JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 2 (203-225), 2026
DOI: 10.47818/DRArch.2026.v7i2211

From SEKA to Sekapark: An analysis of post-industrial transformation through measurable spatial indicators

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Abstract

Post-industrial urban transformation is widely discussed through brownfield redevelopment, industrial heritage conservation, waterfront regeneration, ecological recovery, and culture-led reuse. However, site-scale studies that evaluate such transformations through measurable spatial indicators remain limited. This study examines the transformation of the SEKA Paper Factory in İzmit, Türkiye, into Sekapark as a case of transition from a Fordist industrial production landscape to a post-Fordist cultural, recreational, ecological, and publicly accessible coastal landscape. The research employs a mixed-method design combining field observation, GIS-based spatial analysis, remote sensing, OSM-based network analysis, DEM-based elevation assessment, and archival interpretation. A total of 280 building units were evaluated through physical-structural, ecological-environmental, transport-accessibility, and heritage-urban integration indicators. These include building typology, use status, building condition and intervention priority, NDVI-based vegetation change, elevation-based coastal vulnerability, public transport proximity, pedestrian connectivity, cultural heritage value, and city-center integration. The findings indicate that transformation has been most strongly consolidated along the waterfront through cultural and recreational functions, while parts of the former production core continue to display transitional use and intervention needs. NDVI analysis for 2000–2025 shows that mean NDVI increased from 0.068 to 0.250 and vegetated surface increased to 36.3% by 2025. Accessibility analyses show a strong pedestrian network and close public transport proximity, although the transport assessment is based on stop buffers rather than full route-based accessibility. The study develops and tests an adapted indicator-based spatial evaluation framework for assessing post-industrial transformation at the site scale.

Keywords: brownfield redevelopment, industrial heritage, measurable spatial indicators, post-fordist urbanism, seka–sekapark

1. Introduction

Post-industrial urban transformation refers not only to the cessation of production activities, but also to the spatial, economic, ecological, and cultural restructuring of former industrial areas (Harvey, 1989; CABERNET, 2006; Franz et al., 2008). These areas are often characterized by obsolete production buildings, fragmented urban connections, environmental degradation, limited public accessibility, and uncertain heritage value. Their transformation therefore involves more than functional reuse; it requires the reorganization of spatial continuity, ecological capacity, cultural memory, and urban integration.

The international literature has addressed post-industrial transformation through concepts such as brownfield redevelopment, adaptive reuse, waterfront regeneration, culture-led transformation, ecological restoration, and urban image-making (CABERNET, 2006; Plaza, 2000; Vanolo, 2008; Franz et al., 2008). Cases such as London Docklands, Ruhr IBA, HafenCity, Detroit,

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Article history: Received 10 June 2026, Accepted 31 July 2026, Published 31 August 2026

Bilbao, Katowice, Łódź, and Zorrotzaurre demonstrate different strategies for reactivating former industrial landscapes (Church, 1988; Detroit Future City, 2012; Jordan & von Daniels, 2019; Jacobs & Estensoro, 2020; Sobala-Gwosdz & Gwosdz, 2017; Masierek, 2021). However, many studies remain focused on strategic planning visions, symbolic architectural projects, governance models, or design narratives. Indicators such as building typology, current use, structural condition, vegetation capacity, coastal vulnerability, pedestrian accessibility, and public transport integration are often discussed separately rather than being combined into a unified field-based assessment model.

This limitation creates a methodological gap in the evaluation of post-industrial transformation areas. While existing studies explain why former industrial sites should be reused or regenerated, fewer studies demonstrate how the physical, ecological, and accessibility-related outcomes of such transformations can be measured at the site scale (Franz et al., 2008; Jordan & von Daniels, 2019). As a result, it becomes difficult to compare transformation processes across different periods, sites, and spatial conditions. This study addresses that gap by developing and testing an adapted indicator-based field assessment framework supported by GIS, remote sensing, OSM-based spatial data, and field interpretation.

In this study, urban resilience is understood as the capacity of a post-industrial area to adapt to changing environmental, spatial, social, and functional conditions while maintaining its physical, ecological, and cultural continuity. Within this framework, physical–structural indicators reveal the adaptive capacity of buildings and spaces to accommodate new functions, while ecological–environmental indicators assess vegetation capacity and the reduction of environmental vulnerability. Elevation-based coastal vulnerability indicators identify areas exposed to water-related and climate-related risks, whereas transport and accessibility indicators evaluate the integration of the site with the wider urban system and the accessibility of its public functions. Heritage value, adaptive reuse, and the visibility of industrial traces indicate the continuity of cultural memory and spatial identity. Taken together, these indicators provide a measurable basis for assessing adaptive capacity, vulnerability reduction, and the long-term sustainability of the SEKA–Sekapark transformation.

The SEKA Paper Factory–Sekapark site in İzmit provides a suitable case for testing this methodological framework. Established in 1936 in line with the state-led industrialization policies of the Early Republican period, SEKA represented a Fordist industrial complex composed of production halls, warehouses, technical facilities, administrative buildings, workers' housing, and social facilities (Oral Aydın & Çömlekçioğlu Kartal, 2010; Tunçelli et al., 2020). Following the cessation of production in 2005, the site experienced underuse, structural deterioration, and spatial disconnection. Its subsequent transformation into Sekapark introduced cultural, recreational, ecological, and public waterfront functions into the former industrial landscape (Oğuz et al., 2010).

The SEKA–Sekapark transformation provides an appropriate case for examining multiple spatial indicators, including building typology, use status, condition and intervention priority, NDVI-based vegetation change, elevation-based coastal vulnerability, pedestrian accessibility, public transport proximity, and morphological integration with the city center. These indicators also enable the SEKA case to be discussed in relation to international post-industrial transformation examples: Docklands in terms of accessibility, Ruhr IBA in terms of ecological restoration, HafenCity in terms of waterfront adaptation, Detroit in terms of condition-based spatial analysis, and Katowice–Łódź in terms of culture-led adaptive reuse (Church, 1988; Franz et al., 2008; Jordan & von Daniels, 2019; Detroit Future City, 2012; Sobala-Gwosdz & Gwosdz, 2017; Masierek, 2021).

The aim of this study is to analyze the transformation of SEKA–Sekapark through measurable spatial indicators and to test the applicability of an adapted evaluation framework for post-industrial areas. The study addresses three research questions: (1) How can the SEKA–Sekapark transformation be evaluated through measurable spatial indicators? (2) Which dimensions of the transformation are spatially consolidated, and which remain incomplete? (3) To what extent can an adapted field-observation and GIS-based framework support site-scale assessment of post-industrial transformation areas?

The study focuses on four main dimensions: physical-structural transformation, ecological-environmental change, transport and pedestrian accessibility, and heritage-urban integration. By combining field observations with GIS-based, OSM-based, DEM-based, and remote sensing data, the research seeks to make the transformation process visible, comparable, and methodologically traceable. The contribution of the study is twofold. First, it provides a detailed spatial reading of the SEKA–Sekapark transformation beyond historical, architectural, or project-based interpretations. Second, it tests an adapted indicator-based framework that may support the assessment of similar post-industrial transformation sites in Türkiye and comparable international contexts.

2. Literature Background

2.1. Post-Industrial Urban Transformation Theories

Post-industrial urban transformation refers to the spatial, economic, ecological, and cultural restructuring processes that emerge following the decline of Fordist production regimes. The Fordist period was characterized by large-scale, vertically integrated, and predominantly single-function industrial areas supported by strong relationships among production, labor, logistics, housing, and social facilities (Harvey, 1989). By contrast, the post-Fordist period is associated with flexible production systems, service- and culture-based economies, mixed-use development, public-space provision, accessibility, and urban image-making (Harvey, 1989; Vanolo, 2008).

This transformation is particularly visible in former port areas, waterfronts, mining regions, and heavy industrial zones where production functions have become obsolete. In these areas, transformation involves more than a change in land use or building function. It also requires the reorganization of accessibility, ecological capacity, publicness, heritage value, spatial continuity, and functional integration. These components are directly related to urban resilience because they affect the capacity of former industrial areas to adapt to changing environmental, social, and functional conditions while maintaining their spatial and cultural continuity. However, these parameters are frequently addressed conceptually or individually rather than measured through an integrated site-scale framework. This limitation forms the theoretical basis of the measurability problem addressed in this study.

2.1.1. Fordist–Post-Fordist Spatial Transformation

Harvey (1989) emphasizes that capital produces “spatial fixes” through which idle or underused spaces are reorganized during periods of economic restructuring. From this perspective, Fordist spatial organization can be understood through integrated industrial settlements comprising production halls, logistics corridors, technical infrastructure, administrative units, workers’ housing, and social facilities. In the post-Fordist phase, these formerly single-function production areas are increasingly transformed into multifunctional environments in which cultural, recreational, residential, service, and public-space uses coexist.

London Docklands represents an investment- and infrastructure-oriented example of this transition. Following the decline of the port economy, the area was restructured through finance-oriented development, residential investment, transportation infrastructure, and urban image-making. Nevertheless, the transformation was also criticized for producing socially unequal and spatially fragmented outcomes (Church, 1988). HafenCity represents a different model in which mixed-use development, waterfront accessibility, elevated public spaces, and flood-sensitive planning were incorporated into post-industrial redevelopment (Jordan & von Daniels, 2019). Together, these examples demonstrate that physical transformation alone does not ensure spatial resilience; accessibility, social integration, environmental adaptation, and functional diversity are also essential.

The SEKA Paper Factory can be evaluated as a distinctive example of this theoretical transition in Türkiye. With its large production halls, logistics infrastructure, administrative units, workers' housing, and social facilities, SEKA embodied the Fordist spatial model of Early Republican industrialization (Oral Aydın & Çömlekçioğlu Kartal, 2010; Tunçelli et al., 2020). Following the cessation of production in 2005, the site became an underused industrial landscape. Through the Sekapark project, parts of the area were subsequently transformed into a recreational, cultural, ecological, and waterfront-oriented public space (Oğuz et al., 2010). SEKA–Sekapark therefore provides an appropriate case for examining the transition from a Fordist industrial settlement to a post-Fordist multifunctional landscape through measurable physical, ecological, accessibility-related, and heritage-based indicators.

2.1.2. Brownfield Concept

The concept of brownfield generally refers to previously developed urban areas affected by industrial decline, physical deterioration, environmental degradation, underuse, and loss of spatial integrity. CABERNET (2006) evaluates brownfield areas according to factors such as physical condition, environmental risk, redevelopment potential, and market conditions. Within this framework, brownfield transformation is not limited to the reuse of vacant land or obsolete buildings; it also involves ecological repair, spatial reconnection, functional adaptation, and social reintegration.

The Ruhr IBA process demonstrates how ecological corridors, regional park systems, industrial heritage conservation, and culture-oriented reuse can be combined within a post-industrial landscape strategy (Franz et al., 2008). Similarly, culture-led redevelopment in Katowice illustrates how former mining areas may be reactivated through cultural functions and urban image-making while retaining elements of industrial identity (Sobala-Gwosdz & Gwosdz, 2017). Detroit Future City (2012), by contrast, applies quantitative indicators such as building condition, vacancy, land-use intensity, and green infrastructure capacity to identify different intervention priorities.

These examples indicate that brownfield transformation involves three interrelated challenges: environmental vulnerability, spatial disconnection, and socio-economic or functional exclusion (CABERNET, 2006; Detroit Future City, 2012; Franz et al., 2008). Addressing these challenges can increase adaptive capacity by enabling former industrial areas to accommodate new functions, reduce environmental risks, and reconnect with surrounding urban systems. However, data-driven assessment models require adaptation when applied to industrial sites with strong cultural and historical significance. In the SEKA case, post-production underuse, varying building conditions, former accessibility limitations, and intervention needs resemble brownfield conditions, while the site's industrial heritage value necessitates the inclusion of cultural memory, adaptive reuse, and heritage visibility within the assessment framework.

2.2. International Transformation Cases and Methodological Discussions

International post-industrial transformation cases demonstrate that redevelopment strategies may prioritize different spatial, economic, ecological, and cultural dimensions. London Docklands, Bilbao, and Turin are primarily associated with investment-led redevelopment, symbolic architecture, tourism, creative economies, and urban image-making (Church, 1988; Plaza, 2000; Vanolo, 2008). Ruhr IBA, Katowice, and Łódź foreground ecological restoration, industrial heritage conservation, culture-led adaptive reuse, and the regeneration of deteriorated urban environments (Franz et al., 2008; Sobala-Gwosdz & Gwosdz, 2017; Masierek, 2021). HafenCity and Zorrotzaurre emphasize waterfront redevelopment, mixed-use planning, public accessibility, climate adaptation, and the integration of former industrial land with the wider urban structure (Jordan & von Daniels, 2019; Jacobs & Estensoro, 2020).

These cases reveal that no single strategy is sufficient for achieving comprehensive post-industrial transformation. Investment and urban image-making may improve economic visibility but can also produce spatial fragmentation or social exclusion. Culture-led adaptive reuse can strengthen identity and preserve industrial heritage, but its benefits may remain concentrated around individual buildings or flagship projects. Ecological restoration and climate-sensitive design can reduce environmental vulnerability, while accessibility and mixed-use development can improve urban integration and long-term adaptability.

The international cases are therefore used in this study as conceptual and methodological references rather than as subjects of a full comparative analysis. Their main contribution is to identify recurring dimensions of post-industrial transformation, including building reuse, physical condition, ecological restoration, climate vulnerability, pedestrian accessibility, public transport integration, heritage continuity, and morphological connection. However, these dimensions are frequently assessed separately in the literature. The present study brings them together within a unified field- and GIS-based evaluation framework and tests their applicability in the SEKA–Sekapark transformation area.

2.3. Lack of Measurable Parameters in Transformation Areas

Many studies on post-industrial transformation areas focus on strategic planning visions, design decisions, architectural reuse, governance models, and cultural economy. However, the quantitative monitoring of the physical environment remains limited (Franz et al., 2008; Jordan & von Daniels, 2019). Building condition and deterioration are often addressed through descriptive narratives, while standardized scoring systems are used in relatively few cases. Similarly, ecological improvement and accessibility are frequently discussed separately rather than within an integrated analytical framework.

Although NDVI-based remote sensing indicators are widely used to assess vegetation density and ecological improvement, they are rarely combined with field observations, use status, building condition, and accessibility data in a holistic manner. Pedestrian and public transport accessibility analyses are also commonly discussed qualitatively, while OSM-based network analysis, buffer-based proximity assessment, and building-scale spatial evaluation remain limited in post-industrial transformation studies.

This methodological fragmentation makes it difficult to compare transformation processes across different sites and periods. It also limits the possibility of evaluating whether redevelopment produces measurable improvements in physical condition, ecological capacity, public accessibility, and urban integration. For the SEKA–Sekapark area, the observation form and GIS-based analyses developed in this study respond to this gap by operationalizing indicators such as building condition and intervention priority, use status, NDVI-based vegetation cover, elevation-based coastal vulnerability, pedestrian accessibility, public transport proximity, and cultural-urban integration.

2.4. Theoretical Basis of Observation Form Categories

The observation form is structured around four categories—physical–structural, ecological–environmental, transport–accessibility, and heritage–urban integration—which collectively assess adaptive capacity, environmental vulnerability, urban connectivity, and cultural continuity through measurable spatial indicators.

The physical–structural category includes building typology, current use, and building condition/intervention priority. Building typology helps identify the spatial characteristics and reuse potential of the industrial building stock, while use status indicates whether structures have been successfully reintegrated into contemporary urban life. Building condition and intervention priority reveal areas where deterioration may limit adaptive reuse and long-term functional continuity. These indicators are consistent with building-stock assessments used in post-industrial redevelopment studies and with condition-based approaches such as Detroit Future City (2012) and CABERNET (2006).

The ecological–environmental category includes NDVI-based vegetation cover and elevation-based coastal vulnerability. Vegetation cover provides measurable evidence of ecological capacity and green infrastructure development, while elevation-based coastal vulnerability identifies areas exposed to water-related environmental risks. These indicators are associated with ecological restoration approaches applied in the Ruhr region and with climate-sensitive governance and adaptation strategies developed in waterfront cities such as Hamburg and Rotterdam (Franz et al., 2008; Mees et al., 2014). Together, they indicate whether the transformation contributes to ecological improvement, vulnerability reduction, and long-term environmental sustainability.

The transport–accessibility category includes pedestrian accessibility, public transport proximity, promenade continuity, entrance distribution, and the permeability of physical barriers. These indicators assess whether the transformed site is spatially connected to the city and whether its public functions can be reached through different modes of transportation. Accessibility and connectivity are central components of the Docklands, HafenCity, and Zorrotzaurre transformations, although the social and spatial outcomes of these projects vary (Church, 1988; Jordan & von Daniels, 2019; Jacobs & Estensoro, 2020). Within the SEKA–Sekapark area, these indicators help determine whether public access is distributed throughout the entire site or concentrated mainly along the waterfront.

The heritage-urban integration category includes industrial heritage value, adaptive reuse, visibility of industrial traces, urban image, and morphological–functional integration with the city center. Culture-led transformations in Bilbao, Turin, Katowice, and Łódź demonstrate that former industrial areas can be repositioned through cultural programming, tourism, adaptive reuse, and image-making strategies (Plaza, 2000; Vanolo, 2008; Sobala-Gwosdz & Gwosdz, 2017; Masierek, 2021). However, the preservation of individual buildings alone does not ensure heritage continuity. Industrial structures, routes, technical elements, and production-related spatial relationships must remain visible and legible within the transformed landscape.

In the SEKA case, this category is particularly important because the site represents both a former industrial production complex and a symbolic landscape of Republican-era industrialization. Assessing heritage value together with adaptive reuse and urban integration makes it possible to determine whether the transformation maintains cultural memory while enabling new uses. Accordingly, the four observation-form categories collectively measure the capacity of the SEKA–Sekapark area to adapt to new urban functions, reduce physical and environmental vulnerabilities, preserve industrial identity, and maintain long-term spatial continuity.

2.5. Research Gap in the Transformation of SEKA

Existing studies on SEKA mainly focus on the historical development of the factory, architectural characteristics, production processes, adaptive reuse, and museumization. Oral Aydın and Çömlekçioğlu Kartal (2010) examine the architectural analysis and reuse potential of SEKA Paper Factory I; Tunçelli et al. (2020) discuss cultural and industrial heritage project proposals for the Kocaeli region; and Oğuz et al. (2010) evaluate Sekapark as an example of industrial site transformation. These studies provide a strong background on SEKA's role in Republican-era industrialization and its value as industrial heritage, but they address the spatial analytical dimension of transformation in a limited way.

Figure 1 SEKA Paper Museum site photograph

As shown in Figure 1, the SEKA Paper Museum represents one of the most visible outcomes of adaptive reuse and museumization. However, the SEKA–Sekapark transformation cannot be evaluated only through museumization, architectural conservation, or project-based redevelopment narratives. A broader analytical framework is required to understand how the site has changed physically, ecologically, functionally, and spatially.

Studies that examine the SEKA–Sekapark area through comprehensive and quantitative field analysis based on indicators such as building condition/intervention priority, NDVI-based vegetation cover, elevation-based coastal vulnerability, pedestrian and public transport accessibility, and spatial integration with the city center remain limited. By addressing this gap through an observation form and GIS-based thematic mapping, this study introduces a spatial analytical dimension to the SEKA literature and positions SEKA as a local case that can be discussed on the same analytical ground as international post-industrial transformation examples.

3. Method

This study employs a mixed-method design combining field observation, GIS-based spatial analysis, remote sensing, OSM-based network/proximity analysis, DEM-based elevation assessment, and archival interpretation. The methodological framework was developed to evaluate the SEKA–Sekapark transformation through measurable physical, ecological, accessibility-based, and heritage-urban integration indicators.

3.1. Study Area

The study area includes the historical production site of the SEKA Paper Factory and the Sekapark coastal zone that emerged through its transformation. The boundaries were defined by considering former industrial parcels, preserved factory buildings, current cultural and recreational facilities, coastal public spaces, pedestrian connections, the tram line, and surrounding urban corridors. The multi-scale spatial structure of the study area is presented in Figure 2.

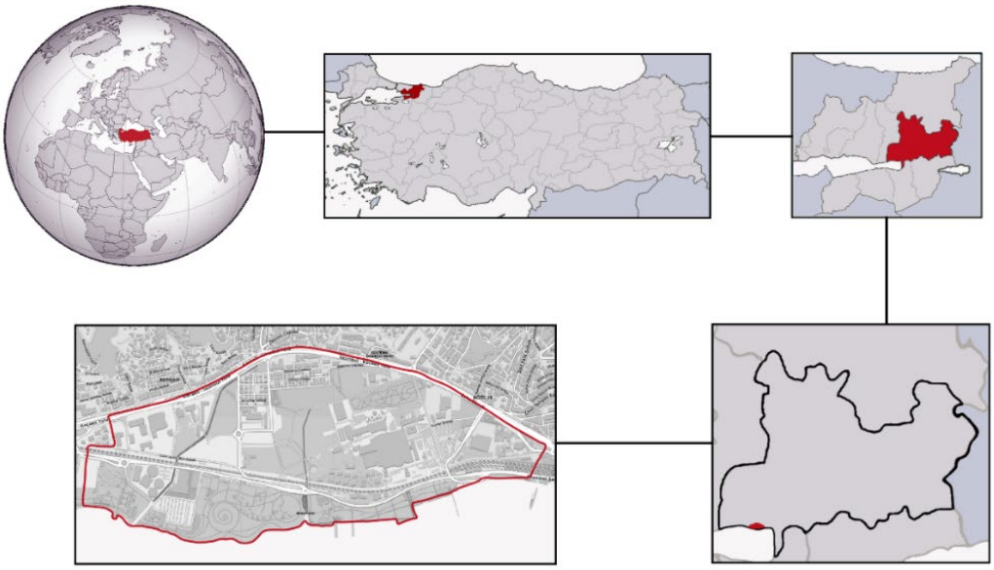

Figure 2 Multi-scale spatial representation of the SEKA–Sekapark area

SEKA was established in İzmit in 1936 as one of the most important industrial complexes of the Early Republican period. Its spatial structure included production halls, warehouses, energy facilities, administrative units, workers' housing, and social facilities (Oral Aydın & Çömlekçioğlu Kartal, 2010; Tunçelli et al., 2020). After production ceased in 2005, the site was transformed into a public coastal park, cultural destination, and recreational urban space within the Sekapark project (Oğuz et al., 2010). The coexistence of industrial heritage buildings, transformed cultural facilities, green public spaces, and accessibility infrastructure makes SEKA–Sekapark a suitable case for evaluating post-industrial transformation through multiple indicators.

3.2. Research Design

The research was structured in three phases. First, a standardized observation form was developed from indicators frequently discussed in post-industrial transformation literature, including building typology, use status, condition/intervention priority, ecological capacity, accessibility, cultural heritage, and urban integration (CABERNET, 2006; Detroit Future City, 2012; Franz et al., 2008; Jordan & von Daniels, 2019). Second, satellite images, OSM-based vector data, NASA SRTMGL1 DEM data, historical SEKA plans, Google Earth historical imagery, and field observation data were processed in a GIS environment. Third, the resulting layers were matched with building-level identifiers and transformed into thematic maps.

3.2.1. Observation Form Approach

The observation form used in this study was developed to integrate measurable physical, ecological, accessibility-based, and heritage-urban integration indicators into a single field-based evaluation tool. The indicators and classification scheme used in the observation form are summarized in Table 1. Fieldwork was conducted between September and October 2025. During this period, 280 building units within the SEKA–Sekapark study area were surveyed. Each building was treated as a separate observation unit. Since the evaluation was conducted through a single-observer approach, inter-observer reliability analysis was not included; however, field observations were cross-checked with photographic records, OSM data, Google Earth imagery, and historical plans where possible.

Table 1 Indicators, Measurement Methods, and Classification Schemes Used in the SEKA–Sekapark Study

Main Category	Sub-Indicator	What It Measures	Classification / Scale
Physical–Structural	Building typology	Original / adaptive function of the building	Production hall / warehouse / technical unit / administrative / residential / social facility / cultural / recreational
	Use status	Current functional activity	Active / Transitional / Idle
	Building condition and intervention priority	Physical condition and required intervention level	1 = urgent intervention / 2 = strengthening / 3 = maintenance / 4 = conservation / 5 = registration potential
Ecological–Environmental	NDVI	Vegetation density and vitality	Mean NDVI, NDVI > 0.30 vegetation mask, vegetation classes
	Coastal vulnerability	Low-elevation exposure within 0–3 m elevation zone	0–1 m high exposure / 1–2 m moderate exposure / 2–3 m low exposure
Transport–Accessibility	Public transport	Proximity to tram and bus stops	100 m and 200 m stop-proximity buffers
	Pedestrian accessibility	Pedestrian route continuity and barrier permeability	Pedestrian / Footway / Steps / Bridge / Underpass Categories
Macro-Scale	Cultural heritage & image	Historical and identity value	Heritage present/absent + cultural function
	Urban center relation	Urban connectivity and pedestrian continuity	Strong / Moderate / Weak

3.2.2. Data Sources

The spatial dataset consists of satellite imagery, DEM data, OSM-based vector data, historical SEKA plans, Google Earth historical imagery, and field observation data. The data sources, their content, purpose of use, and derived indicators are summarized in Table 2. Satellite images supported NDVI-based ecological analysis; DEM data supported elevation-based coastal vulnerability analysis; OSM data provided building footprints, road and pedestrian networks, transport stops, and route geometries; historical SEKA plans supported the interpretation of Fordist-era typologies and original spatial functions; Google Earth imagery supported spatial verification; and field observations validated current use, condition/intervention priority, and missing or inconsistent data points.

Table 2 Data Sources Used in the SEKA–Sekapark Study

Data Source	Content	Purpose of Use	Derived Indicators
Satellite Data	Landsat 7 ETM+ and Sentinel-2 MSI images	Monitoring vegetation change	NDVI, vegetation mask, vegetated area
DEM data	NASA SRTMGL1 DEM, 30 m resolution	Low-elevation coastal exposure assessment	0–3 m coastal vulnerability zones
OSM-Based Vector Data	Building footprints, road–pedestrian network, transport stops, route geometries, and building height tags	Morphological and accessibility analysis	Building geometry, current typology, pedestrian network, and public transport proximity
Historical SEKA plans	Period-based plans obtained from İzmitte SEKA digital archive	Verification of industrial-era typologies and functions	Historical building typology
Google Earth historical imagery	Historical and current image interpretation	Verification of building continuity and spatial configuration	Typological and functional validation
Field Observation Data	On-site building-level records and photographs	Validation of current spatial conditions	Use status, condition/intervention priority, boundary verification

3.2.3. Analytical Techniques

All datasets were processed in EPSG:32635 / UTM Zone 35N where metric calculations were required. The analyses were conducted through QGIS and Python-based tools, including rasterio, numpy, fiona, shapely, pyproj, geopandas, pandas, osmnx, and folium.

NDVI analysis was conducted using Landsat 7 ETM+ Collection 2 Level-2 Surface Reflectance products for 2000, 2005, and 2010, and Sentinel-2 images for 2015, 2020, and 2025. The satellite datasets, product types, spectral bands, spatial resolutions, and projection information used for

NDVI calculation are presented in Table 3. For Landsat 7, red and near-infrared bands correspond to SR_B3 and SR_B4; for Sentinel-2, they correspond to B04 and B08. Raster data were clipped to the SEKA–Sekapark boundary using a GeoJSON boundary file prepared for the SEKA–Sekapark study area, and NDVI was calculated using the standard formula: NDVI = (NIR − Red) / (NIR + Red) (Tucker, 1979). A binary vegetation mask was generated using NDVI > 0.30, and annual statistics including mean NDVI, vegetated surface percentage, and vegetated area were exported as CSV outputs. Because Landsat and Sentinel-2 have different spatial resolutions, and because a separate cloud-cover threshold was not applied, NDVI results were interpreted as broad temporal vegetation patterns rather than precise pixel-level change detection.

Table 3 Satellite Datasets and Bands Used for NDVI Analysis

Period	Satellite / Sensor	Product type	NIR band	Red band	Spatial resolution	Projection
2000–2010	Landsat 7 ETM+	Collection 2 Level-2 Surface Reflectance	SR_B4	SR_B3	30 m	EPSG:32635
2015–2025	Sentinel-2 MSI	Level-2A / available 10 m bands	B08	B04	10 m	EPSG:32635

Building typology was produced through the combined interpretation of OSM-based building geometries, period-based SEKA plans, Google Earth historical imagery, and field observations. Building geometries were obtained in QGIS using the QuickOSM “building” query. The period-based SEKA plans used for typological interpretation were obtained from the İzmitte SEKA digital archive (İzmitte SEKA, n.d.). The detailed typology used in Figure 3 consists of twelve categories representing the historical and contemporary functional diversity of SEKA–Sekapark; for Table 1, these detailed typologies were grouped under broader analytical categories.

Use status was analyzed through a Python–QGIS workflow based on OSM building attributes, road proximity, building size, and field interpretation. Buildings with tags indicating abandonment were classified as idle; buildings with current-use tags such as office, school, museum, or industrial were classified as active; large buildings over 1,500 m^2 without direct road proximity were identified as potential adaptive reuse candidates; and buildings smaller than 80 m^2 or with missing attributes were marked as unknown. These initial classes were harmonized into active, transitional, and idle categories. Transitional buildings include adaptive reuse candidates, buildings with uncertain or limited current use, and structures requiring further field interpretation.

Building condition was evaluated through a five-level condition and intervention-priority score informed by the CABERNET (2006) brownfield framework. The scoring process combined field observation with a Python-based rule classification using building area, number of floors, use status, and proximity to roads. The score is not an engineering-level structural safety assessment, but an indicator-based tool for identifying priority intervention zones. The score values and their planning/conservation meanings are explained in Table 4.

Table 4 Building Condition and Intervention-Priority Score

Score	Interpretation	Planning / conservation meaning
1	Urgent intervention	Demolition-level assessment or urgent intervention
2	Strengthening	Building requires strengthening
3	Maintenance	Building requires maintenance and repair
4	Conservation	Building should be considered within conservation strategies
5	Registration potential	Building has strong heritage value and may be proposed for registration or advanced conservation

Elevation-based coastal vulnerability was assessed using the NASA SRTMGL1 Digital Elevation Model with 30 m spatial resolution. DEM-derived elevation values were classified according to a 0–3 m low-elevation coastal exposure framework: 0–1 m as high exposure, 1–2 m as moderate exposure, and 2–3 m as low exposure. Areas above 3 m were considered outside the low-elevation coastal exposure zone. Sea-level rise scenarios, storm surge, wave dynamics, drainage capacity, and hydraulic flood modeling were not included.

Public transport proximity was analyzed through a stop-based buffer approach using OSM-based transport data. Tram, bus, and train stops were obtained through OSM-based spatial queries, duplicate records were removed, and tram/bus stops were used to generate 100 m and 200 m buffers. These buffers were interpreted as stop-proximity indicators rather than full network-based accessibility areas.

Pedestrian accessibility was analyzed using OSM-based walk-network data within the study boundary. The pedestrian network was extracted using the walking-network option in OSMnx and classified according to pedestrian-related OSM tags, including highway=pedestrian, highway=footway, highway=steps, bridge=yes, and tunnel=yes. These categories were used to evaluate pedestrian continuity, barrier permeability, and the relationship between the coastal promenade and inner urban connections. The OSM tags used in the analysis and the spatial indicators derived from them are summarized in Table 5.

Table 5 OSM Tags and Derived Spatial Indicators

Analysis	OSM data used	Derived Indicator
Building Typology	building=*, building:use=*	Building geometry and typological classification
Use status	building attributes, road proximity, building size	Active / transitional / idle use-status categories
Public transport proximity	tram stops, bus stops, railway/tram/bus route geometries	100 m and 200 m stop-proximity buffers
Pedestrian Accessibility	highway=pedestrian, highway=footway, highway=steps, bridge=yes, tunnel=yes	Pedestrian continuity and barrier permeability

4. Findings

The findings are presented under four dimensions corresponding to the indicator structure defined in the methodology: physical-structural characteristics, ecological-environmental characteristics, transport and accessibility, and heritage-urban integration criteria. The analysis shows that the SEKA–Sekapark transformation did not occur uniformly across the site. Cultural, recreational, and public functions are concentrated along the waterfront, while parts of the former production core continue to display transitional use patterns and intervention needs.

4.1. Physical and Structural Characteristics

The physical and structural analysis explains the transformation of SEKA from a Fordist production complex into a post-Fordist urban landscape oriented toward culture, recreation, and public use. This section evaluates building typology, current use status, and building condition/intervention priority through archival plans, field observations, OSM-based vector data, and thematic mapping.

4.1.1. Temporal Evolution of Building Typology

The temporal evolution of building typology reveals the layered spatial development of the SEKA Paper Factory from its establishment in 1936 to the contemporary Sekapark transformation. As shown in Figure 3, the site includes early production structures, later social and administrative facilities, and post-2005 cultural and recreational reuse areas.

The early industrial phase was characterized by large-span production halls, warehouses, technical units, boiler houses, and pulp preparation areas. These structures reflected the rational and production-oriented spatial logic of Fordist industrial organization. During the expansion period, especially from the 1950s to the 1980s, SEKA developed into a more complex industrial campus with workers' housing, social facilities, educational buildings, healthcare units, sports areas, and administrative structures.

After production ceased in 2005, the typological structure of the site changed significantly. Former industrial buildings were adapted for cultural, educational, and recreational uses, including the SEKA Paper Museum, Kocaeli Science Center, exhibition spaces, workshops, and performance venues. The waterfront was reorganized through landscape interventions, pedestrian routes, and recreational public spaces. Overall, Figure 3 shows three main spatial layers: the Fordist production layer, the institutional industrial campus layer, and the post-Fordist cultural-recreational landscape layer.

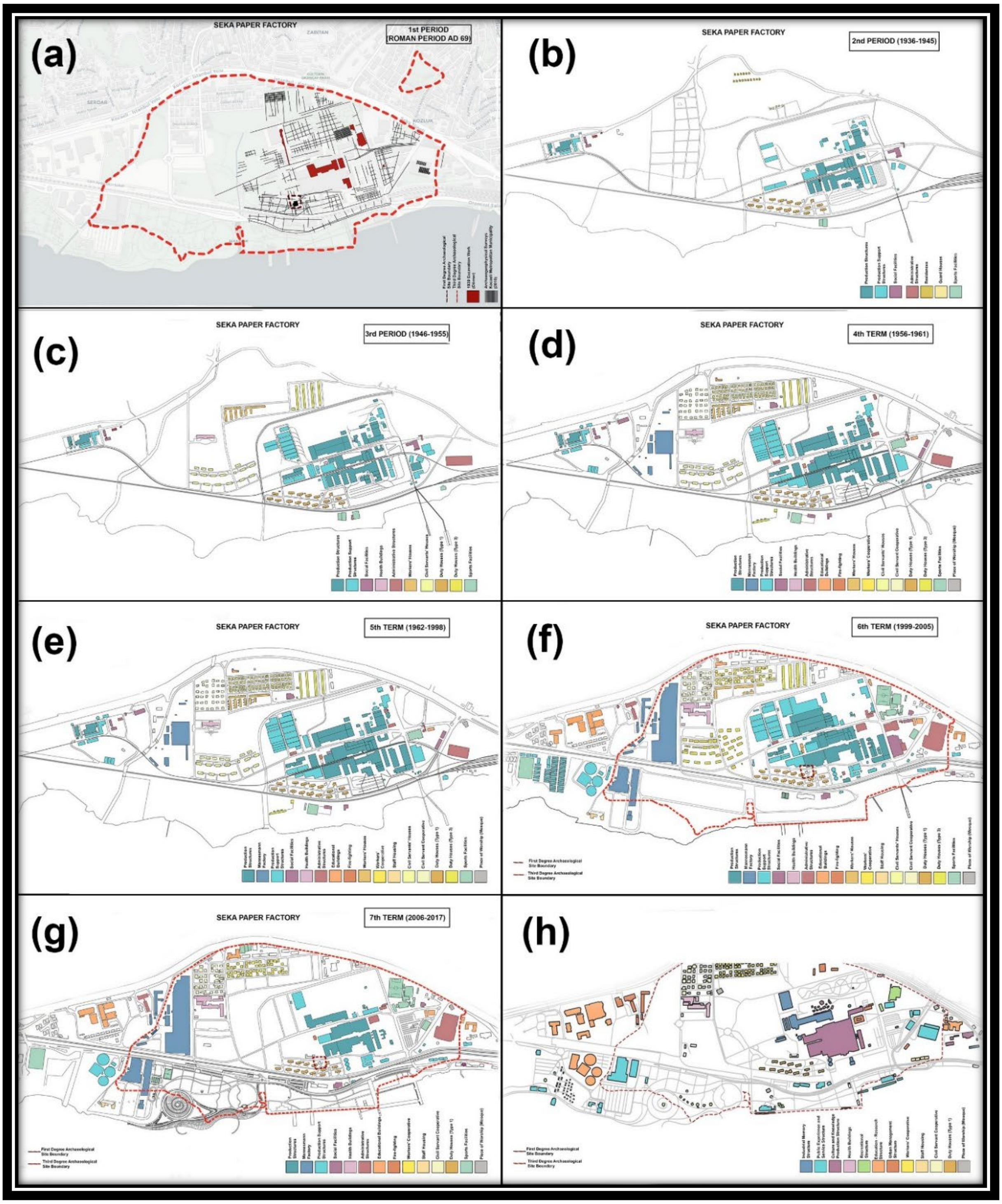

Figure 3 Temporal evolution of SEKA building typology and spatial development phases
Data sources: Historical archival plans, field observations (2025), OSM (2024). The map was produced by the author.

4.1.2. Current Use Status

The current use status of the SEKA–Sekapark area was classified as active, transitional, and idle. As shown in Figure 4, active uses are concentrated primarily along the waterfront and around major cultural and recreational facilities. Out of 280 analyzed building units, 64 buildings (22.9%) were identified as active and 216 buildings (77.1%) as transitional. No building was classified as idle in the final dataset; however, the idle category was retained in the observation form for methodological completeness.

Active buildings include the SEKA Paper Museum, Kocaeli Science Center, Seka Stage, cultural facilities, recreational service units, and waterfront-related functions. Transitional buildings include adaptive reuse candidates, structures with limited or uncertain use, and buildings requiring further field-based interpretation after the automated OSM-based classification.

The dominance of transitional buildings suggests that the transformation is functionally incomplete at the building-stock level despite the strong public activation of the waterfront. This pattern indicates a staged post-industrial landscape in which the waterfront has been consolidated more strongly than the former production core.

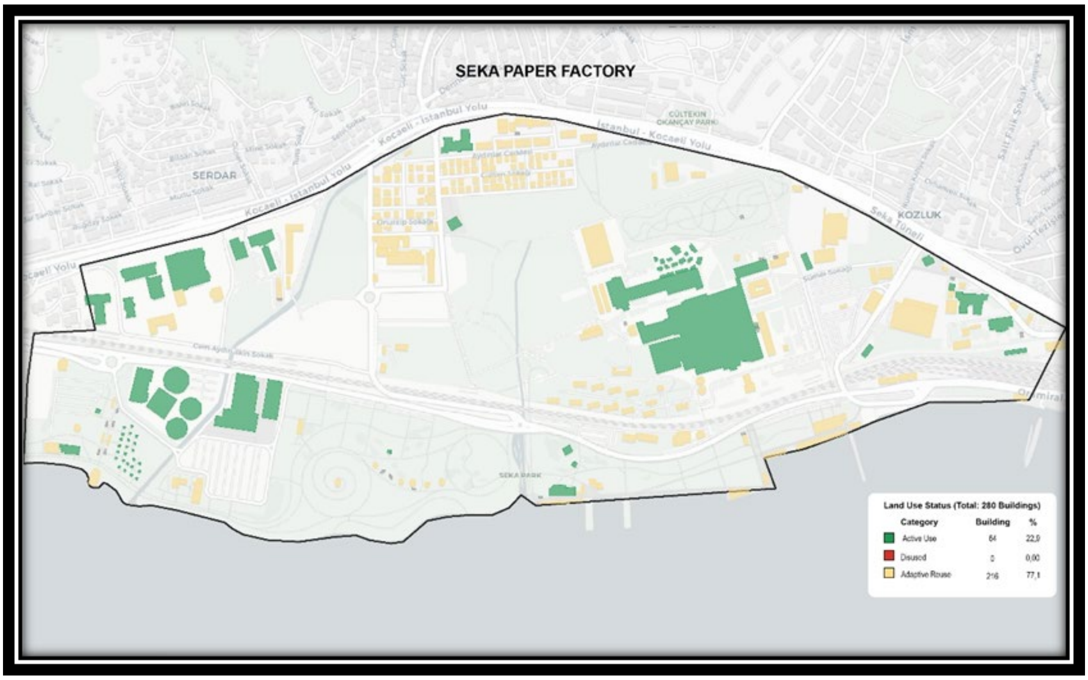

Figure 4 SEKA–Sekapark 2025 building use status
Data sources: Field observations (2025), OSM (2024), QGIS classification (2025). The map was produced by the author.

4.1.3. Building Condition and Intervention Priority

Building condition was evaluated through a five-level condition and intervention-priority score. In this scoring system, lower scores indicate higher intervention needs, while higher scores indicate stronger conservation or heritage-registration potential. Score 1 represents urgent intervention or demolition-level assessment; score 2 represents strengthening need; score 3 represents maintenance and repair; score 4 represents conservation potential; and score 5 represents registration or advanced conservation potential. The spatial distribution of the scores is presented in Figure 5.

The scoring indicates that the former production core contains structures requiring different levels of intervention, ranging from urgent intervention and strengthening to maintenance, conservation, and registration potential. Lower-score structures are mainly associated with areas where functional integration has remained limited, while higher-score structures are generally related to better-preserved or culturally significant buildings. The distribution of score classes indicates that buildings requiring maintenance and conservation are concentrated around the former production core, while registration-potential structures are associated with better-preserved heritage buildings.

This analysis does not represent an engineering-level structural safety assessment. Instead, it provides an indicator-based condition and intervention-priority reading of the building stock. The results therefore support the identification of priority zones for conservation, strengthening, maintenance, and adaptive reuse within the SEKA–Sekapark transformation area.

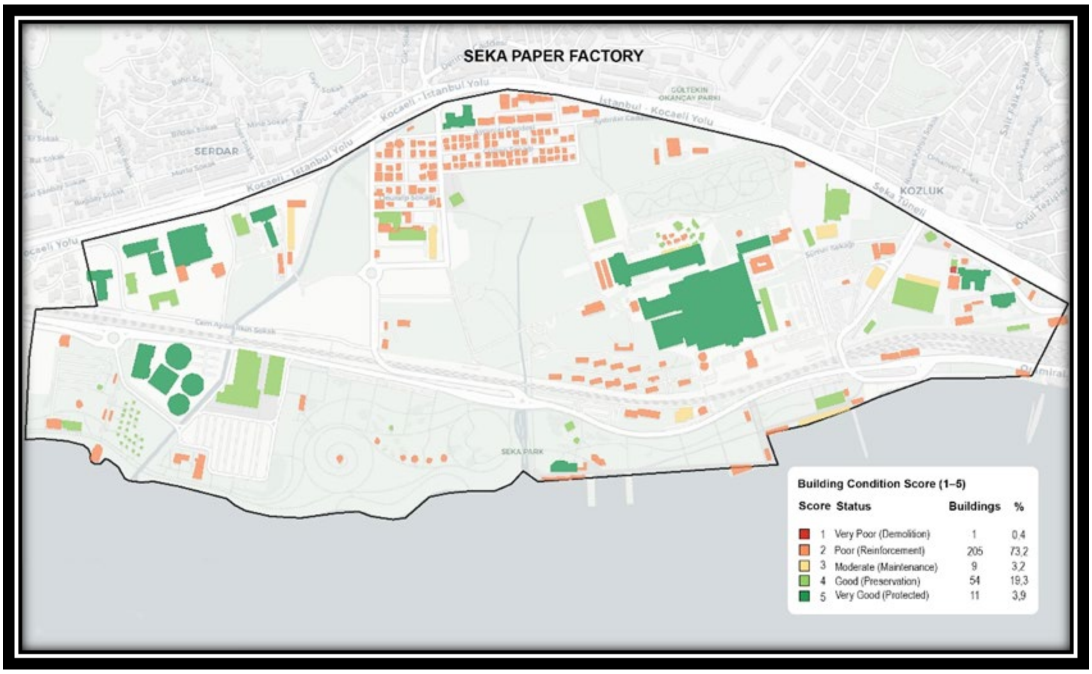

Figure 5 Building condition and intervention-priority score map of the SEKA–Sekapark area
Data sources: Field observations (2025), OSM (2024), QGIS classification (2025). The map was produced by the author.

4.2. Ecological and Environmental Characteristics

The ecological and environmental analysis focuses on vegetation development, landscape recovery, and elevation-based coastal vulnerability. The findings indicate that the transformation of SEKA into Sekapark produced a measurable ecological change, particularly after 2015. However, the low-elevation coastal position of the site also creates exposure that should be considered in long-term climate-adaptive planning.

4.2.1. NDVI-Based Vegetation Analysis, 2000–2025

The NDVI analysis for 2000, 2005, 2010, 2015, 2020, and 2025 reveals a gradual ecological transformation of the SEKA–Sekapark area. As shown in Figure 6, the 2000–2010 period reflects the predominantly impervious and industrial character of the site. Mean NDVI values remained very low during this period: 0.068 in 2000, 0.097 in 2005, and −0.018 in 2010. The vegetated surface ratio calculated using the NDVI > 0.30 threshold was 0% for these three years.

After 2015, NDVI values increased more clearly. Mean NDVI reached 0.162 in 2015, 0.233 in 2020, and 0.250 in 2025. The vegetated surface ratio increased from 12.1% in 2015 to 32.3% in 2020 and 36.3% in 2025. In terms of area, vegetated surfaces reached approximately 176,000 m² in 2015, 469,585 m² in 2020, and 528,295 m² in 2025.

These results indicate a broad increase in vegetation-related surface patterns after the transformation of the former industrial site into Sekapark. The increase in NDVI should be interpreted as a broad temporal vegetation pattern rather than precise pixel-level change detection because the analysis combines Landsat and Sentinel data with different spatial resolutions.

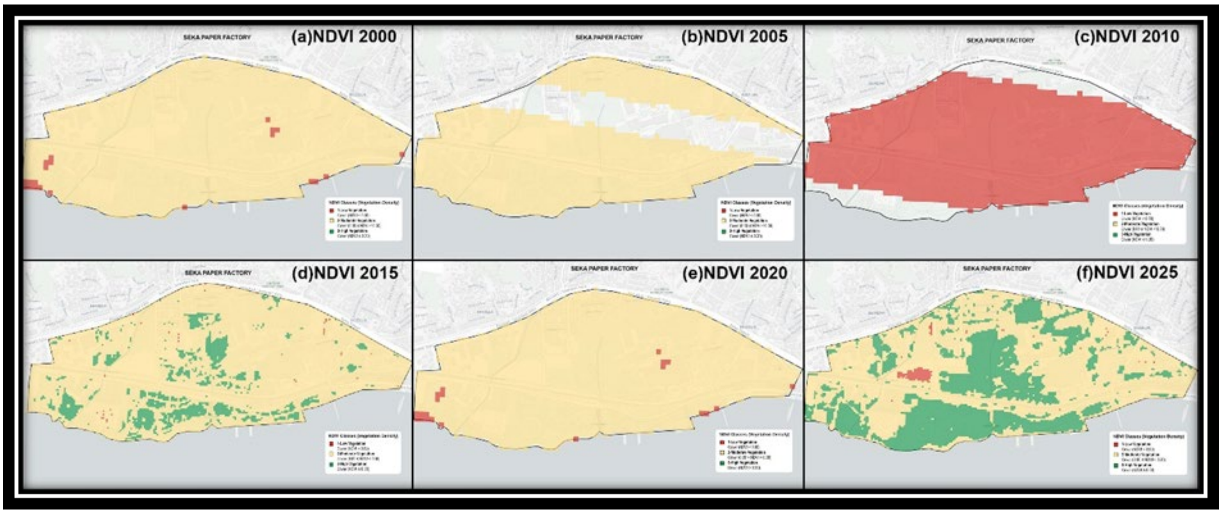

Figure 6 NDVI distribution in the SEKA–Sekapark area for the years 2000, 2005, 2010, 2015, 2020, and 2025
Data sources: USGS EarthExplorer and Copernicus satellite data. The maps were produced by the author.

4.2.2. Elevation-Based Coastal Vulnerability in the SEKA Coastal Zone

The SEKA–Sekapark coastal zone is located in a low-elevation waterfront environment facing the Sea of Marmara. Therefore, an elevation-based coastal vulnerability assessment was conducted using NASA SRTMGL1 DEM data with 30 m spatial resolution. The resulting exposure zones are presented in Figure 7. In this model, 0–1 m was classified as high exposure, 1–2 m as moderate exposure, and 2–3 m as low exposure.

The analysis identified low-lying coastal segments within the 0–3 m elevation range. The overlap between low-elevation zones and recreational waterfront areas indicates that future coastal planning should consider climate-adaptive landscape strategies, including flood-tolerant planting, improved drainage, and flexible public spaces.

Since the model is based only on DEM-derived elevation values, it should not be interpreted as a detailed engineering-level flood simulation. Rather, it provides a strategic spatial framework for identifying low-elevation coastal exposure patterns and guiding climate-sensitive landscape planning decisions.

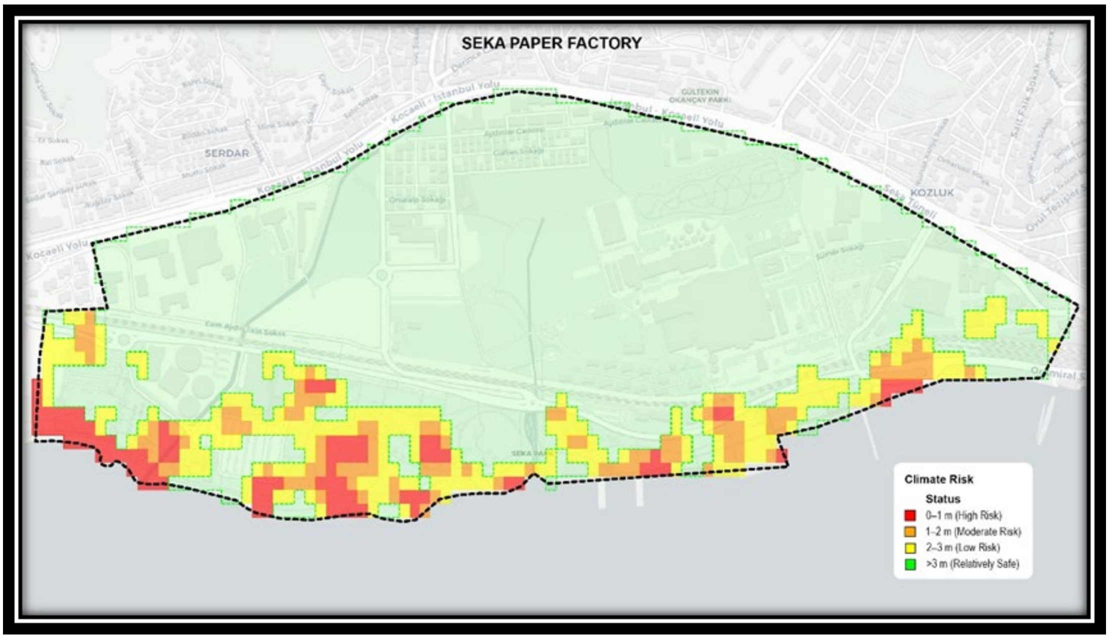

Figure 7 Elevation-based coastal vulnerability zones along the SEKA–Sekapark coastal corridor
Data sources: NASA JPL. (2025). The map was produced by the author.

4.3. Transport and Accessibility

Transport and accessibility are central indicators of post-industrial transformation because former industrial sites are often separated from the city by physical barriers such as railways, highways, walls, and restricted production zones. The SEKA–Sekapark transformation has changed this structure by opening the former industrial landscape to public use and connecting it to urban transport and pedestrian systems.

4.3.1. Public Transport Proximity

Public transport proximity was evaluated through stop-proximity buffers and transport-node distribution. As shown in Figure 8, tram and bus stop locations were mapped together with tram, bus, and railway routes. The analysis identified eight public transport stops around the SEKA–Sekapark area, including five tram stops and three bus stops. The average distance between stops ranged from approximately 350 to 500 m.

The 100 m and 200 m buffer zones around tram and bus stops indicate the areas of immediate pedestrian proximity to public transport nodes. The overlap between certain buffer areas, particularly around Seka Mosque and the western terminal entrance, indicates a strong public transport–pedestrian interface in this part of the site. The tram line runs parallel to the northern boundary of the area and strengthens the relationship between Sekapark and İzmit's urban mobility corridor, while bus routes support eastward connections and multimodal accessibility.

These findings show that SEKA–Sekapark is supported by a closely spaced public transport structure. However, the analysis should be interpreted as a stop-proximity assessment rather than a full network-based accessibility model.

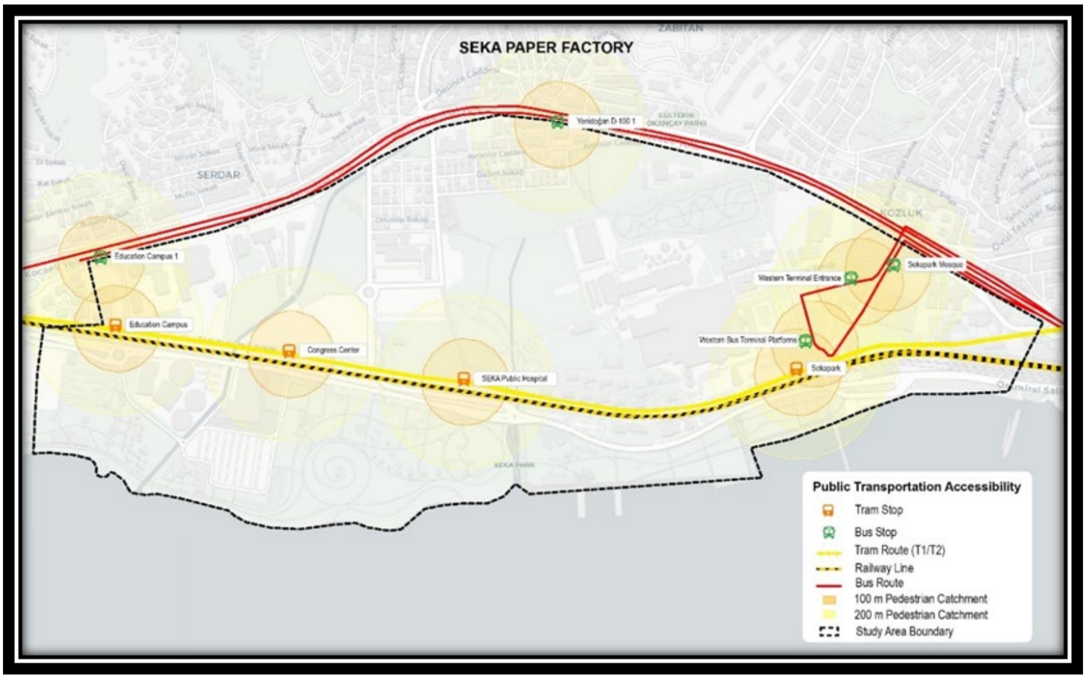

Figure 8 Public transport proximity analysis based on 100 m and 200 m stop buffers in the SEKA–Sekapark area
Data sources: OSM (2024) and field observations (2025). The map was produced by the author.

4.3.2. Pedestrian Accessibility and Barrier Permeability

Pedestrian accessibility was assessed through route continuity, crossing points, and the ability of the network to overcome physical barriers. As shown in Figure 9, SEKA–Sekapark has a strong pedestrian structure organized around a linear coastal spine and a finer secondary network.

The OSM-based pedestrian network analysis identified 197 independent pedestrian paths, 42 pedestrianized street or boulevard segments, 17 overpasses, 14 stepped pedestrian routes, 2 pedestrian bridges, and 1 underpass within the SEKA–Sekapark area. This distribution indicates that the site contains not only a linear coastal promenade, but also a multi-layered pedestrian system that supports internal circulation and connections across physical barriers.

The primary pedestrian route follows the coastline and creates a continuous east–west movement corridor connecting recreational spaces, cultural facilities, green areas, and public waterfront uses. Secondary pedestrian routes provide access between the coastal spine, inner buildings, parking areas, and surrounding urban neighborhoods. Barrier permeability is supported by pedestrian bridges, underpasses, staircase connections, and north–south access routes that reduce the separating effects of highway and railway corridors.

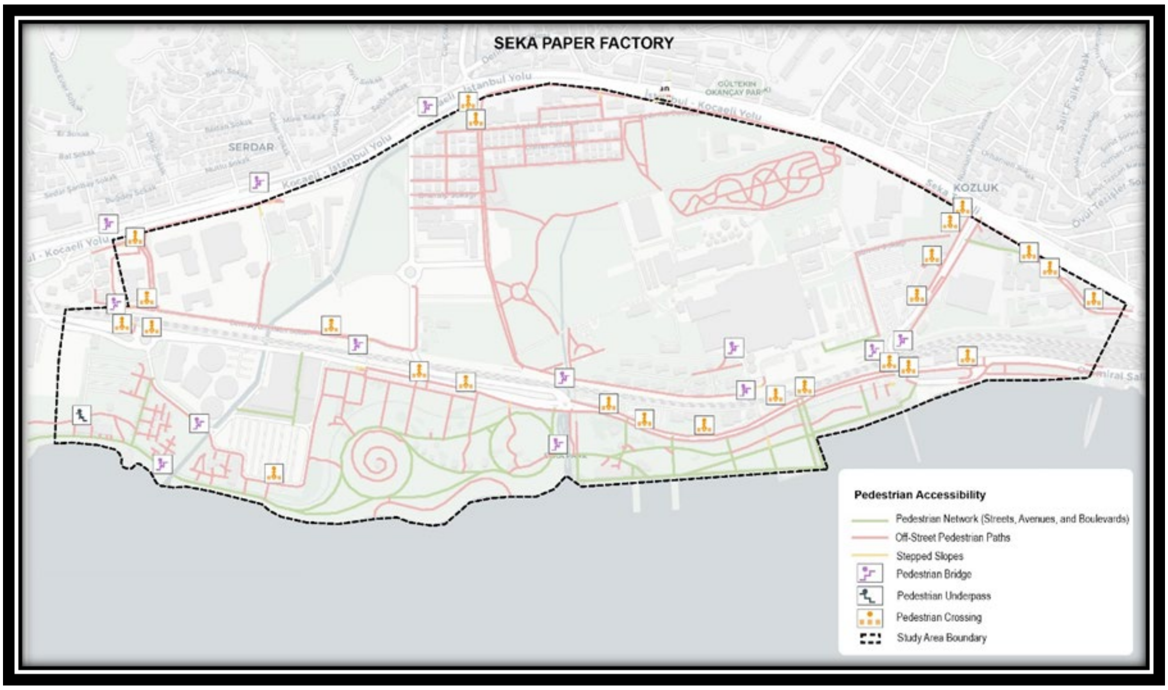

Figure 9 Pedestrian network, main pedestrian spine, and critical connection nodes in the SEKA–Sekapark area
Data sources: OSM (2024) and field observations (2025). The map was produced by the author.

4.4. Macro-Scale Criteria: Heritage and Urban Integration

Heritage and urban integration analysis examines how the SEKA–Sekapark transformation contributes to industrial heritage preservation, cultural identity, public image, and integration with the city center. These criteria are important because post-industrial transformation is not only a physical process but also a symbolic and urban-scale restructuring.

4.4.1. Cultural Heritage and Urban Image

The transformation of SEKA into Sekapark produced a multi-layered cultural landscape in which industrial memory and contemporary public life coexist. As shown in Figure 10, the main heritage and image components can be grouped into three categories: monumental industrial structures, cultural facilities, and tourist-public spaces.

Monumental industrial structures are concentrated around the former production core. The SEKA Paper Museum, preserved factory buildings, locomotive exhibition, and other industrial remnants function as material evidence of the site's production history. Cultural facilities, including the Science Center, exhibition areas, event spaces, performance venues, and workshops, reinterpret industrial heritage through educational and cultural programs. Tourist and public spaces, such as beaches, lawns, walking and cycling paths, amphitheaters, playgrounds, and recreational areas, are concentrated along the waterfront corridor.

Together, these three layers produce a hybrid urban identity. SEKA is no longer only an industrial memory site or a recreational park; it has become a cultural-industrial public landscape where heritage conservation, public use, and urban image-making interact.

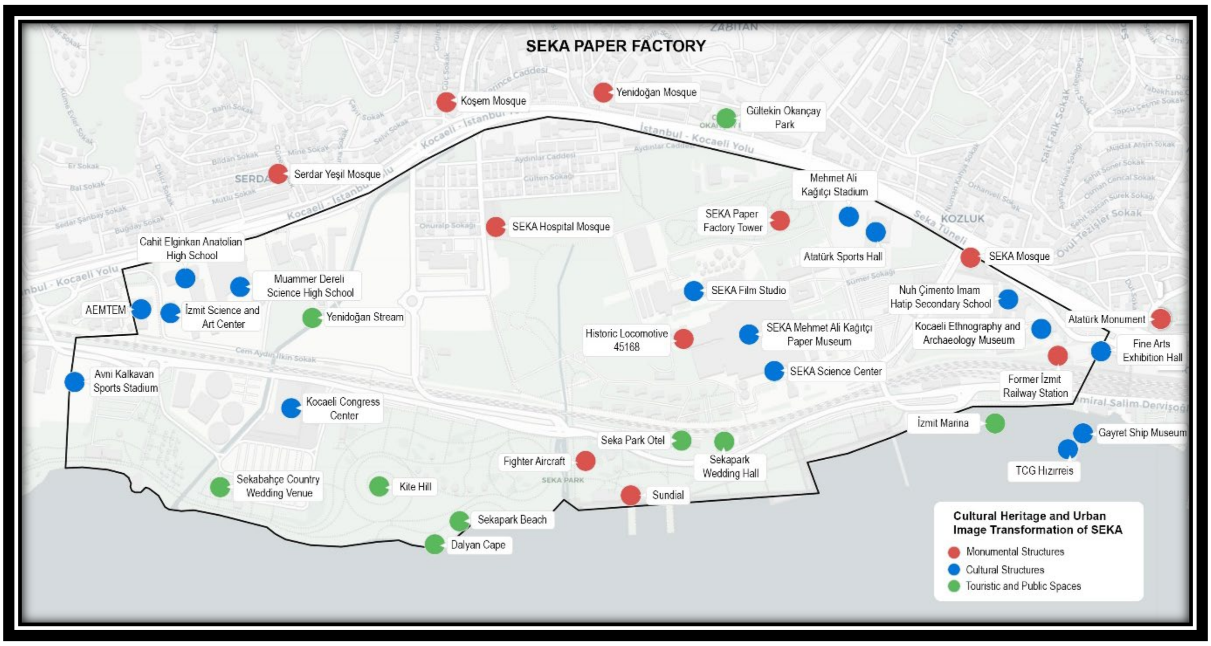

Figure 10 Cultural heritage classification of the SEKA–Sekapark area
Data sources: OSM (2024) and field observations (2025). The map was produced by the author.

4.4.2. Morphological and Functional Integration with the City Center

The relationship between SEKA–Sekapark and the city center was assessed through pedestrian flows, accessibility rings, functional nodes, and morphological permeability. As presented in Figure 11, the findings show that the transformation has strengthened the center–coast relationship and integrated the former industrial area into İzmit's everyday circulation system.

Three main pedestrian flow axes connect the city center with the waterfront. The first extends from Cumhuriyet Park and the Walking Path toward the coast. The second follows the tram corridor and connects central neighborhoods with Sekapark. The third links the Orhan neighborhood and surrounding urban fabric to the coastal area. These axes create a multi-directional movement structure rather than a single access route.

The 1 km and 2 km accessibility rings shown in Figure 11 indicate that Sekapark is reachable from central neighborhoods and functions as an embedded public node within the urban fabric. Functional nodes such as the SEKA Paper Museum, Kocaeli Science Center, Cumhuriyet Park, Yürüyüş Yolu, tram stops, and recreational waterfront areas are located at the intersection of movement corridors. Overall, SEKA–Sekapark strengthens its relationship with the city center through morphological permeability, pedestrian flow organization, and functional integration.

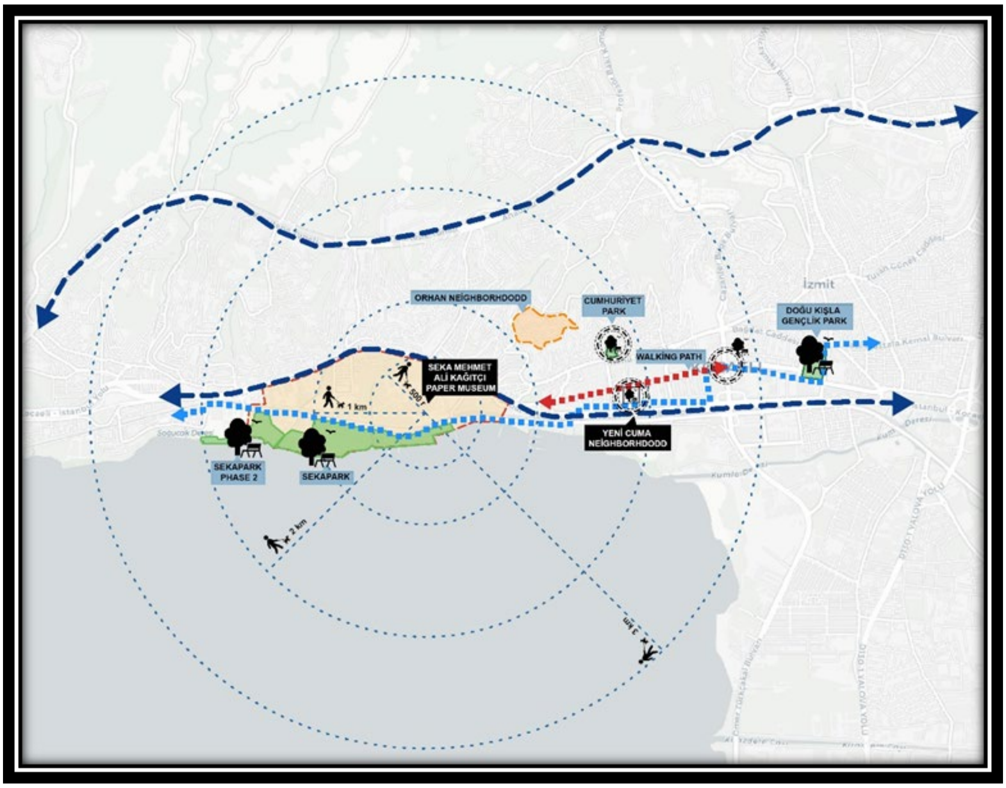

Figure 11 Pedestrian accessibility, orientation patterns, and functional linkages between SEKA–Sekapark and the city center Data sources: OSM (2024) and field observations (2025). The map was produced by the author.

The principal measurable findings obtained from the physical–structural, ecological–environmental, transport–accessibility, and heritage-urban integration analyses are summarized in Table 6.

Table 6 Summary of Key Measurable Findings and Transformation Status in the SEKA–Sekapark Area

Dimension	Indicator	Main finding	Spatial interpretation	Transformation status
Physical–structural	Current use status	Of 280 building units, 64 buildings (22.9%) were classified as active and 216 buildings (77.1%) as transitional. The reported totals leave no building unit in the idle category.	Active cultural and recreational functions are concentrated primarily along the waterfront, whereas transitional buildings are more strongly associated with the former production core.	Partially consolidated
Physical–structural	Building condition and intervention priority	Buildings were evaluated using a five-level scale ranging from urgent intervention (Score 1) to registration or advanced conservation potential (Score 5).	Structures requiring intervention, strengthening, or maintenance are concentrated mainly within the former production core, while better-preserved and culturally significant structures display stronger conservation potential.	Partially consolidated
Ecological–environmental	NDVI-based vegetation change	Mean NDVI increased from 0.068 in 2000 to 0.250 in 2025. The vegetated surface ratio increased from 0% in 2000–2010 to 12.1% in 2015, 32.3% in 2020, and 36.3% in 2025.	Vegetation-related surface patterns increased substantially after 2015, indicating the ecological transformation of the former industrial landscape.	Largely consolidated
Ecological–environmental	Vegetated surface area	Vegetated surface reached approximately 176,000 m² in 2015, 469,585 m² in 2020, and 528,295 m² in 2025.	Vegetation expansion is associated with landscape interventions and the development of green public spaces within Sekapark.	Largely consolidated
Ecological–environmental	Coastal vulnerability	Coastal exposure was classified as high at 0–1 m, moderate at 1–2 m, and low at 2–3 m elevation.	Low-elevation segments overlap with recreational waterfront areas, indicating the need for climate-adaptive landscape planning.	Incomplete

Transport–accessibility	Public transport proximity	Eight public transport stops were identified around the site, including five tram stops and three bus stops. Average distances between stops range approximately from 350 to 500 m.	The tram line and closely spaced transport stops provide a strong public transport–pedestrian interface, particularly around Seka Mosque and the western terminal entrance.	Largely consolidated
Transport–accessibility	Stop-proximity buffers	Immediate public transport proximity was evaluated through 100 m and 200 m buffers around tram and bus stops.	Overlapping buffer areas indicate strong proximity to public transport nodes in specific parts of the site. The result represents stop proximity rather than full route-based accessibility.	Largely consolidated
Transport–accessibility	Pedestrian accessibility	The analysis identified 197 independent pedestrian paths, 42 pedestrianized street or boulevard segments, 17 overpasses, 14 stepped pedestrian routes, 2 pedestrian bridges, and 1 underpass.	A continuous coastal spine and a multi-layered secondary network support internal circulation and reduce the barrier effects of highway and railway corridors.	Largely consolidated
Heritage-urban integration	Cultural heritage and urban image	Heritage and image components were classified into three groups: monumental industrial structures, cultural facilities, and tourist–public spaces.	Preserved industrial structures maintain material memory, cultural facilities reinterpret industrial heritage, and public waterfront spaces integrate the site into everyday urban life.	Partially consolidated
Heritage-urban integration	City-center relationship	Three principal pedestrian flow axes connect the city center and surrounding neighborhoods with the waterfront. The analysis also included 1 km and 2 km accessibility rings.	Multi-directional pedestrian flows and the distribution of cultural and recreational nodes strengthen the morphological and functional relationship between Sekapark and İzmit city center.	Largely consolidated

Note: The transformation-status categories represent an interpretive synthesis of the spatial findings and do not constitute an additional numerical scoring system.

5. Discussion

The findings show that the SEKA–Sekapark transformation can be interpreted as a multi-layered post-industrial restructuring process in which industrial heritage conservation, ecological recovery, public accessibility, and cultural-recreational reuse intersect. The former Fordist production complex has been redefined as a post-Fordist public coastal landscape; however, the transformation is not spatially homogeneous. The waterfront has been strongly activated through cultural, recreational, and landscape-oriented functions, while parts of the former production core continue to display transitional use and intervention needs. This uneven spatial pattern is one of the key outcomes of the study.

The first implication concerns industrial heritage and adaptive reuse. The preservation and reuse of selected industrial buildings, particularly the SEKA Paper Museum and related cultural facilities, have allowed the industrial memory of the site to remain visible within the contemporary urban landscape. This supports the view that post-industrial transformation should not be understood only as physical redevelopment, but also as cultural reinterpretation. Nevertheless, the persistence of buildings requiring intervention within the former production core indicates that heritage-led transformation remains incomplete. Conservation strategies should therefore extend beyond the most visible or symbolically significant structures and include less prominent industrial buildings that still carry spatial and historical value.

The second implication relates to ecological transformation. The marked increase in vegetation after 2015 indicates that landscape interventions strengthened the ecological capacity of the former industrial site. However, the NDVI workflow combines different satellite sensors and does not include a separate cloud-cover threshold; therefore, the results should be interpreted as general temporal vegetation patterns rather than exact pixel-level change detection.

The third implication concerns accessibility and urban integration. Pedestrian accessibility analysis shows that SEKA–Sekapark is supported by a multi-layered walk network composed of pedestrianized streets, footways, steps, bridges, overpasses, and underpasses. Public transport analysis also shows a close distribution of tram and bus stops around the site. These findings confirm that accessibility is a decisive factor in transforming former industrial areas into active public landscapes. However, the public transport assessment is based on stop-proximity buffers rather than full route-based network accessibility, and this limitation should be considered when interpreting the results.

The fourth implication relates to coastal vulnerability. The 0–3 m elevation-based assessment using NASA SRTMGL1 DEM data shows that some recreational waterfront areas overlap with low-elevation exposure zones. This does not reduce the public value of Sekapark, but it reveals an important planning issue for the long-term resilience of the area. Since the analysis is based on 30 m DEM-derived elevation values rather than detailed hydraulic modeling, the results should be interpreted as a strategic coastal exposure assessment. The overlap between low-elevation zones and recreational waterfront areas indicates that future coastal planning should consider climate-adaptive landscape strategies, including flood-tolerant planting, improved drainage, and flexible public spaces.

Methodologically, the study contributes to post-industrial transformation literature by testing an adapted observation-form approach supported by GIS, remote sensing, DEM analysis, OSM-based spatial data, and field observations. Existing studies often examine building condition, vegetation change, accessibility, cultural heritage, and urban integration separately. In contrast, this study brings these indicators together within a single field-based evaluation framework. The application of the framework to 280 building units demonstrates that physical, ecological, accessibility-based, and heritage-urban integration indicators can be evaluated together at the site scale.

Several limitations should be acknowledged. First, the study is based on a single case, which limits generalizability. Second, some spatial data rely on OSM-based vector information, which may contain incomplete or inconsistent attributes; therefore, OSM data were interpreted together with field observations, Google Earth imagery, and historical plans. Third, NDVI analysis may be affected by image date, seasonal variation, atmospheric conditions, cloud cover, and satellite resolution. Fourth, the coastal vulnerability analysis is based on NASA SRTMGL1 DEM data with 30 m spatial resolution and should not be interpreted as an engineering-level flood-risk model. Fifth, the building condition score is an indicator-based condition and intervention-priority score rather than a detailed structural safety assessment. Finally, this study does not include detailed user surveys, economic impact analysis, visitor behavior, or social perception data. Future research should integrate these dimensions to better understand the social and economic outcomes of post-industrial transformation.

6. Conclusion and Recommendations

This study analyzed the transformation of the SEKA Paper Factory into Sekapark through measurable physical, ecological, accessibility-based, and heritage-urban integration indicators. By combining field observations, GIS-based spatial analysis, remote sensing, DEM-based elevation assessment, OSM-based network/proximity analysis, and archival interpretation, the research evaluated the transformation of a former Fordist industrial production complex into a post-Fordist cultural, recreational, ecological, and publicly accessible coastal landscape.

The findings demonstrate that SEKA–Sekapark is a significant example of post-industrial restructuring in Türkiye. The former industrial site has been redefined through cultural reuse, waterfront publicization, ecological improvement, and strengthened urban accessibility. However, the transformation is spatially uneven. The waterfront has been strongly activated through cultural and recreational functions, while parts of the former production core continue to display transitional use patterns and intervention needs. Therefore, the transformation should not be interpreted as a fully completed process, but rather as a staged redevelopment that still requires targeted conservation, maintenance, strengthening, and adaptive reuse strategies.

The main methodological contribution of the study lies in the development and testing of an adapted observation-form framework. The framework brings together indicators that are often evaluated separately, including building typology, use status, condition/intervention priority, NDVI-based vegetation change, elevation-based coastal vulnerability, public transport proximity, pedestrian connectivity, cultural heritage value, and city-center integration. By applying these indicators to 280 building units, the study demonstrates that post-industrial transformation areas can be evaluated in a measurable, comparable, and spatially explicit manner.

Based on the findings, several recommendations can be proposed. Buildings assigned Scores 1–3 should be prioritized for urgent intervention, strengthening, maintenance, or adaptive reuse according to their specific condition. Ecological improvement should be extended beyond the waterfront through stronger green infrastructure and greater planting continuity. Low-elevation coastal segments should be redesigned through climate-adaptive landscape strategies, including flood-tolerant vegetation, improved drainage, and flexible public spaces. Pedestrian and bicycle connectivity should be strengthened, especially in fragmented or parking-dominated areas. Future management strategies should preserve the balance between industrial heritage, cultural programming, recreational use, and ecological resilience.

Future studies should test the proposed framework in other post-industrial transformation areas in Türkiye and comparable international cases to evaluate its transferability. Further research should also integrate user surveys, visitor behavior analysis, economic impact assessment, social perception data, higher-resolution DEMs, detailed structural assessments, and long-term monitoring of ecological and spatial change. Such additions would provide a more comprehensive understanding of how post-industrial transformation affects not only the physical landscape, but also social use, economic value, and urban identity.

In conclusion, the SEKA–Sekapark transformation demonstrates that former industrial areas can be evaluated through integrated and measurable spatial indicators. Successful post-industrial transformation requires more than the reuse of industrial buildings or the creation of public open space; it requires the coordinated evaluation of physical condition, ecological capacity, accessibility, cultural heritage, and urban integration. In this sense, SEKA–Sekapark offers both a valuable case for understanding industrial waterfront transformation in Türkiye and an adapted methodological framework for assessing similar post-industrial landscapes.

CRediT Authorship Contribution Statement

Aslıhan Uygun: Writing – original draft, Formal analysis, Investigation, Data curation, Conceptualization, Visualization. Elif Sağlık: Writing – review & editing, Methodology, Conceptualization, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

Note: *This study is based on the first author's master's thesis, which was carried out under the supervision of the second author.*

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Resume

Aslıhan Uygun is currently pursuing her M.Sc. degree in Landscape Architecture at the Graduate School of Education, Çanakkale Onsekiz Mart University. She received her B.Sc. degree in Landscape Architecture from Çanakkale Onsekiz Mart University in 2024. Her master's research focuses on the post-industrial transformation of the SEKA Paper Factory–Sekapark area through measurable spatial indicators. Her research combines field observations, GIS-based spatial analysis, remote sensing, accessibility assessment, and industrial heritage evaluation. Her academic interests include post-industrial landscapes, urban transformation, industrial heritage, adaptive reuse, sustainable landscape planning, and GIS-based landscape analysis.

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