directorate of Nature

Conservation and National Parks of the Ministry of Agriculture and Forestry, Kayseri Province Department Directorate. The Hürmetçi Marsh Proposed Natural Protected Area, located within the borders of İncesu and Hacılar districts of Kayseri province, was registered as a "Natural Protected Area-Qualified Natural Protected Area" and "Natural Protected Area-Sustainable Protection and Controlled Use Area" with the Approval of the Ministry dated 13.04.2023 and numbered 6218651. In addition, the region was approved and declared as a "Sensitive Area to be Strictly Protected" with the Presidential Decree dated 01.08.2023 and numbered 7456, published in the Official Gazette. Figure 6 shows the Hürmetçi Marsh Proposed Natural Protected Area (Republic of Türkiye Ministry of Environment Urbanization and Climate Change, 2023).

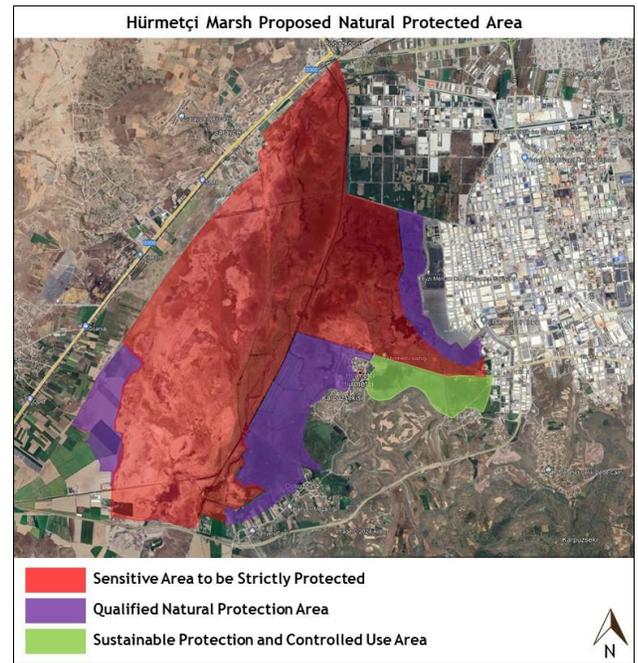


Figure 6. Hürmetçi Marsh Proposed Natural Protected Area (Republic of Türkiye Ministry of Environment Urbanization and Climate Change, 2023).

Figure 6 illustrates a proposed natural protected area for the Hürmetçi Marsh, designating areas for varying levels of protection and controlled use. The largest zone, marked in red, is identified as a "Sensitive Area to be Strictly Protected," where conservation efforts will be most stringent to preserve critical habitats. Surrounding this is the "Qualified Natural Protection Area" in purple, which allows for limited, controlled activities that do not compromise the ecosystem (The area between KOIZ and Hürmetçi Marsh). The green zone, labelled as "Sustainable Protection and Controlled Use Area," permits regulated human activities that balance environmental protection with sustainable land use. This proposed plan aims to safeguard the ecological integrity of the Hürmetçi Marshes while managing the proximity to nearby industrial areas. The 2018 CORINE Land Cover Map of the region is shown in Figure 7 CORINE (Coordination of Information on the Environment) is the database of Land Cover Classes determined by the European Environment Agency.

According to CORINE Land Cover Map of the Hürmetçi Marsh Wetland, different land covers are observed in sensitive protection area and buffer zone. Almost all of the Sensitive Areas to be Strictly Protected consist of marsh, pasture, and sparsely vegetated areas. The south of the area consists mainly of agricultural areas.

decision is communicated to relevant authorities; if no suitable location is identified, the application is rejected (Legislation Information System, 2019).

The location of Organized Industrial Zones (OIZs) is determined by several critical factors. Proximity to raw materials minimizes transportation costs and expedites production, while closeness to suppliers, markets, and distribution networks ensures efficient transportation and logistics. Access to energy resources like electricity, natural gas, and water is vital for cost-effective, uninterrupted production. Environmental impacts, including pollution, waste management, and sustainability, must be assessed. A skilled and sufficient labor force, supported by nearby educational institutions and vocational training centers, is

essential. Compliance with legal and regulatory requirements is crucial for smooth operation. Strategic advantages arise from proximity to trade routes, ports, and border crossings. Social and economic considerations, including local employment, regional development, and quality of life, play a role in site selection. Land availability and affordability are significant, as is access to robust infrastructure and essential services such as health and security. Issues like environmental pollution, waste management, and sustainability should be considered. However, according to the sample area examination in this study, KOIZ is located almost adjacent to the Hürmetçi Marsh Wetland as an important environmental value. Figure 9 shows the development stages of KOIZ over the years.



Figure 9. Development Stages of KOIZ in Time (Google Earth-2024)

The development of KOIZ towards the Hürmetçi Marsh wetland over the years raises concerns for the future because it can cause many negative effects on this wetland. The proximity of wetlands and organized industrial zones can cause several issues for settlements, living things, and people (Figure 10).

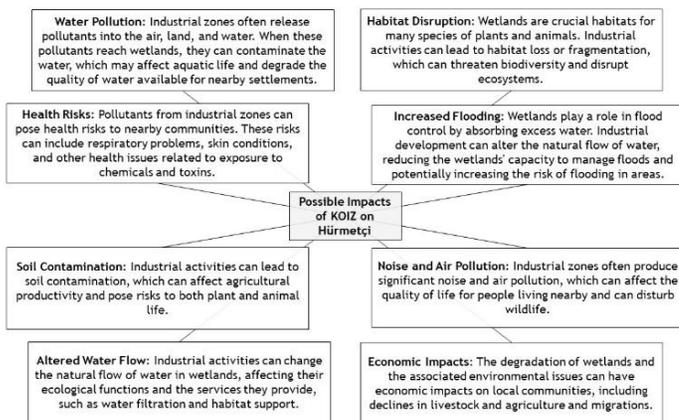


Figure 10. Possible Impacts of KOIZ on Hürmetçi Marsh

Wetlands, particularly the Hürmetçi Marsh, face significant threats from intense human activities, including urbanization, industrialization, and agriculture, leading to destruction and loss of natural habitats. This destruction results in biodiversity loss and threatens the ecological functions of wetlands, which serve as natural climate regulators. The proximity of the Kayseri Organized Industrial Zone (KOIZ) poses several potential negative effects on the Hürmetçi Marsh, including water pollution, habitat disruption, health risks, increased flooding, soil contamination, noise and air pollution, altered water flow, and economic impacts. The local communities, whose primary livelihoods depend on agriculture and livestock, would face severe

consequences from the wetland's degradation, including reduced income, increased unemployment, and potential out-migration, which could disrupt the social fabric and exacerbate regional economic disparities. Furthermore, agricultural and livestock activities in the area are likely to contribute to increased water pollution. Notably, there is a lack of official reports on water quality in the wetland, including sampling points and examination methods, leading to public anxiety about water safety. Neglecting water quality monitoring poses a critical threat to the health of the wetland ecosystem and local people. According to Yılmaz (2018) study, it is predicted that Hürmetçi Marsh are facing a great threat in terms of heavy metal pollution. It has been determined that heavy metal rates in stations close to the KOIZ are above the criteria determined by EPA (United States Environmental Protection Agency) and WHO (World Health Organization). It has been determined that zinc, nickel and copper rates are well above the required values. It is predicted that the reason for these high values is industrial pressure, agricultural activities and livestock. It has been a matter of concern for the people in the settlement area that some factories in the KOIZ discharge their wastewater and sewage systems into channels (Yılmaz, 2018).

PESTLE Analysis of KOIZ's Impact on Hürmetçi

KOIZ is one of the largest organized industries in Türkiye and it is almost impossible to move this zone to another place to eliminate its impact on the Hürmetçi reeds. However, in order to reduce the negative environmental problems, PETSTLE analysis was carried out and suggestions were developed within the scope of the study. PESTLE analysis is a strategic management tool that helps to prepare a framework for changes, make informed decisions, and develop strategies that align with the external environment. In line with the data obtained regarding Hürmetçi Marsh and KOIZ, PESTLE analysis is given in Table 2.

Factors		Details
P	Political	Government Regulations and Environmental Policies: Türkiye's environmental policies, such as the "Regulation on the Protection of Wetlands" and the Ramsar Convention, emphasize wetland preservation. These policies mandate sustainable management and prevent damaging activities like water extraction, pollution, and habitat destruction.
		Industrial Development Policies: Industrial development policies, including those supporting Organized Industrial Zones (OIZs), are aimed at regional economic growth. The decision to place KOIZ near the wetland reflects priorities set by policymakers to boost local economies.
E	Economic	Economic Benefits of KOIZ: KOIZ generates significant economic activity and employment opportunities for the region, bolstering local incomes and economic growth. It attracts various industries that contribute to exports, which can justify its proximity to key logistical routes, though this comes at an environmental cost.
		Cost of Environmental Degradation: Industrial expansion near the wetland can lead to environmental degradation, which imposes economic costs on other sectors. For instance, local agriculture and husbandry in Hürmetçi Marsh could suffer, leading to a loss of revenue and a decline in the quality of life for dependent communities.
		Long-term Sustainability: The economic benefits of KOIZ may be short-lived if the wetland's resources are not conserved. Sustainable economic practices that incorporate environmental protections could enhance the longevity of both KOIZ and the wetland ecosystem, maintaining balance between industrial growth and ecological preservation.
S	Social	Community Livelihoods and Traditional Practices: Hürmetçi Marsh has supported local agricultural and animal husbandry practices, crucial to the socio-economic fabric of the region. KOIZ's impact on water quality, air quality, and biodiversity threatens these traditional livelihoods, creating potential social and economic instability.
		Public Health Concerns: Proximity to KOIZ raises public health concerns for nearby residents due to increased air and water pollution. Heavy metal contamination, as noted in previous studies, can have adverse health impacts, including respiratory and developmental issues, creating social tensions and potentially increasing healthcare costs.
		Community Awareness and Engagement: The degree of local community awareness and involvement in environmental conservation can influence the success of preservation efforts. Engaging the local population through environmental education and promoting community-led conservation efforts could be a strategic way to protect the wetland while fostering public support for sustainable practices within KOIZ.
T	Technological	Pollution Control Technologies: The adoption of advanced wastewater treatment, air purification, and waste management technologies within KOIZ could mitigate its environmental impact on the wetland. Exploring modern industrial technologies to reduce emissions and wastewater contamination would align KOIZ's operations with sustainable practices.
		Sustainable Industrial Practices: KOIZ could implement greener practices, such as zero-liquid discharge systems, or invest in research for low-waste production methods. Such innovations would help reduce KOIZ's ecological footprint, lessening the adverse impacts on the wetland.
		Monitoring and Data Collection: Investing in environmental monitoring technologies, such as remote sensing, GIS, and continuous water quality testing, can provide critical data on KOIZ's impact on Hürmetçi Marsh. Data collected could guide further research and inform policy adjustments to enhance protection for the wetland.
L	Legal	Environmental Protection Laws: Türkiye's environmental laws, such as the Environmental Law No. 2872, Law No. 4915, Law No. 3958 and also Law No. 7456 and regulations under the Ramsar Convention, mandate the protection of wetlands like Hürmetçi Marsh. These laws prohibit pollution, habitat destruction, and excessive water extraction but may be inadequately enforced due to industrial influence and economic pressures.
		Enforcement of Industrial Regulations: Laws governing OIZs, including environmental impact assessments (EIA) and licensing, are intended to ensure sustainable development. Compliance checks and stronger enforcement measures are essential to curb practices that harm the wetland. Regular EIA requirements and strict penalties for violations can improve KOIZ's environmental accountability.
		Legal Framework for Community Involvement: Legal provisions could also support greater community involvement in decision-making processes related to wetland protection. Involving local stakeholders in legal frameworks could increase transparency and accountability, ensuring that industrial activities do not endanger Hürmetçi Marsh.
E	Environmental	Water and Soil Pollution: The expansion of KOIZ has introduced pollutants, including heavy metals and chemical runoffs, into the wetland's ecosystem, threatening water quality and soil health. This contamination affects biodiversity, harms wildlife, and poses health risks to nearby communities reliant on the wetland.
		Biodiversity Loss: Hürmetçi Marsh, home to a variety of plant and animal species, is under threat from habitat encroachment and pollution from KOIZ. The loss of biodiversity impacts ecosystem services such as water purification, flood control, and climate regulation, which are vital for the wetland's health.
		Climate Resilience and Adaptation: The wetland serves as a natural buffer against climate-related risks like drought and flooding. KOIZ's impact on Hürmetçi Marsh could diminish its ability to moderate local climate conditions. Climate-sensitive planning and adaptation strategies, like buffer zones and regulated land-use practices, would enhance the wetland's resilience to industrial pressures.

The PESTLE analysis outlines key factors influencing the relationship between the Kayseri Organized Industrial Zone (KOIZ) and the Hürmetçi Marsh Wetland, emphasizing the need for a balanced approach to industrial development and environmental conservation. Politically, Turkey's environmental regulations aim to protect wetlands, but industrial policies promoting OIZs often prioritize economic growth over ecological concerns. Economically, while KOIZ generates significant activity and job creation, its proximity poses risks to local agriculture and long-term sustainability.

Socially, the impact on traditional livelihoods and public

health highlights the importance of community engagement in conservation efforts. Technological advancements in pollution control and sustainable practices can mitigate environmental impacts, while legal frameworks necessitate stricter enforcement of environmental protection laws and encourage community participation. Environmentally, issues like water and soil pollution, biodiversity loss, and reduced climate resilience call for proactive management strategies to preserve the health of the wetland ecosystem. Overall, the analysis stresses the need for integrated planning and collaboration among stakeholders to ensure the sustainability of both the industrial zone and the wetland.

Table 3. Strategies Based on PESTLE Analysis

Factors		Strategies
P	Political	Policy Enforcement: Ensuring strict adherence to the Laws and Ramsar Convention guidelines through regular inspections and enforcement of regulations for industries near the wetland. Inter-Governmental Collaboration: Establishing a local task force involving governmental bodies, environmental agencies, and KOIZ representatives to monitor and address wetland preservation challenges collaboratively.
E	Economic	Eco-friendly Industrial Incentives: Providing financial incentives and subsidies for KOIZ companies that adopt eco-friendly practices, such as reduced taxes or grants for using green technology. Ecotourism Development: Developing sustainable ecotourism initiatives that highlight the wetland's ecological value and create alternative revenue streams for the local community. Industrial Waste Fees: Introduce fees or taxes on industries generating waste near sensitive areas, with funds redirected to wetland preservation and community development.
S	Social	Community Involvement Programs: Establishing community education programs on wetland conservation and responsible industrial practices to increase awareness and engagement. Public Health Monitoring: Regular health screenings and assessments for nearby residents to detect and address any health issues arising from potential pollution. Community-Driven Conservation Efforts: Encouraging local stewardship by involving community members in conservation activities, such as planting vegetation buffers or monitoring water quality.
T	Technological	Advanced Wastewater Treatment Facilities: Installing or upgrade waste treatment facilities within KOIZ, focusing on capturing and treating harmful substances before they reach the wetland. Green Technology Adoption: Promote cleaner production technologies within KOIZ, such as closed-loop systems, which minimize waste and emissions. Continuous Environmental Monitoring Technology: Using advanced monitoring tools like sensors and data analytics to regularly assess air, soil, and water quality around KOIZ and the wetland area.
L	Legal	Enhanced Penalties for Non-Compliance: Introducing stricter penalties for industries violating environmental laws, particularly those contaminating water sources close to Hürmetçi Wetland. Legal Framework for Buffer Zones: Legislate buffer zones around sensitive areas like the Hürmetçi Marsh to ensure a mandatory safe distance between industrial activities and the wetland. Clear Compliance Requirements: Standardizing compliance requirements and reporting for industries, including regular environmental impact assessments and transparent pollution disclosure.
E	Environmental	Buffer Zone Creation: Establishing and maintain a buffer zone around Hürmetçi Marsh, including reforestation and green barriers to limit pollution from KOIZ. Wetland Restoration and Conservation: Investing in wetland restoration activities, such as reintroducing native plant species and removing invasive plants to strengthen the wetland's ecological resilience. Climate-Resilient Hydrological Management: Managing water levels and flows to maintain the wetland's natural hydrology, mitigating the impact of industrial water consumption on the marsh's ecosystem.

Results and Discussion

In this section, suggestions and recommendations have been developed as a result of the PESTLE analysis. Table 3 presents some recommendations and strategies based on PESTLE Analysis.

The proposed strategies for managing the Kayseri Organized Industrial Zone (KOIZ) and the Hürmetçi Marsh Wetland are practical and aim to address ecological challenges through a multifaceted approach. Political strategies include enforcing environmental laws and forming a local task force for inter-governmental collaboration, which can enhance compliance and communication among stakeholders. Economically, offering eco-friendly industrial incentives and promoting sustainable ecotourism can drive green practices and generate alternative revenue streams for local communities. Social strategies focus on community involvement programs and public health monitoring to raise awareness and engage residents in conservation efforts. Technologically, implementing advanced wastewater treatment facilities and promoting cleaner production technologies are feasible measures for reducing industrial pollution. Legal strategies, such as establishing stricter penalties for non-compliance and creating buffer zones, can effectively protect the wetland, while environmental strategies emphasize the importance of wetland restoration and climate-resilient water management. Together, these strategies can foster sustainable

industrial growth while safeguarding vital wetland ecosystems. Overall, the outlined strategies are practical for addressing the environmental challenges posed by KOIZ to the Hürmetçi Marsh Wetland. Successful implementation will require strong political will, inter-agency collaboration, community involvement, technological investment, and adherence to legal frameworks. By balancing industrial growth with ecological preservation, these strategies can promote sustainable development while protecting vital wetland ecosystems.

Conclusion

Wetlands are vital ecosystems that provide significant ecological, economic, and social benefits, such as supporting biodiversity, enhancing water quality, and mitigating climate change. However, industrial zone expansion poses serious threats to wetlands through pollution from toxic metals, chemicals, and industrial wastewater, which degrade water quality and disrupt natural hydrology, leading to habitat fragmentation and biodiversity loss. This industrial development not only increases ecological stress but also diminishes the capacity of wetlands to deliver essential ecosystem services. Addressing these challenges requires collaborative efforts between policymakers and industry to implement sustainable strategies, including advanced wastewater treatment, green infrastructure, and circular

economy practices like reuse and recycling, to balance industrial growth with environmental protection. The research examines the environmental impacts of the Kayseri Organized Industrial Zone (KOIZ) on the biodiversity-rich Hürmetçi Marsh Wetland. Using qualitative methods and PESTLE analysis, it highlights how KOIZ activities and expansions threaten the wetland's ecological health by exploring political, economic, social, technological, legal, and environmental factors affecting this interaction.

As the results PESTLE analysis, political strategies emphasize strict policy enforcement and collaboration among governmental bodies to ensure environmental regulations are upheld. Economic initiatives focus on incentivizing eco-friendly practices, promoting ecotourism, and introducing waste fees to fund conservation efforts. Social strategies advocate for community involvement through education and public health monitoring. It is essential to share water quality data with local communities and provide training on maintaining high water standards. Technological advancements aim to upgrade wastewater treatment facilities and adopt green technologies to reduce industrial pollution. Legal measures propose stricter penalties for violations, establishing buffer zones, and clear compliance requirements to protect the wetland. Lastly, environmental strategies emphasize creating buffer zones, restoring wetland ecosystems, and managing water levels to enhance ecological resilience, highlighting the need for coordinated efforts to balance industrial development with environmental conservation. These comprehensive strategies should involve cooperation at local, national, and international levels to sustain the health and functionality of ecosystems, protecting the environment and public health.

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