

Research article

Scenario-based facility plant design strategies for post-industrial coastal area transformation: A decision support framework for sustainable urban landscape at İzmir Port, Türkiye

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Abstract: The transformation of post-industrial coastal areas holds critical potential for sustainable urban development yet planting design decisions in this process are largely based on qualitative and subjective principles. This study aims to demonstrate how plant design strategies can be structured using a quantitative, transparent, and multi-criteria decision support model, in the case of İzmir Port. The research adopts a two-stage methodology integrating site-specific data obtained through SWOT analysis with the Analytical Hierarchy Process (AHP). Among the six main criteria weighted by expert evaluation, 'Ecological Suitability and Sustainability' (33.19%) received the highest priority, followed by 'Green Infrastructure and Ecological Connectivity' (19.46%) and 'Aesthetic and Visual Quality' (19.46%). This weighing confirms the central role of ecological restoration in the transformation of the region. The AHP results were used to create a 'design spectrum' based on the relative importance of the criteria, and four different plant design scenarios (Ecological Maximisation, Social-Aesthetic Focused, Cultural Heritage Focused, Economic-Feasibility Focused) were developed. A comprehensive evaluation of the scenarios revealed that the Ecological Maximisation scenario was the most suitable option within the framework of all the defined criteria. Consequently, this study offers a repeatable and scenario-based decision-making framework that prevents arbitrary decisions in post-industrial port transformations. The presented integrated SWOT-AHP-Scenario model provides an adaptable methodological contribution for similar coastal transformation projects.

Keywords: post-industrial landscape, İzmir Port, plant design strategies, Analytic Hierarchy Process (AHP), scenario-based design, urban ecological transformation

1. Introduction

The spatial structure that emerged after the industrial revolution led to the emergence of many industrial areas that had lost their function within urban fabrics (Suptelo and Sehida, 2020). These areas bring with them ecological, aesthetic, and social problems, along with their physical abandonment; however, they also constitute strategic opportunities in terms of their potential for repurposing (Radziszewska-Zielina et al., 2022). Particularly in coastal cities, the transformation of defunct port and industrial areas constitutes one of the main focal points of urban landscape restructuring (Dormidontova and Belkin, 2018; Lee, 2019). The success and sustainability of this transformation process are attributed by many researchers to the adoption of nature-based approaches that consider urban ecology (Aerts et al., 2014; Graells et al., 2021).

In recent years, in line with sustainable urban development approaches, landscape design strategies that prioritise ecological infrastructure rather than just construction are gaining increasing importance in the transformation of post-industrial areas (Nassauer and Opdam, 2008; Özelmaz and Kısar Koramaz,

2025). At the heart of these ecological infrastructure-focused strategies lies plant design. In the transformation of post-industrial areas, plants are no longer considered merely an aesthetic element; they are regarded as a multifunctional ecological tool that creates habitats for biodiversity (Norton et al., 2016), increases climate resilience by reducing the urban heat island effect (Kisvarga et al., 2023), and reconstructs the cultural landscape by reconciling industrial past with new uses (Erdem Kaya, 2023).

In the context of Türkiye, İzmir Port, one of the most important examples of coastal cities, stands out as an urban area that has largely lost its industrial function and has transformation potential. The port area not only preserves its historical industrial heritage but also possesses a dynamic structure that allows for the restructuring of ecological and social functions thanks to its strong connection with the city centre. However, these obstacles highlighted in the literature (Parlapan et al., 2023) also lead to a lack of a concrete, multifunctional, and feasible framework, particularly for plant design that will form the ecological backbone of the area.

Determining plant design strategies specifically for the Port of Izmir requires a systematic evaluation of complex site-specific criteria (microclimate, soil pollution, historical context, user expectations, etc.). While the post-industrial transformation literature offers case studies and theoretical frameworks in the context of port cities (Warsewa, 2017; Osmond et al., 2024), there is a significant gap in the application of integrated, quantitative decision support systems to guide plant design decisions. Existing studies are mostly limited to qualitative evaluations (Fiorentino et al., 2024) or architectural-spatial planning (Bertocci et al., 2019), and do not offer a systematic methodology that prioritises ecological, social, and aesthetic parameters.

The aim of this study is to develop a scenario-based and quantitative decision support model for multifunctional plant design in the post-industrial transformation of Izmir Port. To this end, the study first evaluated the current state of the area using SWOT analysis and then created a multi-criteria decision model by weighing ecological, social, economic, and managerial criteria using the Analytical Hierarchy Process (AHP). As an output of this model, different plant design scenarios based on the obtained criterion priorities were developed and subjected to suitability analysis. Thus, this research addresses the existing gap in the literature by proposing an integrated and quantitative methodology for plant design decisions in post-industrial port transformations; it also offers a strategic tool to local actors and planners. Beyond a purely design-oriented case study, this framework is intended to function as a repeatable technological, operational, and institutional decision-support infrastructure. Unlike conventional qualitative assessments, the proposed

model explicitly connects ecological priorities to procurement capacity, maintenance budgeting, workforce availability, and institutional coordination—thereby enabling more accountable, transparent, and implementable landscape planning decisions.

It should be emphasised, however, that the scope of the proposed framework is intentionally limited to the planning and evaluation of green infrastructure and plant design strategies. Accordingly, this study does not seek to develop a comprehensive urban master plan or redefine macroscopic land-use functions for the Izmir Port area. Rather, it focuses on the ecological and planting infrastructure, which constitutes a critical yet frequently overlooked dimension of post-industrial regeneration. In this respect, regardless of the future functional uses assigned to the site through broader planning processes, the proposed framework provides a specialised decision-support tool for the design and management of the green infrastructure required to support those uses.

2. Materials and methods

This study selected the Izmir Port and the surrounding post-industrial areas within the Konak district of Izmir as its research area. The site is located in Umurbey Neighbourhood, at approximately 38°26'42"N 27°09'21"E coordinates and has an average elevation of 1 m above sea level (Adak, 2022). The location of the study area and its relationship with its surroundings are shown in Fig. 1.

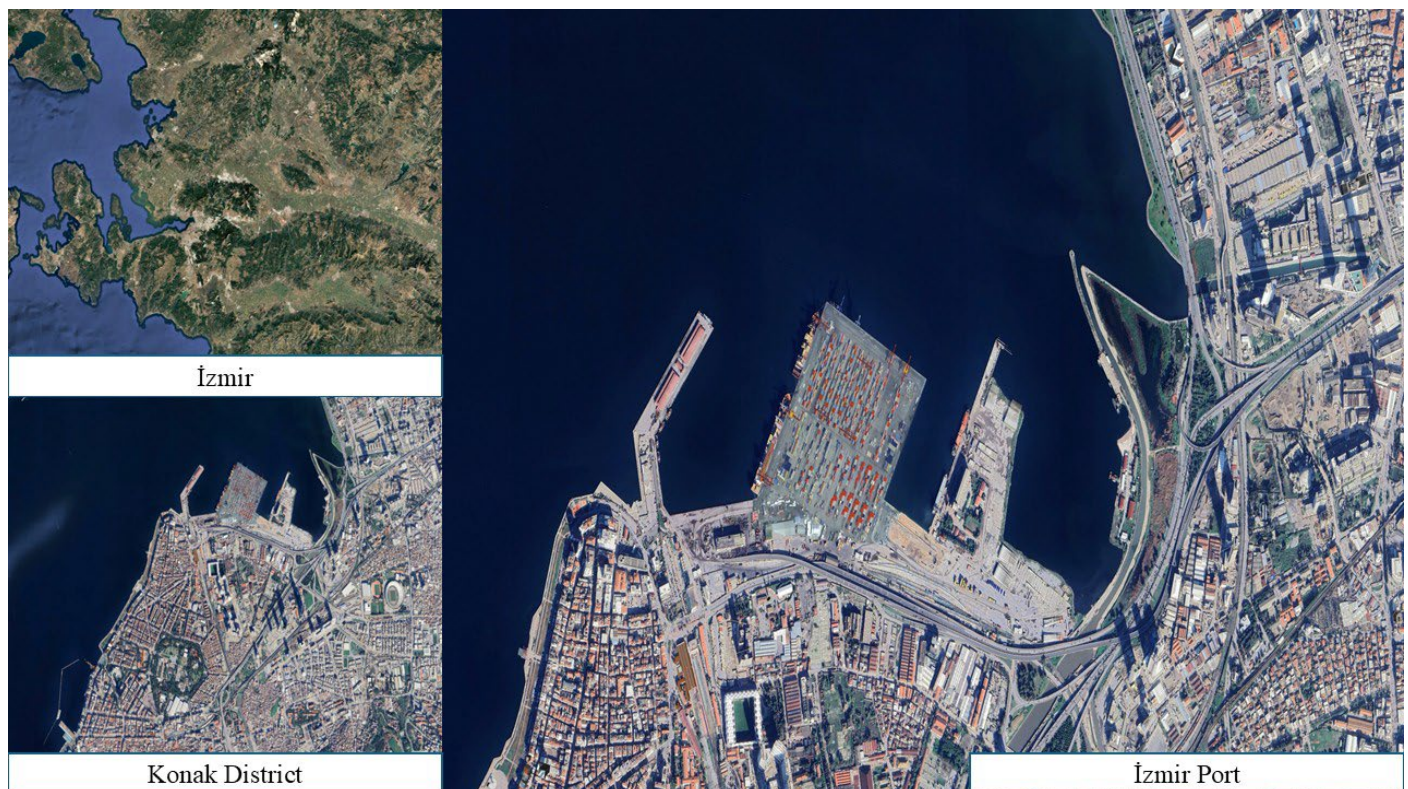


Fig. 1. Location and satellite images of the study area: Izmir and the Konak District post-industrial port zone in Turkey. (Source: Google Earth Pro, 2025)

The study method was carried out in three stages. These stages are:

1. **SWOT Analysis Method:** In the first stage, the physical (construction, transportation, impermeable surface ratio), ecological (vegetation, habitat fragmentation,

coastal accessibility), and social (public space use, cultural heritage elements) characteristics of the Izmir Port area were evaluated through systematic fieldwork. Systematic fieldwork and on-site observations were conducted between March and May 2025. These evaluations formed the basis for the SWOT (Strengths,

Weaknesses, Opportunities, Threats) analysis, a widely used decision support tool in strategic planning (Durgun, 2007; Mansuroğlu and Dağ, 2016). The SWOT matrix, especially in complex urban systems such as post-industrial areas, prepares the ground for the development of design criteria and alternative scenarios in subsequent stages by simultaneously evaluating internal and external factors.

2. Analytic Hierarchy Process (AHP) Method: The second phase of the study involves determining the decision criteria for plant design and measuring the relative importance of these criteria using the Analytical Hierarchy Process (AHP). The SWOT analysis in the first phase revealed numerous qualitative factors influencing the transformation of the area. However, to develop an effective design strategy, it is necessary to quantitatively determine the priorities (weights) of these factors relative to each other. This need constitutes the main justification for choosing the AHP method, one of the multi-criteria decision-making techniques. AHP allows decision-makers to weight criteria derived from qualitative analyses such as SWOT in a hierarchical structure using their expert judgments, thus creating a robust, quantitative foundation for subsequent scenario evaluation (Darko et al., 2019).

The AHP method was carried out by following the four steps proposed by Saaty (2003). Accordingly, in the first stage, the problem is defined, the problem structure is created, and the necessary criteria are determined. Then, the hierarchical structure of these determined criteria is established. In the second stage, a pairwise comparison matrix is created to evaluate the criteria in the hierarchical structure relative to each other. Saaty's 1-9 scale is used in these pairwise comparisons of the criteria. Saaty's 1-9 scale is shown in Tab. 1 (Podvezko, 2009).

Tab. 1. Saaty's 1-9 scale. (Source: Ariff et al., 2008)

Level of Importance	Definition
1	Equally important
3	Moderately important
5	Highly important
7	Extremely important
9	Absolutely important
2, 4, 6, 8	Intermediate values

In the application of the AHP method, the opinions of a panel of 10 experts were consulted. Considering the interdisciplinary nature of the study, the panel was composed of participants with academic and professional experience in the fields of landscape architecture, urban and regional planning, architecture, environmental engineering, and ecology. This panel composition was specifically selected because evaluating the operational and maintenance feasibility of landscape projects requires professional expertise in plant performance, site management, and ecological dynamics, rather than regional macroeconomic forecasting. The expert panel evaluations and pairwise comparison questionnaires were completed in June 2025.

In the third stage, the normalisation process of the values in the pairwise comparison matrix is performed.

A normalised decision matrix is created from the normalised values. In the fourth step, the average of the row sums of the normalised matrices is taken to calculate the weight values of the criteria. After calculating the criterion weights, all other calculations are completed. Once all stages and calculations are completed, the consistency ratio of the AHP method is expected to be less than 0.1. A consistency ratio of less than 0.1 indicates that the comparisons made are logical and consistent (Gür and Kahraman, 2024).

3. Scenario Development Approach: The final criterion weights obtained with AHP were used in constructing alternative scenarios for plant design. The scenarios were developed to systematically model different priority policies in the decision-making process. The absolute values and relative rankings of the criterion weights were used as the basis for scenario selection (Turcksin et al., 2011). For this purpose, extreme values (highest and lowest) in the weight distribution and semantically related mid-order criterion pairs were identified, and four scenarios were constructed, each representing a decision-making attitude (Lee and Geum, 2017). This approach has made it possible to offer a spectrum of design alternatives for decision-makers with different constraints and priorities, instead of a single, uniform solution (Jamini et al., 2025). The scenario creation procedure consisted of the following steps:

Determining the Focus Criteria: By analysing the weight matrix, the primary criterion or pairs of criteria to be focused on in the scenarios were selected. In cases where criteria had identical quantitative eigenvector weights (e.g., C3 and C6 both scored 0.1946; C2 and C5 both scored 0.1076), the selection and pairing were guided by the semantic and functional affinity of the criteria to ensure coherent design philosophies. For instance, ecological criteria (C1 and C6) were conceptually paired together, whereas social and aesthetic criteria (C2 and C3) were combined to form a unified, user-oriented scenario.

Establishing the Conceptual Design Framework: For each set of focus criteria, an overall design philosophy and strategy have been defined to meet the requirements of those criteria.

Detailed Concrete Scenario Development: Each conceptual framework has been detailed in light of the site-specific conditions derived from the SWOT analysis in the first stage and similar practices in the literature. This detailing includes plant species selection, composition principles, material recommendations, and spatial organisation.

3. Results

As the first stage of the working method, the İzmir Port area was observed on site. As a result of the on-site observations, a SWOT analysis was performed for the area. The SWOT analysis performed is shown in Tab. 2. The SWOT analysis of İzmir Port systematically revealed the internal and external factors related to the transformation of the area. The analysis showed that the most defining strength of the area is its large area directly connected to the sea and its integrated location with the city centre; while its most critical weaknesses are widespread impermeable surfaces and soil pollution resulting from industrial activities. The main opportunities were identified as the creation of green infrastructure networks and sustainable recreational uses; while the main threats were the risk of uncontrolled development and the failure to protect industrial heritage.

Tab. 2. SWOT analysis of İzmir Port and its surroundings. (Source: Authors, 2026)

Strengths (S)	Weaknesses (W)
- Possession of a large area with direct access to the sea - Proximity to the city centre and public transportation routes - Possession of a high-potential coastal view - The majority of the area is being abandoned (suitability for redevelopment) - Presence of industrial structures with cultural history and memory	- Impermeability of widespread asphalt surfaces in the area - Heavy metal soil contamination from port activities - Disruption of ecosystem integrity - Lack of topsoil - Long-term effects of noise and air pollution
Opportunities (O)	Threats (T)
- Developing new uses compatible with urban transformation master plans - Establishing green infrastructure systems that can connect to ecological corridors - Potential for integrated design with the İzmir Bay ecosystem - Topography and wind regime suitable for nature-based solutions around the port - Suitability for projects focused on sustainable tourism, recreation, and the green economy	- Continued risk of uncontrolled development - Investment pressure leading to neglect of social space needs - Property issues affecting public access to port areas - Risk of industrial heritage being demolished without preservation - Insufficient public participation in project development processes

These findings were directly used in the next stage to create the criteria set for the AHP method. The SWOT analysis outputs produced in the first phase of the study directly provided input to the AHP process in the second phase. The factors identified in the SWOT were used as the basis for creating the criterion pool for AHP, and these factors were presented to the expert panel as a background information note before the pairwise comparison questionnaire. Thus, the aim was to shape the expert assessments within the context of the realistic strengths/weaknesses and opportunities/threats of the field. The following six criteria were determined for use with the AHP method:

Ecological Suitability and Sustainability (C1): The selection and composition of plants, their adaptation to the region's climate, soil, and habitat conditions, and their contribution to long-term ecological sustainability are evaluated. In this context, the potential for integrating nature-based solutions such as the use of local species, low maintenance and water requirements, carbon sequestration capacity, and rainwater management is assessed.

Social Use Potential (C2): The capacity of plant design to support public use and social interaction of the space. This potential is evaluated through the creation of functional units such as shading, walkways, seating areas, children's play areas, and an organisation that enriches the user's experience of the space.

Aesthetic and Visual Quality (C3): The contribution of the visual characteristics of plant composition, such as colour, texture, form, layering, and seasonal dynamics, to the aesthetic value and identity of the urban landscape. Visual integrity, harmony with the city skyline, and thematic narrative coherence are key evaluation elements.

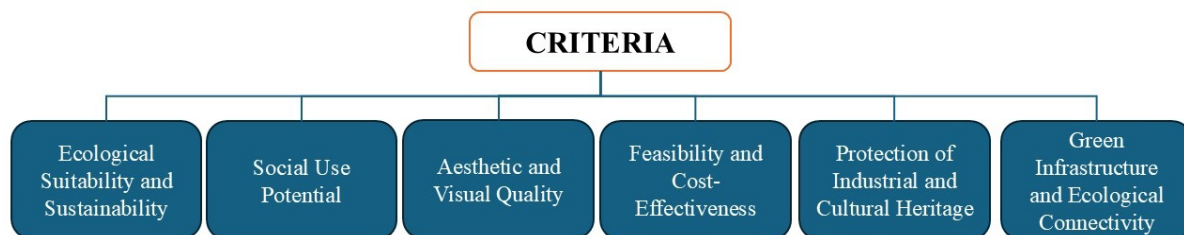
Feasibility and Cost-Effectiveness (C4): The technical feasibility and economic cost-effectiveness of the proposed plant design

during the construction, maintenance, and management phases. It should be clarified that this criterion does not evaluate macroeconomic real estate valuation or regional commercial development; rather, it focuses exclusively on operational landscape costs. Factors such as drought-tolerant species selection, modular/portable systems, low maintenance requirements (workforce and equipment), and the use of local resources are evaluated within this criterion.

Protection of Industrial and Cultural Heritage (C5): Plant design has the ability to preserve, interpret, and make visible the industrial history and cultural memory of an area. This is achieved through plant compositions and thematic landscape layers that engage in dialogue with, complement, or contrast with existing industrial remnants and structures.

Green Infrastructure and Ecological Connectivity (C6): The plant design's function is to support biodiversity by connecting it to the surrounding green infrastructure systems and ecological networks. In this context, the effectiveness of strategies that improve ecosystem services such as habitat provision, pollinator attraction, and microclimatic regulation is evaluated.

The hierarchical structure of the criteria is shown in Fig. 2. After completing the first stage of the AHP method, the second stage of the method was completed to establish a pairwise comparison matrix for the criteria. The pairwise comparison matrix is shown in Tab. 3. After completing the pairwise comparison matrix, the third stage of the AHP method was initiated. In this stage, the values in Tab. 3 were normalised. The normalised pairwise comparison matrix is presented in Tab. 4. After creating the normalised pairwise comparison matrix, the fourth and final stage of the AHP method was performed. In this stage, the eigenvector's weights were calculated by taking the average of each row. The eigenvector weights of the criteria are shown in Tab. 5.

**Fig. 2.** Hierarchical structure of criteria. (Source: Authors, 2026)

After weighing the criteria using the eigenvector method, consistency analysis was performed to test the reliability of pairwise comparisons. The calculated consistency ratio (CR) of 0.0059, which is well below the CR < 0.10 threshold suggested by Saaty (2003), indicates that the expert evaluations are consistent and reliable. The final criterion weights obtained with AHP formed the main input for the third and final stage of the study, which is scenario development and evaluation. The scenarios were constructed to represent different design priorities, considering the outliers and semantic relationships in the criterion weight distribution, as described in detail in the methodology.

Tab. 3. Pairwise comparison matrix. (Source: Authors, 2026)

Criteria	C1	C2	C3	C4	C5	C6
C1	1.00	3.00	2.00	4.00	3.00	2.00
C2	0.33	1.00	0.50	2.00	1.00	0.50
C3	0.50	2.00	1.00	3.00	2.00	1.00
C4	0.25	0.50	0.33	1.00	0.50	0.33
C5	0.33	1.00	0.50	2.00	1.00	0.50
C6	0.50	2.00	1.00	3.00	2.00	1.00

Tab. 4. Normalised pairwise comparison matrix. (Source: Authors, 2026)

Criteria	C1	C2	C3	C4	C5	C6
C1	0.426	0.375	0.426	0.364	0.353	0.333
C2	0.142	0.125	0.106	0.182	0.118	0.083
C3	0.213	0.250	0.213	0.273	0.235	0.167
C4	0.107	0.062	0.071	0.091	0.059	0.056
C5	0.142	0.125	0.106	0.182	0.118	0.083
C6	0.213	0.250	0.213	0.273	0.235	0.167

Tab. 5. Eigenvector weights of the criteria. (Source: Authors, 2026)

Criteria	Weights
C1	0.3319
C2	0.1076
C3	0.1946
C4	0.0638
C5	0.1076
C6	0.1946

3.1. Design scenarios

As stated in step 3 of the methodology, Scenario 1 was developed focusing on the two criteria with the highest values in the AHP weighing ranking: C1: Ecological Compatibility and Sustainability (0.3319) and C6: Green Infrastructure and Ecological Connectivity (0.1946). The scenario proposes a multi-layered plant landscape for the transformation of Izmir Port, maximising ecosystem services through nature-based solutions. The design considers wind, salinity, and impermeable surface pressures in the coastal area, utilising local species suited to the region's climatic, topographical, and edaphic characteristics.

The plant composition is designed according to the principle of zoning. In the areas closest to the coast, a buffer zone is envisioned with salt and wind-tolerant native species such as *Tamarix smyrnensis* and *Dorycnium hirsutum*. This zone aims to filter coastal influences. Towards the interior, shrub and tree species such as *Myrtus communis*, *Pistacia lentiscus*, *Celtis australis*, and *Phillyrea latifolia* are proposed to create a vertical structure and habitat. In the undergrowth, aromatic ground cover species such as *Helichrysum italicum* and *Thymus vulgaris* are considered for soil conservation and visual continuity.

This scenario explicitly frames planting design as a component of a strategic blue-green infrastructure (BGI) system. Following Karaismailoğlu and Karahan (2025), BGI is understood here not as a set of isolated ecological elements but as an integrated urban infrastructure for climate adaptation, stormwater management,

and resilience. In the Izmir Port context, the proposed bioswales, permeable surfaces, coastal buffer zones, and ecological corridors function as a systemic network rather than as dispersed design interventions. This BGI framing has direct institutional implications: it allows municipalities to align planting decisions with existing urban resilience strategies, climate action plans, and infrastructure investment programmes. Furthermore, to directly address the threat of heavy metal and organic soil pollution identified in the SWOT analysis, the integration of species with known phytoremediation capacities is a critical component of this scenario.

Species adapted to contaminated post-industrial soils are proposed alongside salt-tolerant taxa to actively remediate the site. For instance, resilient Mediterranean taxa such as *Nerium oleander* are widely documented for their high heavy metal accumulation capacity and stress tolerance in industrial zones (Khandare et al., 2017). Concurrently, fast-establishing species like *Cynodon dactylon* can be utilised for soil stabilisation and heavy metal tolerance, while robust biofilters such as *Arundo donax* are incorporated in drainage areas to mitigate organic loads (Mirza et al., 2010; Mukhtar et al., 2026).

The selection of inorganic materials and furnishings to support the proposed plant composition has also been designed to be in harmony with natural materials, enhancing the functionality of the landscape. Compacted gravel, natural stone, and adobe-based ground coverings are envisioned to guide visitor circulation and ensure water permeability. Bioswales and rain gardens are integrated into the design for both aesthetic and functional rainwater management. In line with the aim of supporting the area's bird populations, observation terraces and walking platforms are planned to be constructed from natural wood materials. User-oriented elements such as information boards and directional signs are complemented by the proposed use of recycled metal or Corten steel.

As stated in step 3 of the methodology, Scenario 2 was developed focusing on criteria C2: Social Use Potential (0.1076) and C3: Aesthetic and Visual Quality (0.1946). The scenario proposes a design for the transformation of Izmir Port that revitalises public life, creates user-oriented open green spaces, and incorporates plant landscaping as a tool for social interaction. In this scenario, the plant composition has been designed with user comfort, visual appeal, and multi-functionality in mind. To provide shade in open green areas, species with high leaf density and pronounced seasonal variability have been emphasised. Trees such as *Platanus orientalis*, *Gleditsia triacanthos*, and *Morus alba* create a cooling microclimate in hot climates and serve as natural shade for walkways and seating areas.

In the lower layer, aromatic, flowering, and textured plants are proposed to provide visual diversity and user interaction. Species with seasonal flowering cycles, such as *Lavandula angustifolia*, *Salvia nemorosa*, *Rosa rugosa*, and *Rudbeckia hirta*, are intended to enhance the aesthetic richness of the area and create a sensory (scent, texture) landscape experience. These species are also expected to attract pollinating insects, mediating a socio-ecological relationship. To reduce the maintenance burden of the lawn areas, the use of alternative ground cover species such as *Tulbaghia violacea* and *Festuca glauca* is planned.

The social and aesthetic rationale of this scenario is grounded in biophilic design theory. As Onur and Acar (2025) argue, human-nature interaction in urban landscapes generates measurable psychological restoration, place attachment, and social legitimacy for post-industrial transformation projects. In this scenario, sensory qualities (scent, texture, seasonal colour) are not merely decorative but serve as functional mediators of user

well-being and public acceptance. The inclusion of aromatic species, flowering cycles, and soft-textured ground covers is therefore an evidence-based strategy to enhance restorative environmental quality and to secure social support for long-term maintenance.

In this socially-oriented scenario, plant arrangements are organised into thematic zones based on spatial use. For example, soft-textured and low-allergen species are suggested around children's playgrounds; aromatic plants for picnic areas; and linear flowerbeds along walkways, providing guidance through the flowering cycle. Inanimate landscape elements are designed to integrate functionality and aesthetics to enhance the user experience. Natural stone or recycled wood is envisioned for seating elements; colourful, modular, raised seating blocks are planned for children's play areas. Semi-permeable shade is aimed for through the integration of pergolas and shade structures with climbing plants. Permeable concrete, coloured stone paving, or natural compacted earth surfaces are proposed for walkways. Furthermore, micro-interventions that increase user participation, such as 'community garden' sections supporting social interaction, urban farming practices, or interactive plant identification panels, are also included in the scenario.

Scenario 3 was developed focusing on criteria C5: Preservation of Industrial and Cultural Heritage (0.1076) and C3: Aesthetic and Visual Quality (0.1946). The scenario proposes a plant design language that preserves, interprets, and makes visible the industrial past and cultural memory of the area in the transformation of Izmir Port. The plant design is conceived with an understanding that creates meaningful connections with historical structures, represents memory, and alludes to the former functions of the area. Accordingly, visually simple, texturally distinct plant species that contribute to the historical narrative have been highlighted. For example, grey-green aromatic species such as *Lavandula stoechas*, *Rosmarinus officinalis*, *Artemisia absinthium*, and *Achillea millefolium* are intended to harmonise with the neutral and rusty tones of the industrial past. The use of these low-growing species with controlled spreading is envisioned in rows in front of building facades or along former railway lines.

The plant composition is based on thematic zones and linear arrangements. Linear plant boundaries created along former railway lines aim to preserve traces of the past and provide visual guidance. In areas near industrial structures, species with a high architectural character, such as *Buxus sempervirens*, *Juniperus*

sabina, and *Olea europaea*, have been proposed to ensure unity of form and texture. Thematically, each building group is planned to be associated with different plant palettes; for example, the old warehouses are envisioned to be framed with lavender and juniper species, while the control towers are framed with thyme and silver-leaved species.

The choice of inert materials was made to give meaning and structure to this botanical composition. The preservation of the old rail systems and the integration of modular plant boxes into them were planned. These boxes were proposed to be made of Corten steel in rust tones, reflecting the historical texture and creating a contrast with the plants. For the seating elements, industrial designs combining concrete and metal were adopted; these elements were designed in close relation to the plants, aiming to offer users a point of contact between history and nature. For the walkways, the use of crushed stone and loose stone paving was envisioned, providing both a nostalgic effect and a permeable surface.

Scenario 4 was developed focusing on criterion C4: Feasibility and Cost-Effectiveness (0.0638), which has the lowest weight. The scenario proposes a design for the transformation of Izmir Port addressing needs for limited budgets or temporary use, based on principles of low maintenance costs, rapid implementation, and adaptable planning. The proposed plant design within this scenario is based on a composition of cost-effective, native, and well-adapted species. Species suitable for xeriscape principles and requiring low maintenance are prioritised. Empirical studies on ornamental species under limited irrigation provide direct support for this approach. [Sezen et al. \(2023\)](#) demonstrated that *Salvia splendens* maintains acceptable visual quality under deficit irrigation regimes, while [Sezen et al. \(2024\)](#) reported similar resilience in *Antirrhinum majus*, with water savings of 40–60% compared to full-irrigation controls.

These findings validate that well-chosen xeriscape plants can substantially reduce both water demand and maintenance pressure without compromising aesthetic performance. In this context, species such as *Sedum acre*, *Thymus serpyllum*, and *Teucrium chamaedrys* subsp. *chamaedrys* stand out as plants with low water requirements, tolerance to soil conditions, and the ability to establish quickly ([Staats and Klett, 1995](#); [Sezen et al., 2018](#); [Dönmez et al., 2024](#)). Mats created with these plants both prevent soil loss and provide visual integrity.

Tab. 6. Operational comparison of the four planting design scenarios. (Source: Authors, 2026)

Parameter	Scenario 1 (Ecological Maximisation)	Scenario 2 (Social-Aesthetic)	Scenario 3 (Cultural Heritage)	Scenario 4 (Economic-Feasibility)
Estimated relative cost (1=lowest, 5=highest)	5	3	4	1
Irrigation demand	High (first 2 years), moderate thereafter	Moderate	Low-moderate	Very low
Maintenance frequency	High (establishment phase), low thereafter	Moderate	Low	Very low
Workforce expertise required	Specialist (ecologists, horticulturists)	Medium (landscape technicians)	Medium (heritage-sensitive design)	Low (semi-skilled)
Monitoring ease	Complex (biodiversity indicators)	Simple (user satisfaction surveys)	Medium (heritage integrity)	Very simple (cost tracking)
Institutional suitability	Long-term resilience plans	Public park budgets, tourism	Heritage departments	Temporary use, pilot projects, tight budgets

The design of the plant composition is generally shaped by the principles of modularity and off-site applicability. The creation of seasonal flower islands through direct seeding is planned to provide both visual richness and cost-effective temporary solutions. In addition, the creation of temporary green facades or entrance areas through container-type green applications (ready-made pot systems) is proposed. This approach allows for the creation of landscape scenarios that can be easily rearranged according to changing needs without requiring permanent intervention in the application area.

In this scenario, the use of inanimate materials is also based on low-cost, recycled, or reused materials. For example, planters made from old container parts, seating areas made from pallets, or walkways covered with natural stone chips have been proposed. Borders made from local stones or recycled wooden logs are planned to define plant boundaries. Lighting systems are envisioned as portable, solar-powered units. To support institutional decision-making, the four scenarios are compared below across key operational parameters as shown in Tab. 6. This comparison enables planners and municipalities to match scenario selection with available budget, workforce capacity, maintenance infrastructure, and monitoring requirements.

4. Discussion

This study developed four different plant design scenarios based on criterion priorities measured by AHP. Each scenario reflects a different transformation priority and decision-making attitude. This spectrum of scenarios demonstrates that there is no single "right" solution, but rather that decision-makers can choose from this toolbox based on available budget, time, policy priorities, and social expectations.

Scenario 1 (Ecological Maximisation): Focusing on the highest weighted criteria (C1, C6), this scenario is the most sustainable alternative, but likely requires the highest initial investment and expertise, aiming to maximise biodiversity, climate resilience, and ecosystem services. This scenario tests the limits of nature-based solutions. **Scenario 2 (Social-Aesthetic Focused):** Prioritising public quality of life and visual appeal (C2, C3), this scenario is one of the most acceptable and feasible options that will be embraced by urban dwellers and encourage social interaction. However, it is less ambitious than Scenario 1 in terms of ecological integrity.

Scenario 3 (Cultural Heritage Focused): This scenario, which establishes a strong dialogue with industrial identity and aesthetics (C5, C3), is a critical strategy that legitimises transformation while preserving the spirit and memory of the place. It offers a more niche and thematic approach compared to the other scenarios. **Scenario 4 (Economic-Feasibility Focused):**

This scenario, centring on the lowest weighted criterion (C4), demonstrates how rapid and low-cost green interventions can be designed under practical constraints. Rather than a long-term solution, it models a temporary or complementary role, laying the groundwork for the implementation of other scenarios.

4.1. Study's place in literature and methodological contribution

The existing literature offers a wealth of case studies (Ottoman industrial areas in Dearne Valley, Istanbul) and conceptual frameworks (Ling et al., 2007; Eskidmir et al., 2019) on the transformation of post-industrial areas, as well as general landscape strategies (Zhang and Choi, 2022). However, these studies are mostly limited to qualitative analyses and descriptive suggestions, and do not offer a quantitative and transparent decision support mechanism, especially for concrete implementation decisions such as plant design.

This study addresses this practical need. The integrated methodology presented (SWOT → AHP → Scenario Spectrum) does not merely analyse the field or establish general principles but offers decision-makers a multi-criteria and weighted comparison of different design philosophies. The AHP method systematises expert opinion, placing the "aesthetics or ecology or cost?" dilemma on a quantitative basis. The developed scenarios then demonstrate how these quantitative priorities can be translated into a concrete design language.

While SWOT and AHP are well-established methodologies, the main contribution of this research is not introducing a novel mathematical algorithm but rather proposing a model for integrating plant design decisions from arbitrariness and purely intuitive design into a transparent, repeatable, and debatable decision-support process. This model offers an adaptable methodological framework not only for Izmir Port but also for all similar coastal industrial transformation areas.

4.2. Institutional infrastructure and operational embeddedness

Fig. 3 illustrates how the framework can be embedded into institutional routines. The process begins with a participatory SWOT analysis (Stage 1), followed by AHP weighing by an interdisciplinary expert panel (Stage 2). The resulting criterion weights inform scenario selection (Stage 3), which in turn directly feeds into project approval documentation, budget justification, maintenance protocol design, and monitoring indicators. For example, if a municipality adopts Scenario 4 (Economic-Feasibility), the operational parameters from Tab. 6 (low workforce expertise, very low irrigation demand) can be used to write a tender for maintenance services, to justify a lower annual budget to the city council, or to train semi-skilled municipal staff.

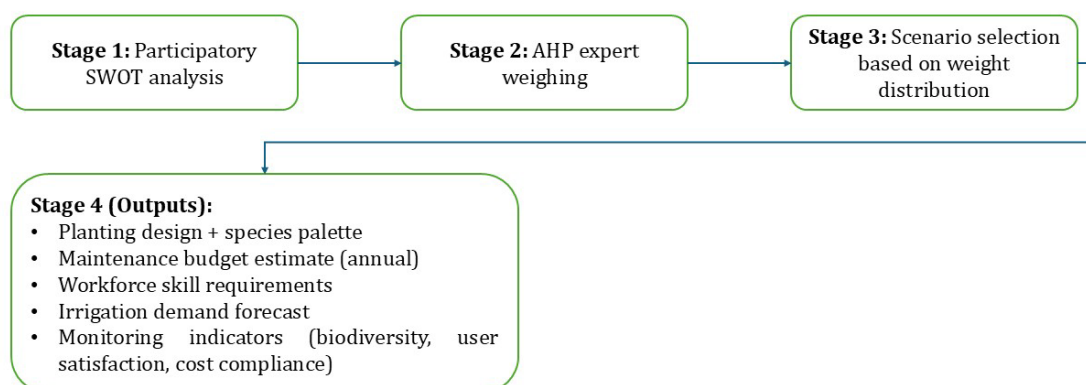


Fig. 3. Institutional workflow for embedding the SWOT-AHP-scenario framework into municipal planning processes. (Source: Authors, 2026)

This institutional framing addresses a common failure mode in post-industrial landscape projects: the gap between design vision and long-term stewardship. By making operational parameters (cost, irrigation, workforce, monitoring) explicit at the scenario selection stage, the framework helps align design decisions with the actual delivery capacity of the implementing institution. This is particularly relevant for public-sector projects where budget cycles are short, staff turnover is high, and ecological or aesthetic ambitions often erode due to underfunded maintenance. Furthermore, this institutional workflow directly operationalises the opportunity identified in the SWOT analysis: 'Developing new uses compatible with urban transformation master plans.' By providing a structured, data-driven approach to green infrastructure, the framework ensures that planting strategies can be seamlessly integrated as the ecological layer within broader urban master plans.

5. Conclusion and recommendations

This study developed a quantitative plant design model based on multi-criteria decision-making (AHP) for the transformation of post-industrial coastal areas, using the Izmir Port as an example, and presented a spectrum of scenarios reflecting different priority policies. The main findings of the study can be summarised as follows:

The AHP analysis revealed that the most decisive criterion for plant design decisions in the context of Izmir Port is Ecological Suitability and Sustainability (C1: 33.19%), closely followed by Green Infrastructure and Ecological Connectivity (C6: 19.46%) and Aesthetics and Visual Quality (C3: 19.46%). This result confirms the central role of ecological restoration and nature-based solutions in the transformation of the region. Social and cultural criteria (C2 and C5: 10.76%) are of complementary importance in ensuring the social acceptance of the design and the preservation of its identity.

The four scenarios developed (Ecological Maximisation, Social-Aesthetic Focused, Cultural Heritage Focused, Economic-Feasibility Focused) offer decision-makers a set of tools to choose from, based on existing constraints and priorities, rather than a single "best" solution. Evaluation of the scenarios using AHP weights showed that the ecologically focused scenario had the highest overall score. This is consistent with the urgent need for ecological remediation in the area.

This study combines SWOT analysis with AHP to systematise a frequently neglected step in the transformation of post-industrial spaces: the transition from qualitative analysis to quantitative and transparent design decisions. This integrated approach prevents arbitrary decisions, placing the decision-making process on a traceable, repeatable, and debatable foundation.

5.1. Recommendations for implementation

Priority Application: In the transformation process of Izmir Port, it is recommended that Scenario 1 (Ecological Maximisation) framework be adopted as the main planning strategy in light of AHP findings and scenario evaluation. This will lay the foundation for rapidly improving the region's carbon sink capacity, climate resilience, and biodiversity.

Complementary Integration: While preserving the main ecological backbone, the social and cultural elements of Scenarios 2 and 3 should be integrated into the design through smaller-scale interventions such as recreation areas and heritage corridors. Scenario 4 can be used as a guide for temporary use areas or pilot applications.

Strengthening Participatory Processes: Directly addressing the threat of 'insufficient public participation in project development processes' identified in the initial SWOT analysis, the developed scenarios should be presented to stakeholders for their views through participatory design workshops and public opinion surveys, and the final decision should be shaped by both technical analysis and social acceptance.

Model for Local Governments: In similar post-industrial port transformation projects, it is recommended that the SWOT → AHP → Scenario Development model presented in this study be adopted as a decision support protocol. This will enable planners to work with a comprehensive data set and an objective prioritisation mechanism.

5.2. Suggestions for future research

The scenarios developed in this study can be spatialized using Geographic Information Systems- (GIS) based suitability analyses and transformed into a more detailed feasibility study. AI-powered design tools can optimise the plant species selection process and develop resilient compositions based on climate change projections. Comparative studies using similar methodology in different coastal cities will test the generalisability of the model and contribute to the literature. Ultimately, this study demonstrates that sustainable urban transformation is only possible through transparent decision-making processes that systematically evaluate ecological, social, economic, and cultural parameters.

Beyond this general principle, the specific contribution of this research lies in showing how such transparency can be operationalised. The integrated SWOT-AHP-scenario framework provides a repeatable, institutionally embeddable infrastructure that connects high-level ecological ambitions to procurement realities, maintenance budgets, workforce capacities, and monitoring protocols. For Izmir Port—and for similar post-industrial coastal sites elsewhere—this framework transforms planting design from an intuitive, one-off exercise into a defensible, data-informed, and adaptable planning tool. The four scenarios are not the endpoints but a decision-making spectrum through which different institutions, under different constraints, can navigate the trade-offs between ecological restoration, social benefit, heritage preservation, and fiscal feasibility.

Conflict of interest

The authors declare no conflicts of interest.

CRediT author statement

Necmettin Gür: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration.

Özgür Kahraman: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration.

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