

Original Research Article

From Experience to Strategy: Developing a Systematic Framework for Green Landscape Design Based on Global Project Analysis

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Abstract | Green landscape design, as an innovative approach to addressing environmental, social, and economic challenges in contemporary cities, requires an integrated and multidimensional framework for sustainability assessment. Existing studies indicate that, despite numerous international indicators and models, there is still no comprehensive and locally adaptable framework to evaluate landscape sustainability that simultaneously covers the environmental, social, and economic dimensions. This theoretical and practical gap has led to the lack of a systematic and measurable structure for assessing landscape design projects in Iran. The main objective of this study is to develop an indicator-based framework for evaluating green landscapes, emphasizing the integration of environmental, social, and economic dimensions. To achieve this goal, five international projects were selected: Shanghai Houtan Park (China), Superkilen (Denmark), Maggie Daily and Beltline Westside (United States), and Kashiwa No-ha Smart Green Park (Japan), and one local case, Tehran's Water and Fire Park, were comparatively analyzed to identify similarities, differences, and potential for local adaptation. Research method: The research employs a qualitative content analysis method with an inductive–deductive approach. In the first step, a systematic search was conducted in Scopus and Web of Science databases to extract indicators related to the three dimensions of sustainability. In the second step, selected projects were analyzed based on criteria such as geographic diversity, climate, and design innovation. Indicators were categorized through three coding stages -open, axial, and selective- to develop a conceptual framework of goal–indicator–strategy. Finally, the findings were validated against expert opinions and global frameworks (e.g., LSA, MEA, and SITES) to ensure the reliability and applicability of the proposed framework. The results indicate that, in international projects, the environmental dimension-particularly indicators such as habitat connectivity, water resource management, and habitat quality-plays a more prominent role. In contrast, in the local case, social indicators, including community participation and social capital, are more emphasized. The findings also reveal a lack of habitat cohesion and weaknesses in water management in domestic projects. The novelty of this study lies in the integration of indicators inductively derived from literature and implemented projects, combined with a deductive coherence based on global frameworks and local adaptation within the Iranian context. The proposed framework can serve as an analytical and strategic tool for landscape architects, urban managers, and policymakers in pursuing sustainable development. It is recommended that future research employ field-based and participatory methods to further validate and optimize this framework.

Keywords | *Green landscape design, Sustainability indicators, Ecosystem performance, Social participation, Ecosystem services.*

Introduction | In recent decades, cities have faced crises such as climate change, ecosystem degradation, natural resource pollution, biodiversity loss, and increasing social and environmental inequalities. These challenges are so

intertwined that cities have become major hubs of vulnerability to environmental unsustainability, highlighting the urgent need for innovative approaches in the design and management of urban spaces. The intensification of phenomena such as rising surface temperatures, urban heat islands, flash floods, and air

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pollution all signal a pressing need for novel strategies in urban environmental management that can simultaneously address the environmental, social, and economic needs of citizens.

In this context, landscape architecture and environmental design, as an interdisciplinary field, can play a key role in integrating ecosystem services, enhancing the quality of public spaces, and increasing urban resilience. By combining knowledge from ecology, aesthetics, culture, and technology, this field offers practical solutions for ecosystem restoration, the improvement of public spaces, and the strengthening of human–nature connections within urban settings. By adhering to principles of sustainable and nature-based design, landscape architecture can integrate green infrastructure into the urban fabric and enhance cities' resilience to environmental crises.

In this study, “green landscape” is defined not merely as environmental greenness but as a systematic design approach that simultaneously integrates ecological dimensions (environmental impact reduction, biodiversity, ecosystem services), social dimensions (equity and participation), and economic dimensions (cost efficiency and ecosystem service value) within an operational framework (Wu et al., 2017; Council of Europe, 2024, 1-4). In other words, a green landscape provides a context in which physical design, ecology, and social participation interact to enhance urban livability and resilience. Thus, green landscape design is not simply about increasing vegetation cover, but a purposeful integration of physical design, ecological processes, and participatory governance, which can be measured through indicator-based approaches (Wu et al., 2017; Council of Europe, 2024, 2-4).

According to Habibi (2017) and Ghiassaei et al. (2019), aesthetics in landscape architecture goes beyond visual aspects and plays an important role in culture, ethics, and sustainable design. They introduce three approaches—phenomenological, psychological, and ecological—demonstrating that aesthetic experience can act as a catalyst for rethinking human–environment relationships and as a bridge between perceptual, ethical, cultural, and environmental values. This interdisciplinary perspective, which complements perceptual and sensory experiences with ecological and functional approaches, provides a valuable theoretical basis for developing a green landscape design framework and strengthening its perceptual dimension. As emphasized by Habibi (2017), the phenomenological, psychological, and ecological approaches are not contradictory but together offer a comprehensive understanding of landscape experience; accordingly, green landscape design becomes a space for the convergence of perception, ethics, and ecology.

Despite these potentials, a major gap in the literature and professional practice of landscape architecture is the lack of a comprehensive, indicator-based framework for evaluating landscape sustainability that can simultaneously and measurably address environmental, social, and

economic dimensions. Most existing indicators are primarily qualitative or focus solely on limited environmental aspects (Aad & Nemer, 2023). Although some of these indicators can be adapted to the landscape domain, the quantitative and objective translation of “landscape sustainability” remains challenging (Aad et al., 2024), and a unified perspective on social–economic–environmental dimensions is rarely provided. This limitation hampers the assessment of sustainability achievements in landscape projects, while the diversity of viewpoints and sources further prevents the formation of a reliable theoretical consensus and framework. Therefore, developing a structured, indicator-based, and context-sensitive framework, grounded in both quantitative and qualitative data, enabling stakeholder participation, and adaptable to local conditions, is essential.

Accordingly, the focus of this study is the absence of such a framework, and the response is the development of an indicator-based, locally adaptable framework for evaluating the sustainability of green landscape designs. This framework goes beyond general concepts to provide operational measures for the environmental, social, and economic dimensions. It is derived from a deductive–inductive combination of literature review and comparative project analysis and can be applied in Iran and other contexts. The research question is: which indicators, and how, can be operationally organized in a goal–indicator–strategy chain to guide sustainability assessment in green landscape design? The study's response lies in the formulation and validation of this chain, enabling the simultaneous integration of environmental, social, and economic dimensions through measurable indicators. The innovation of this study is the explicit articulation of the goal–indicator–strategy chain and the proposed mechanism for localizing indicators to different climates and governance structures, including Iran.

Literature Review

The concept of landscape sustainability was first introduced in the European Landscape Convention in 2000 and later gained prominence within the agenda of the Sustainable Development Goals (SDGs). This concept provides a macro-level framework for developing comprehensive policies (Millennium Development ..., 2012), protecting landscape qualities (Sowińska-Świerkosz & Michalik-Śnieżek, 2020), and managing landscapes in an integrated manner across large scales (Wu et al., 2017; Palang et al., 2000; Council of Europe, 2024, 3-5). Among these approaches, the green approach in landscape design is considered a practical pathway toward sustainability, emphasizing the efficient use of natural resources, biodiversity conservation, enhancement of ecosystem services, and mitigation of environmental impacts in design and implementation processes (Palang et al., 2000; Nautiyal & Goel, 2021). In essence, a green landscape represents a design–management approach that, relying on ecological processes, social equity,

and economic efficiency, seeks to preserve/enhance ecosystem services and biodiversity, reduce environmental impacts, and improve well-being and spatial equity. Beyond mere greening, this approach operationalizes through spatial strategies, stakeholder participation, and data-driven decision-making. It aims to balance the relationships among humans, nature, and built structures, providing sustainable, healthy, and climate-adaptive spaces through intelligent design interventions. Moreover, sustainable landscape development, and by extension green approaches, has a high capacity to serve as an effective framework for achieving SDGs and can offer solutions aligned with complex environmental and social challenges (Sayer et al., 2013; Nautiyal & Goel, 2021).

• International frameworks for landscape sustainability assessment

Over the past two decades, a range of international frameworks and systems has been developed to evaluate sustainability, each attempting to address environmental, social, and economic dimensions in the design and management of built environments. These frameworks can be broadly classified into research frameworks and implementation and certification systems. Research frameworks primarily focus on theory development and analytical methods, while certification systems are employed in practice to evaluate and validate projects.

Among research frameworks, the Landscape Sustainability Assessment (LSA) stands out as a prominent approach. By combining quantitative and qualitative indicators and employing participatory methods, LSA assesses the integration of social, environmental, and physical dimensions across landscape projects at various scales (Aad & Nemer, 2023). Its strength lies in the multidimensional and systemic perspective it provides on landscapes; however, challenges remain, such as difficulties in localizing indicators, ensuring quantitative measurability, and coding reliability. Another notable framework is Ecosystem Services, initially introduced in the Millennium Ecosystem Assessment (MEA, 2005) and later developed through The Economics of Ecosystems and Biodiversity (TEEB, 2010). This framework offers a robust theoretical tool for analyzing the links between ecosystem services and landscape quality, guiding high-level policymaking. Yet, due to its broad perspective, it largely remains strategic and has been less operationalized as a practical design tool. Similarly, green infrastructure models (Benedict & McMahon, 2006) emphasize habitat connectivity, ecological functions, and resilience, highlighting the links between landscapes and natural processes; however, social and economic dimensions are not fully integrated and remain limited to environmental and physical aspects.

In contrast, certification systems such as LEED (U.S. Green Building Council ..., 2014), SITES (SITES Initiative, 2016), and BREEAM (Building Research Establishment, 2016) function primarily as ranking and

project certification tools. These systems provide high value in project validation and compliance with global standards and have effectively promoted sustainable design practices in the field. Nevertheless, their main focus is auditing and ranking processes rather than knowledge generation or analytical framework development. Moreover, limitations exist in terms of comprehensive social-economic dimensions and adaptability for local contexts.

To clarify these approaches, Table 1 compares international frameworks and systems for landscape sustainability assessment. The comparison shows that each framework addresses specific dimensions and has particular strengths, but all face gaps that hinder comprehensive coverage and local applicability. As observed, none of the existing frameworks alone fully integrates environmental, social, and economic dimensions quantitatively. This gap indicates the necessity of developing a comprehensive, indicator-based, and locally adaptable framework capable of simultaneously covering the three dimensions at the landscape design level while responding to local conditions and stakeholder participation. By combining deductive-inductive methods and comparative project analysis, such an approach can fill theoretical and practical gaps and provide new guidance for landscape design in diverse contexts, including Iran. Mansouri & Habibi (2010) analyzed the Dry Shiraz River context and proposed a localized framework based on the three components of river, city, and people, integrating physical, aesthetic, and social factors in management decision-making. This study represents one of the first coherent attempts to link cultural, social, and environmental values in landscape assessment in Iran, providing a foundation for localizing the present framework. Their approach illustrates that landscape sustainability in Iran requires the integration of environmental components with cultural and perceptual values, aligning with the present research's goal of developing a goal-indicator-strategy chain.

In line with recent research in landscape aesthetics, Habibi (2017) emphasizes an interdisciplinary perspective combining experiential and human-centered approaches. He posits that aesthetic experience can serve as a platform to enhance ethical and environmental values, thereby linking environmental knowledge with cultural perception. Such a perspective can elevate landscape assessment frameworks from purely physical evaluations to perceptual and ethical dimensions.

• Environmental indicators

Environmental indicators, as a core component in assessing landscape sustainability, encompass both structural-functional and performance-dynamic dimensions of ecosystems. Previous studies indicate that combining these categories provides a more comprehensive picture of ecological quality and landscape functionality (Threlfall et al., 2017; Habel et al., 2021).

- Structural-functional indicators

These indicators focus on the physical characteristics and ecological processes related to landscape structure.

Table 1. Critical review of international landscape sustainability assessment frameworks and systems. Source: Authors.

Framework	Covered Dimensions	Strengths	Gaps and Limitations	Source
LSA	Environmental, Social, Physical	Systematic perspective; integration of quantitative and qualitative indicators; stakeholder participation	Weak economic dimension; challenges in localization and quantitative measurability	Aad & Nemer (2023)
Ecosystem Services (MEA/TEEB)	Environmental, partly Economic	Links ecosystem services with landscape quality; strengthens macro-level policy frameworks.	Limited applicability at the design scale; weak social coverage	Millennium Ecosystem Assessment (2005), The Economics ... (2010)
Green Infrastructure	Environmental (habitat connectivity, ecology)	Emphasis on ecological connectivity and resilience	Insufficient social and economic coverage	Benedict & McMahon (2006)
LEED	Economic, Environmental	Global applicability; project certification; focus on energy and building performance	Limited coverage of open landscapes; low flexibility for localization	USGBC (2014)
SITES	Environmental, Economic, and partly Social	Direct focus on open spaces and landscape; practical indicators	Limited social dimension; difficult to localize	SITES Initiative (2016)
BREEAM	Economic, Environmental	Widely applied in construction projects; strong operational tools	Limited attention to landscape and social dimensions; engineering-oriented	Building Research Establishment (2016)

In previous studies, structural–functional environmental indicators have been widely recognized as essential for enhancing urban landscape sustainability and biodiversity. Native vegetation cover is a key factor that improves urban ecosystem structure, strengthens biodiversity, and enhances ecosystem performance (Threlfall et al., 2017). Habitat connectivity reduces fragmentation, maintains habitat quality, and increases ecosystem resilience to climate change, facilitating species persistence and population growth (Oropeza-Sánchez et al., 2025).

Urban vegetation, such as trees and shrubs, plays a vital role in regulating the water cycle and enhancing soil infiltration, directly affecting water resource management and urban sustainability (European Environment Agency, 2020; Gillefalk et al. 2021). Additionally, the size and spacing of habitat patches are critical for biodiversity conservation and habitat quality; increasing patch size and reducing distances between them can prevent biodiversity loss (Fahrig, 2013; Haddad et al., 2015). In agricultural landscapes, shrub network structures and habitat matrix permeability are effective indicators for increasing species diversity and facilitating dispersal (Grof-Tisza et al., 2024; Guarengi et al., 2023). Furthermore, multi-criteria ecosystem service analyses and landscape quality assessments are important tools for sustainable planning and management (Aad et al., 2024; Xi et al., 2024).

Despite extensive research on environmental indicators and their importance for urban landscape sustainability, a lack of comprehensive and integrative frameworks remains, particularly frameworks that operationalize these indicators in a locally adaptable, measurable, and practical manner for green landscape design. Moreover, many studies focus on isolated dimensions, with limited attention to interactions between environmental indicators and other sustainability aspects.

Therefore, developing an integrated framework that maintains scientific rigor while allowing local adaptation and stakeholder participation is essential (Table 2).

- Performance–dynamic indicators

Environmental performance indicators, including species density, serve as key measures for evaluating habitat health and ecosystem functionality. Habel et al. (2021) demonstrated that species density is an efficient indicator for analyzing environmental quality and ecosystem performance, particularly in biodiversity-rich regions of Africa. Habitat quality fundamentally determines ecosystem performance and biodiversity conservation; for instance, Thomas et al. (2021), in Amazonian forests, showed a positive relationship between habitat quality and seed production, biomass, and sustainability of key species.

Ecosystem stability, as a measure of resilience and resistance to environmental changes, has been assessed in studies such as Chambers et al. (2023) and Board et al., through novel indicators in the Sagebrush ecosystem in the USA. Remote sensing technologies and ecological modeling are also key tools for monitoring vegetation dynamics and assessing ecological sustainability. Wang et al. (2022) demonstrated that satellite data and predictive models can identify vegetation change trends and their feedback to regional and global climate, thereby supporting natural resource management and environmental conservation.

Assessing environmental performance, particularly in terms of species density and habitat quality, is crucial for ensuring landscape sustainability and resilience. However, many existing performance indicators focus on regional or species-specific analyses and have been less capable of evaluating complex urban and rural landscapes comprehensively and quantitatively. Developing indicators applicable across scales

and integrating modern monitoring technologies remains a major challenge, which the present study aims to address (Table 2).

Although environmental indicators cover a wide range of criteria, many studies focus on limited dimensions (e.g., biodiversity or vegetation cover) and rarely integrate structural and functional aspects into a comprehensive framework. Thus, it is essential to organize indicators in an integrated and locally adaptable system that can address both quantitative and qualitative dimensions in green landscape design.

• **Social indicators**

Social capital is recognized as a key factor in promoting social participation and sustainable development. Studies indicate that active social networks, organizational leadership, and local community trust play significant roles in successful resource management and community empowerment (Hernandez & Berardi, 2024; Fu & Mao, 2022; Bouma et al., 2008; Pritchard et al., 2024). Legitimate and inclusive stakeholder representation in decision-making enhances trust and social belonging (Arnstein, 1969; Cornwall, 2008; Fung, 2006; Gaventa & Barrett, 2012).

Structured participatory techniques, such as

interactive mapping workshops, help balance power and promote social ownership (Eaton et al., 2021; Barbrook-Johnson & Penn, 2022b). Clear two-way communication further strengthens local knowledge and enables informed decision-making (Newig et al., 2023). Declining public trust in governmental institutions is a major challenge that can be mitigated through increased transparency and accountability (OECD, 2024; Valgarðsson et al., 2025). Well-designed quantitative participatory tools are also necessary to maintain participant satisfaction (Brett et al., 2014).

Diverse stakeholder engagement—including residents, experts, farmers, and governmental agencies—improves decision-making quality and project sustainability (Reed et al., 2009). Furthermore, environmental justice, encompassing equitable distribution of resources and public services, plays a crucial role in enhancing health and quality of life (Rigolon, 2016).

Although the importance of social capital and stakeholder participation in landscape design projects is well-established, many existing social indicators are either qualitative or lack quantitative, objective measurement mechanisms suitable for a comprehensive sustainability assessment framework. Additionally, the limited consideration of cultural and social

Table 2. Categorization of landscape assessment indicators based on environmental aspects. Source: Authors.

Category	Indicator/ Variable	Description/ Application	Sources
Structural–Functional Environmental	Native vegetation cover	Improves landscape sustainability, biodiversity, and ecosystem performance	Threlfall et al. (2017), European Environment Agency (2020)
	Habitat connectivity	Reduces fragmentation, enhances habitat quality, biodiversity, and climate resilience.	Oropeza-Sánchez et al. (2025)
	Water consumption management	Optimizes water use and rainfall management in urban environments	European Environment Agency (2020), Gillefalk et al. (2021)
	Rainfall management	Optimizes seasonal rainfall handling to mitigate drought and soil erosion	Gillefalk et al. (2021)
	Habitat patch size	Quantitative indicator for sustainability, species diversity, and habitat quality	Fahrig (2013)
	Distance between habitat patches	Helps maintain populations of sensitive species and biodiversity	Haddad et al. (2015)
	Shrub network structure	Indicator of insect abundance and biodiversity correlation in agricultural areas	Sharmin et al. (2024)
	Landscape matrix quality	Influences environmental indicators and overall landscape sustainability	Aad et al. (2024)
	Habitat substrate permeability	Affects habitat quality and ecological connectivity	Guarenghi et al. (2023)
	Scale of analysis	Defines an analytical framework for environmental assessment	Xi et al. (2024)
Environmental Performance	Species diversity, habitat quality, and network robustness	Integrates quantitative and qualitative measures for ecosystem sustainability	Aad et al. (2024)
	Species density	Indicator of habitat quality and ecosystem performance	Habel et al. (2021)
	Habitat quality	Core indicator of biodiversity and ecological health	Thomas et al. (2021)
	Ecosystem stability	Reflects ecological resilience against environmental change	Chambers et al. (2023)
	Remote sensing and modeling technologies	Evaluate vegetation change and ecological sustainability.	Wang et al. (2022)

context reduces the practical applicability of these indicators. Addressing this gap through multi-dimensional quantitative social indicators is one of the key objectives of the present research (Table 3).

• Economic indicators

Sustainable landscape management (SLM) from an economic perspective requires substantial initial investments, which may pose limitations on stakeholder participation, particularly in low-income areas. However, research by Tadesse (2023) in southern Ethiopia demonstrated that despite these upfront costs, such investments yield positive economic returns and high cost-effectiveness, with a favorable benefit–cost ratio (BCR) and positive net present value (NPV), providing a strong economic rationale for adopting this approach.

A significant reduction in annual maintenance costs is another key advantage of SLM, enhancing long-term economic efficiency. Tadesse (ibid.) found that following the implementation of initial interventions, maintenance costs decreased substantially and were negligible relative to the gains in land productivity and crop yield. The adoption of modern technologies and systematic planning—such as the use of efficient machinery and the selection of native plant species—plays a crucial role in reducing maintenance costs while preserving landscape quality (Ayob et al., 2022; Tadesse, 2023).

The economic importance of sustainable landscape management is also emphasized in agricultural areas of developing countries, particularly for combating soil erosion and improving land productivity. Tadesse’s (2023) study in the Barcha-Adado watershed reported an average intervention cost of approximately USD 171 per hectare, with farmers experiencing a 28% increase in crop yield and a more than fivefold return on initial investment (BCR = 5.16). Additionally, targeted forest policies and optimal forest management can reduce long-term maintenance costs and maintain urban landscape quality (Holland et al., 2022). Valuing ecosystem services in urban green spaces, such as carbon storage, directly influences property values, and smaller parks have been shown to play an effective role in increasing housing prices, providing a novel practical framework for urban planning (Chen et al., 2023).

Although economic indicators play a crucial role in justifying and sustaining landscape management, many studies in this field have been limited to case-specific analyses, highlighting the lack of indicator-based and quantitative frameworks capable of comprehensively analyzing costs and benefits in green landscape projects. Moreover, accounting for local conditions and economic diversity across different regions adds complexity to economic assessment. The present

Table 3. Categorization of landscape assessment indicators based on social aspects. Source: Authors.

Category	Indicator/ Variable	Description / Application	Sources
Social	Community participation	Facilitates participatory processes, enhances trust, cooperation, and social capital.	Bouma et al. (2008), Fu & Mao (2022), Hernandez & Berardi (2024), Pritchard et al. (2024)
	Legitimate and inclusive stakeholder representation	Ensures equitable representation to foster trust and social belonging	Arnstein (1969), Fung (2006), Cornwall (2008), Gaventa & Barrett (2012)
	Structured participatory methods	Workshops, participatory mapping, and visioning for balanced power and deeper engagement	Cochrane & Corbett (2018), Eaton-González et al. (2021), Barbrook-Johnson & Penn (2022a), Barbrook-Johnson & Penn (2022b)
	Transparent and two-way communication	Encourages local knowledge emergence and social learning	Gerlak et al. (2023), Newig et al. (2023), McIlwain et al. (2024)
	Strengthening social capital (trust and cooperation)	Enhances effective collaboration in landscape planning	Bouma et al. (2008), Fu & Mao (2022), Hernandez & Berardi (2024)
	Public institutions and trust	High policy execution potential, but risk of declining public trust	Stevenson & Wolfers (2011), Beshi & Kaur (2019), UN DESA & Perry (2021), OECD (2024), Valgarðsson et al. (2025)
	Quantitative participatory methods (surveys)	May cause participant fatigue and lower satisfaction	Brett et al. (2014), Esmail et al., 2015), Boivin et al. (2018)
	Stakeholder diversity	Involvement of residents, experts, and local groups enhances inclusiveness	Reed (2008), Reed et al. (2009), Ensor & Harvey (2015)
	Environmental justice	Ensures equitable access to resources and public spaces through inclusive design	Schlosberg (2013), Wolch et al. (2014), Jennings & Gaither (2015), Rigolon (2016)
	Transparency and continuous interaction	Key indicators of environmental justice and social satisfaction	Daley & Reames (2015), Firman et al. (2024)

study seeks to address these gaps by proposing a flexible and comprehensive framework to support integrated economic evaluation (Table 4).

Research Method

This study was conducted using a qualitative content analysis approach, employing both deductive and inductive reasoning. Its primary objective was to systematically extract and categorize landscape sustainability indicators within the context of green landscape design, through structured analysis of reputable scientific sources and the examination of international case studies. The research process consisted of three main stages: systematic literature search, coding and classification of indicators, and validation of results.

• Systematic literature search

In the first stage, a systematic search of articles was conducted in the Scopus and Web of Science databases using keywords related to “landscape sustainability,” “green landscape design,” “landscape design assessment,” and “ecological, social, and economic indicators.” The search covered the period from 2010 to 2025. Only articles that directly or indirectly addressed sustainability assessment in landscape design were included. Screening was performed based on the following criteria:

- Inclusion criteria: Direct relevance to landscape design, presence of an assessment framework or quantitative and qualitative indicators, and a peer-reviewed publication.
- Exclusion criteria: Articles lacking a focus on landscape or without indicator-based information.

From over 180 initial articles, 46 studies met the eligibility criteria for analysis.

• Selection of case studies

The selection of case studies aimed to represent climatic, geographic, and functional diversity in green landscape design projects. The main selection criteria were:

1. Climatic and geographic diversity: Projects were chosen from different regions worldwide (Asia, Europe, North America) to ensure that the proposed framework would not be limited to a specific context and could be generalizable.

2. Documentation and data availability: Only projects with reliable scientific sources, technical reports, or documented assessments were selected to ensure a trustworthy qualitative content analysis.

3. Representation of innovative green landscape design approaches: Projects were selected for their integration of environmental, social, or economic indicators, allowing comparative analysis with the proposed framework.

4. Educational value and replicability: Projects were expected to provide transferable insights suitable for adaptation to Iranian conditions.

Accordingly, five prominent international examples-including Shanghai Houtan Park in China, Superkilen in Denmark, Maggie Daily and Beltline Westside in the United States, and Kashiwa No-ha Smart Green Park in Japan-were selected. This number was intentionally limited, as qualitative content analysis prioritizes depth and diversity of data rather than statistical quantity. The selection of five diverse cases allowed sufficient comparison to identify similarities and differences while preventing excessive data dispersion.

To account for local context and assess the applicability of the framework in Iran, Tehran’s Ab-o-Atash Park was also included. This park, utilizing native plant species, enhancing public spaces, and fostering social interactions, serves as a representative site for comparative analysis and evaluation of the framework’s applicability in a local context. Projects lacking documented data, comprehensive indicators, or replicability potential were excluded, ensuring that the final dataset met all criteria simultaneously.

• Content coding and indicator classification

Next, the content of the selected articles was examined and coded using qualitative content analysis. Coding was conducted in three stages-open, axial, and selective-and reviewed by two independent researchers to ensure inter-coder reliability. This process allowed indicators to be extracted not merely descriptively, but in the form of a structured conceptual model. The study’s innovation lies in employing the full cycle of qualitative coding, enabling integration of textual data with global theoretical

Table 4. Classification of landscape assessment indicators based on economic aspects. Source: Authors.

Category	Indicator/ Variable	Description/ Application	Sources
Economic	Implementation cost of SLM	Substantial initial investment required for sustainable landscape management	Tadesse (2023)
	Annual maintenance cost	Initial investment provides a foundation for sustainable landscape management.	Tadesse (2023), Ayob et al. (2022)
	Short- and long-term economic return	—	Holland et al. (2022)
	Cost reduction through forest policies	—	Holland et al. (2022)
	Ecosystem service valuation	—	Chen et al. (2023)
	Positive Net Present Value (NPV)	65% of NBS projects in European cities show positive NPV	Bockarjova et al. (2022)

frameworks, thereby enhancing the conceptual coherence and local adaptability of the proposed model.

- **Open coding:** Concepts and indicators were extracted without prior assumptions, with all statements and phrases related to landscape sustainability recorded as initial codes.

- **Axial coding:** Initial codes were grouped based on conceptual similarities and relationships, forming main categories (environmental, social, economic) and identifying interconnections among these categories and their subcomponents.

- **Selective coding:** Final categories were selected and integrated into the conceptual framework to construct a coherent and locally adaptable model.

Additionally, the frequency of each indicator in the sources and its position within the conceptual structure of the articles were assessed to determine validity and comprehensiveness. The outcome of this process was a context-sensitive model for assessing landscape sustainability, combining quantitative and qualitative data, aligning with reputable global frameworks, and adaptable to diverse climatic and social conditions, serving as a practical tool for design and urban policy-making.

Environmental performance indicators, which in some studies are treated as independent dimensions, were classified as a sub-dimension within the environmental category due to high conceptual overlap and direct relevance to landscape environmental quality. This decision preserved the three-dimensional structure (environmental, social, economic) while maintaining the operational significance of functional indicators as a separate category within the framework.

Indicator selection considered climatic and cultural characteristics of each region. In this regard, Ghiassi et al. (2019) highlighted the importance of simultaneously analyzing physical and perceptual components in arid landscapes of Iran, showing that combined indicators provide a more accurate representation of human-environment interactions. This integrative approach was applied in the present framework by linking environmental indicators with social and perceptual indicators, confirming that the goal-indicator-strategy chain should address both environmental and perceptual aspects to ensure landscape sustainability beyond the physical level.

• **Validity and reliability**

To minimize bias and enhance the validity of results, several complementary measures were implemented in four main stages:

- **Inter-coder reliability:** The entire coding process was reviewed by two independent researchers, with results compared at multiple stages and inter-coder agreement calculated to ensure consistency and coherence of categorization.

- **Theoretical validation:** Findings were compared with established global theoretical frameworks (e.g., LSA, MEA, TEEB) to identify overlaps and discrepancies and support conceptual coherence.

- **Practical validation:** Results were evaluated through

collective feedback from academic experts and professional landscape designers via expert panels and review sessions, ensuring clarity, applicability, and suitability of the framework for Iranian conditions.

- **Indicator frequency analysis:** To increase precision, the frequency of each indicator across selected articles was calculated to identify those most supported in the literature, and their position in the conceptual structure was assessed to confirm theoretical validity and operational relevance.

Overall, the innovation of this study lies in combining inductive extraction of indicators from texts and projects with deductive alignment based on global frameworks, while also considering local adaptability in Iran. The resulting context-sensitive model for assessing landscape sustainability is adaptable to diverse climatic and social conditions, emphasizes stakeholder participation and local data, and maintains conceptual alignment with global frameworks.

• **Limitations**

This study did not involve direct interaction with stakeholders through interviews, questionnaires, or workshops; the focus was on extracting and validating indicators from scientific literature and international projects. Nevertheless, dimensions related to participation and environmental justice were incorporated into the proposed framework to allow future field studies and local stakeholder engagement. Additional limitations include the limited number of case studies, reliance on secondary sources rather than primary field data, and challenges in generalizing the indicators to the social and climatic contexts of Iran and similar countries. Therefore, the findings are considered a theoretical and analytical step, laying the groundwork for future field testing, localization, and practical development in subsequent research.

Findings

The findings of this study are organized around the three main dimensions of sustainability: environmental, social, and economic. Environmental performance indicators were integrated as a sub-dimension within the environmental indicators to maintain the three-dimensional structure of the framework. This approach not only prevents conceptual dispersion but also allows for more precise analysis of the environmental quality of projects. To enhance comprehensiveness and local applicability, Tehran's Ab-o-Atash Park was included as a representative case from Iran. This inclusion not only demonstrates local potentials but also enables the assessment of overlaps and gaps in the framework within the local context.

• **Environmental indicators**

Several key variables related to landscape sustainability were identified in the review of environmental indicators, as emphasized in previous studies. One of the most critical indicators is native vegetation cover, which plays a vital role in enhancing landscape sustainability, maintaining biodiversity,

and supporting ecosystem functions (Threlfall et al., 2017; European Environment Agency, 2020). Habitat connectivity has also been highlighted as an effective factor in reducing habitat fragmentation and increasing ecosystem resilience to climate change (Oropeza-Sánchez et al., 2025). In the local Tehran case, the spatial linkage between Ab-o-Atash Park and Taleghani Park via the Nature Bridge is recognized as one of the most successful examples of urban green connectivity, playing a key role in enhancing environmental quality (Nasri Roodsari & Hoseini, 2022).

Regarding water resource management, indicators such as water consumption management and rainfall management are of high importance, helping optimize water use, reduce drought, and prevent soil erosion (European Environment Agency, 2020; Gillefalk et al., 2021). Similarly, the organization of urban river valleys in Tehran has shown that these areas can function as high-performing green infrastructure for stormwater management and increased infiltration (Sabri & Sabri, 2011). Quantitative indicators such as habitat patch size and inter-patch distance have also been widely used to assess sustainability and species diversity conservation (Fahrig, 2013; Haddad et al., 2015). Moreover, the structure of shrub networks and habitat permeability have been shown to positively correlate with insect abundance and habitat quality (Sharmin et al., 2024; Guarengi et al., 2023). Finally, broader indicators such as landscape context quality, analysis scale, and a combination of quantitative and qualitative criteria-including species diversity, habitat quality, and network robustness-serve as comprehensive frameworks for assessing landscape sustainability and ecosystem performance (Aad et al., 2024; Xi et al., 2024).

In examining environmental performance indicators, species density has been highlighted as an important measure for assessing habitat quality and overall ecosystem performance (Habel et al., 2021). Habitat quality, as a key indicator of ecosystem performance and biodiversity, plays a critical role in maintaining ecosystem health (Thomas et al., 2021). Ecosystem stability, indicating sustainability and resilience against environmental changes, was also considered an important criterion in this study (Chambers et al., 2023). Additionally, the use of advanced technologies such as remote sensing and modeling for evaluating vegetation changes and ecological sustainability has enhanced the accuracy and depth of environmental performance analyses (Wang et al., 2022).

• Social indicators

In the study of social indicators, community participation was identified as a key mechanism for building trust, fostering collaboration, and increasing social capital (Fu & Mao, 2022; Hernandez & Berardi, 2024). Legitimate and inclusive stakeholder representation is essential to ensure genuine participation of all groups and to cultivate a sense of social belonging (Arnstein, 1969; Cornwall, 2008). Structured participatory methods such as workshops, interactive

mapping, and participatory imaging help balance power and deepen engagement (Eaton-González et al., 2021; Barbrook-Johnson & Penn, 2022b). Transparent and two-way communication fosters local knowledge emergence and social learning, improving participatory processes (Gerlak et al., 2023; McIlwain et al., 2024).

At the local level, behavioral studies in the Ab-o-Atash complex have demonstrated that spatial organization and physical elements significantly enhance social interactions, social capital, and the formation of a positive mental image of the city (Sabri & Sabri, 2011). Social capital indicators, focusing on trust and collaboration, are influential in facilitating landscape planning (Bouma et al., 2008). Conversely, involvement of governmental institutions, while increasing the likelihood of decision implementation, may reduce public trust and pose challenges ((Valgarðsson et al., 2025; OECD, 2024). Quantitative participatory methods, such as questionnaires, may lead to participant fatigue and lower satisfaction, which should be considered in the design of participatory processes (Brett et al., 201). Stakeholder diversity-from local residents to experts and governmental bodies-enhances efficiency and inclusivity in participatory processes (Reed, 2008). Furthermore, the concept of environmental justice, ensuring equitable access to resources and public spaces through effective participation and appropriate design, is a key indicator for improving quality of life (Schlosberg, 2013; Rigolon, 2016). In Tehran, studies indicate that the uneven distribution of urban green spaces across districts has caused social inequalities and reduced environmental justice (Nasri Roodsari & Hoseini, 2022). Transparency and continuous engagement, as key indicators of environmental justice, significantly influence social satisfaction (Firman et al., 202).

• Economic indicators

In the economic domain, the cost of implementing sustainable landscape management is recognized as a significant initial investment required for executing sustainable landscape projects (Tadesse, 2023). However, annual maintenance costs in this management approach are relatively low, contributing to long-term economic returns (Tadesse, 2023; Ayob et al., 2022). Short- and long-term economic return indicators are generally reported in the literature, though further detailed analysis is required (Tadesse, 2023). Forest policies can also play an effective role in reducing costs and optimizing the economic performance of sustainable landscape projects (Holland et al., 2022). Additionally, the valuation of ecosystem services serves as a key indicator, highlighting the economic importance of nature and ecosystems in landscape management (Chen et al., 2023). Local evidence shows that investment in Tehran's urban green structures not only increases land value and attracts tourists but also improves citizens' quality of life (Nasri Roodsari & Hoseini, 2022; Nezami & Bahreini, 2016).

Approximately 65% of nature-based solution (NBS) projects in European cities exhibit positive net present value (NPV), indicating profitability and economic justification for such projects (Bockarjova et al., 2022).

For comparative analysis of indicators across selected projects, extracted data were organized into the three main sustainability dimensions: environmental, social, and economic. Environmental performance indicators, sometimes treated as an independent dimension in other studies, were integrated within the environmental dimension due to high conceptual overlap and direct relevance to assessing landscape environmental quality. Project comparisons were conducted based on these three dimensions, with each indicator recorded according to its frequency and prominence in documents and projects. Tehran's Ab-o-Atash Park was included as a local case for this analysis. Table 5 presents the results of this comparison and the overlaps with the local case. The analysis revealed that, across all projects, the environmental dimension was more prominent than the social and economic dimensions, while social and economic indicators exhibited less diversity and frequency. This finding underscores the need to reconsider the prioritization of indicators within the Iranian context.

Analysis and Discussion

A comparative review of six prominent green landscape design projects-including Shanghai Houtan Park, Superkilen Park, Maggie Daley Park, BeltLine Westside Park, Kashiwa No-ha Smart City Green Park, and Tehran's Ab-o-Atash Park-offers a unique opportunity for a critical analysis of the multi-level dimensions of landscape design. This analysis was conducted within the theoretical frameworks of Complex Adaptive Systems (CAS) and Participatory Design (PD), which form the core of achieving multidimensional sustainability objectives.

In the ecological sustainability dimension, the projects focused on enhancing habitat network connectivity and improving the quality and spatial configuration of habitat patches. For instance, Shanghai Houtan Park, by employing advanced hydrological models and ecosystem engineering, has effectively managed the water cycle, increasing the capacity for storage and recycling of water resources, such that indirect rainfall is naturally absorbed and filtered. Similarly, Kashiwa No-ha Smart City Green Park utilized remote sensing (RS) and big data analytics (BDA) to enable continuous monitoring of environmental dynamics, reflecting a high level of convergence between technology and ecology. These strategies can be interpreted based on the theories of "dynamic landscapes" and "spatial network analysis." Tehran's Ab-o-Atash Park, through its spatial linkage to Taleghani Park via the Nature Bridge, represents a prominent example of creating urban habitat connectivity. This connection not only improves environmental quality but also symbolizes the integration of natural landscapes with urban infrastructure.

Ecosystem stability and performance resilience have been

further strengthened through Adaptive Management Systems (AMS) and real-time monitoring technologies. The application of tools such as remote sensing, GIS, and machine learning algorithms for predicting ecological changes and designing compensatory measures-especially in projects like Kashiwa No-ha-demonstrates the effective implementation of advanced tools in urban landscape management.

In the social dimension, the projects drew upon participatory governance and social capital theories. Superkilen Park and BeltLine Westside Park, through complex stakeholder engagement processes and structured participatory tools (SET), sought to implement mechanisms of environmental justice within green landscape projects. Transparent, two-way communication, particularly in culturally and socially diverse contexts, enhanced social cohesion and local acceptance. The analysis of these processes, grounded in the theories of "participatory communication" and "networked processes," underscores their critical importance. Tehran's Ab-o-Atash Park, with its diverse cultural and social functions and continuous citizen presence, has played a significant role in strengthening social capital and fostering collective interactions. These observations indicate that even without formal participatory processes, thoughtful spatial design and cultural activities can provide a foundation for environmental justice and social belonging.

Economically, the projects emphasized long-term investment and reduced maintenance costs through circular economy approaches and ecosystem service provision. For example, the high initial costs of Shanghai Houtan Park and Kashiwa No-ha are justified through increased net present value (NPV) and sustained utilization. These approaches rely on advanced eco-economic modeling and multi-criteria decision analysis (MCDA) to quantitatively and qualitatively assess the balance between environmental and economic benefits. In Iran, investment in Tehran's Ab-o-Atash Park has increased the value of surrounding lands, attracted domestic and international tourism, and enhanced urban economic indicators, making it a notable example of linking environmental benefits with local economic returns. Conversely, parks like Maggie Daley and BeltLine Westside, despite employing fewer technological tools, have achieved significant contributions to future-oriented landscape sustainability through optimization of natural and social structures.

Another key aspect of the analysis is the application of multi-criteria methods in evaluating green landscape projects. Specifically, Shanghai Houtan Park and Kashiwa-no-ha utilized fuzzy-based MCDM models and Analytic Hierarchy Process (AHP) to measure and prioritize ecological, social, and economic indicators. These methods, by considering data uncertainty and stakeholder perspectives, facilitated comprehensive and realistic decision-making processes.

Among the cases studied, Tehran's Ab-o-Atash Park, as a local example, provides a clear view of opportunities and challenges

Table 5. Comparative analysis of environmental, social, economic, and functional indicators in six parks with a green landscape design approach. Source: Authors.

Category	Indicator/Variable	Shanghai Houtan Park	Superkilen Park	Maggie Daley Park	BeltLine Westside Park	Kashiwa-no-ha Smart City Green Park	Ab-o-Atash Park
Environmental	Native vegetation cover	Diverse native plant species	Limited local species	A combination of native and non-native plants	Drought-tolerant native plants	Extensive native vegetation cover	Native and drought-resistant species
	Habitat connectivity	Interconnected habitats	Weak connectivity	Connection to adjacent parks	Strong ecological linkage	Optimal habitat connectivity	Effective connection via Tabiat Bridge
	Water consumption management	Water recycling systems	Efficient water use	Smart irrigation system	Rainwater management	Optimized water use	Traditional irrigation with high consumption
	Rainwater management	Effective stormwater control	Limited rainfall management	Urban runoff management	Efficient rainwater control	Integrated rainfall management	Limited rainwater runoff management
	Habitat patch size	Large and connected patches	Small and scattered patches	Medium-sized patches	Large and continuous patches	Large and cohesive patches	Medium and relatively continuous patches
	Distance between habitat patches	Short distance	Large distance	Moderate distance	Short distance	Short distance	Moderate distance
	Shrub network structure	Dense and cohesive network	Scattered network	Strong network structure	Extensive network structure	Integrated shrub network	Sparse and less cohesive network
	Landscape matrix quality	Natural and open landscape	Diverse urban landscape	Aesthetic and recreational landscape	Mixed natural-urban landscape	Sustainable urban landscape	Iconic and recreational urban landscape
	Habitat substrate permeability	High permeability	Moderate permeability	Adequate permeability	High permeability	Optimal permeability	Moderate permeability
	Scale of analysis	Regional scale	Local scale	Urban scale	Local and regional scale	Regional scale	Urban scale
Functional	Species diversity, habitat quality, and network robustness	High diversity, excellent quality	Moderate diversity, medium quality	Moderate diversity, good quality	Good diversity, high robustness	High diversity, strong quality, and stability	Moderate diversity, medium quality
	Species density	High density	Medium density	Low density	Medium density	High density	Medium density
	Habitat quality	Excellent	Moderate	Low	Moderate	Excellent	Moderate
	Ecosystem stability	High stability and resilience	Moderate stability	Low stability	Moderate stability	High stability and resilience	Moderate stability
Remote sensing and modeling technologies	Extensive use	Limited use	Minimal use	Moderate use	Extensive use	Not applied	

Rest of Table 5.

Category	Indicator/ Variable	Shanghai Houtan Park	Superkilen Park	Maggie Daley Park	BeltLine Westside Park	Kashiwa-no-ha Smart City Green Park	Ab-o-Atash Park
Social	Community participation	Active community engagement	Broad participation	Limited participation	Considerable participation	Strong civic participation	Strong participation
	Legitimate and inclusive stakeholder representation	Comprehensive representation	Limited representation	Adequate representation	Good representation	Inclusive stakeholder involvement	Limited representation
	Structured participatory techniques	Highly structured methods	Moderate participatory methods	Unstructured processes	Structured participatory methods	Advanced participatory techniques	Absence of a formal participatory process
	Transparent and two-way communication	Clear and effective communication	Limited communication	One-way communication	Two-way communication	Continuous and transparent communication	Limited communication
	Strengthening social capital	High trust and cooperation	Moderate trust	Limited cooperation	Strong social capital	High trust and cooperation	High
	Governmental institutions and public trust	High institutional trust	Moderate trust	Low trust	Acceptable trust	High public and institutional trust	High public and governmental trust
	Quantitative participatory methods (surveys)	Extensive use	Limited use	Minimal use	Moderate use	Extensive use	Extensive use
	Stakeholder diversity in the participation process	High diversity	Moderate diversity	Limited diversity	Adequate diversity	High diversity	High diversity
	Environmental justice	Acceptable equity	Limited equity	Moderate equity	High equity	Strong environmental justice	Moderate equity
	Transparency and continuous interaction	Ongoing interaction	Limited interaction	Low interaction	Active engagement	Transparent and continuous interaction	Limited interaction
Economic	Cost of implementing sustainable landscape management	Moderate	Low	High	Moderate	Moderate	High
	Annual maintenance cost	Low	Low	High	Moderate	Low	Moderate to high
	Short- and long-term economic returns	Positive long-term returns	Moderate short-term returns	Unclear returns	Positive long-term returns	Positive long-term returns	Positive short- and long-term returns
	Cost reduction through forest policies	Effective policies	Limited policies	Weak policies	Effective policies	Optimal policies	Limited urban policies
	Ecosystem service valuation	High value	Moderate value	Moderate value	High value	High value	High value
	Increase in Net Present Value (NPV)	Positive NPV	Positive NPV	Unclear NPV	Positive NPV	Positive NPV	Positive NPV

in implementing a sustainability framework in Iran. The park has performed well in enhancing social interactions and reinforcing symbolic urban capital, particularly through its connection to the Nature Bridge, which has improved social communication quality and fostered a sense of belonging. However, shortcomings in water and rainfall management, lack of modern monitoring technologies, and absence of structured participatory processes indicate that, despite its high physical and social capacities, the environmental dimension has not been fully strengthened. This highlights the need to adapt global frameworks to Iran's climatic and managerial conditions and underscores the importance of implementing genuine stakeholder participation mechanisms in the future.

From a theoretical perspective, the linkage between green landscape design and Transdisciplinary Sustainability Theory (TST) is evident in these projects. By integrating environmental, economic, and social knowledge, this approach aims to define the design process as a dynamic, adaptive, and learning system. Projects like Superkilen Park, which prioritize socio-cultural interactions as the central axis of design, exemplify the practical implementation of this theory, strengthening social capital through inclusive design.

In the field of smart technologies, the application of machine learning and artificial intelligence in landscape monitoring, particularly in Kashiwa-no-ha, represents a forward step. Deep learning algorithms analyzing multi-source sensor and satellite imagery data enable more precise assessment of ecological dynamics and future trend predictions. These technologies serve as tools for adaptive management and responsive environmental design, playing a key role in future-oriented landscape planning.

Economically, the projects were analyzed using bioeconomic models and ecosystem service valuation within multi-criteria valuation frameworks. These frameworks not only assess direct economic value but also consider long-term and indirect impacts of landscape services on public health, social well-being, and sustainable development. For instance, ROI analyses in Maggie Daley Park and BeltLine Westside Park, emphasizing multi-level effects, reflect this comprehensive perspective.

Finally, emphasis on participatory governance and institutional capacity development in green landscape projects indicates that, without robust institutional structures and appropriate legal frameworks, achieving long-term objectives is highly challenging. From this standpoint, BeltLine Westside Park serves as a successful example of integrating public policy, social participation, and landscape design, offering a model for similar projects at urban and metropolitan scales.

In summarizing the discussed topics, Table 6 presents a comparative analysis of key landscape design indicators within the green approach. This table enables a simultaneous assessment of the environmental, social, and economic

dimensions, highlighting the strengths and weaknesses of each project side by side. As observed, in most international projects, the environmental dimension tends to dominate over the social and economic aspects. In contrast, in the Ab-o-Atash Park project, although social indicators such as community participation and social capital are prominent, weaknesses in water resource management and habitat network structure are evident. Therefore, Table 7 not only illustrates the diversity and abundance of indicators across different contexts but also underscores the necessity of revising design patterns and policy-making in Iran to achieve a balanced environmental-social-economic triad. Moreover, the comparative analysis indicates that the proposed framework can bridge the gap between international theories and local conditions, serving especially in Iran as a practical tool for guiding green landscape projects. Accordingly, the findings provide a clear depiction of existing capacities and shortcomings rather than reiterating general principles, thereby laying the groundwork for field testing and future policy development in sustainable landscape design.

The study by Mansouri and Habibi (2011) emphasizes the importance of preserving the natural structure and cultural heritage of urban landscapes. They demonstrated that modifications in planting patterns, a return to organic natural forms, and avoidance of non-native interventions enhance both aesthetic quality and environmental sustainability. These findings confirm the necessity of integrating ecological and social indicators within the framework proposed in this study. In the final analysis, Habibi's (2017) findings on the interconnection among aesthetic-phenomenological, psychological, and ecological approaches can elevate the target-indicator-strategy framework from a technical level to a perceptual and value-based level. Consequently, green landscape design is meaningful not only in improving environmental performance but also in enhancing the sensory and ethical experiences of users. Ghiassae et al. (2019) revealed that in arid climates, landscapes possess an objective-subjective nature and cannot be understood solely from physical or environmental perspectives. This result confirms that transferring global frameworks to Iran requires the development of locally adapted indicators, reflecting climate, cultural perceptions, and social structure—a consideration also embedded in the “target-indicator-strategy” model. Similar to Mansouri and Habibi (2011), it can be concluded that landscape sustainability relies on an approach that integrates local, natural, and cultural values into the policymaking and design process.

However, the main challenge in adapting global frameworks to Iran lies in the lack of stable institutional infrastructure and deficiencies in quantitative data and participatory processes. While the proposed framework represents a step toward localizing these models, its full implementation requires redefining managerial and educational mechanisms at both urban and national levels.

Table 6. Comparative analysis of key sustainable green landscape design indicators in six selected parks based on environmental, social, economic, and environmental performance dimensions (Notes: The colors in the table represent the relative importance or emphasis of each topic within the project. Green shades are divided into five levels, from darkest to lightest: high emphasis (5 - darkest), fairly high (4), medium (3), fairly low (2), and low emphasis (1 - lightest)). Source: Authors.

Indicator Categories		Indicator/Variable	Water and Fire Park	Kashiwa-no-ha Smart City Green Park	BeltLine Westside Park	Maggie Daley Park	Superkilen Park	Shanghai Houtan Park
Environmental	Structural	Native Vegetation Cover	3	4	2	3	2	4
		Habitat Connectivity	4	3	5	2	3	2
		Water Use Management	2	3	2	5	2	3
		Rainfall Management	2	4	3	2	3	2
		Habitat Patch Size	2	4	3	2	3	4
	Distance Between Habitat Patches	2	4	3	2	3	4	
	Shrub Network Structure	2	3	2	5	2	3	
	Landscape Surface Quality	4	5	2	3	2	3	
	Habitat Substrate Permeability	2	3	2	3	2	4	
	Scale of Analysis	2	3	2	3	2	3	
	Species Diversity, Habitat Quality, and Network Robustness	2	3	2	3	2	3	
Functional	Species Density	2	3	2	3	2	3	
	Habitat Quality	2	3	2	3	2	3	
	Ecosystem Stability	2	3	2	3	2	3	
	Remote Sensing and Modeling Technologies	2	3	2	3	2	3	
Social	Community Participation	4	3	2	3	2	3	
	Legitimate and Inclusive Stakeholder Representation	2	3	2	3	2	3	
	Participatory Design Techniques	2	3	2	3	2	3	
	Transparent and Two-Way Communication	2	3	2	3	2	3	
	Strengthening Social Capital	4	3	2	3	2	3	
	Government Institutions and Public Trust	2	3	2	3	2	3	
	Quantitative Participatory Methods (Questionnaires)	4	3	2	3	2	3	
	Diversity of Stakeholders in the Participation Process	2	3	2	3	2	3	
	Environmental Justice	2	3	2	3	2	3	
Transparency and Continuous Interaction	2	3	2	3	2	3		
Economic	Cost of Implementing Sustainable Landscape Management	2	3	2	3	2	3	
	Annual Maintenance Cost	2	3	2	3	2	3	
	Short- and Long-Term Economic Returns	4	3	2	3	2	3	
	Cost Reduction Through Forestry Policies	2	3	2	3	2	3	
	Ecosystem Services Value	4	3	2	3	2	3	
	Increase in Net Present Value (NPV)	4	3	2	3	2	3	

Table 7. Framework of key indicators for green landscape design Source: Authors.

Dimension	Assessment Indicators	Priority	Design Goals	Implementation Strategies
Environmental (Structural)	Native vegetation cover	Very high	Ecological	Use native and resilient species, maintain biodiversity, and avoid invasive plants.
	Habitat connectivity	Very high	Ecological	Reduce fragmentation, create wildlife corridors, and enhance ecosystem stability.
	Water use and rainfall management	High	Ecological & Economic	Apply water recycling and stormwater management systems, and prevent soil erosion.
	Habitat patch size and distance	High	Ecological	Maintain large, cohesive patches and minimize gaps for species mobility
	Landscape matrix quality & soil permeability	High	Ecological	Design permeable surfaces for stormwater absorption and soil health
Environmental (Performance)	Species density and diversity	Very high	Ecological	Enhance species richness for ecosystem health and resilience
	Habitat quality and stability	Very high	Ecological	Improve ecosystem durability against climate and human pressures
	Remote sensing and modeling technologies	High	Ecological & Managerial	Use real-time data and predictive analytics for adaptive management
Social	Active community and stakeholder participation	Very high	Social	Balance power, ensure inclusivity, and maintain long-term commitment
	Transparent two-way communication	Very high	Social	Create continuous communication channels, enhance trust and knowledge
	Stakeholder diversity and environmental justice	High	Social	Ensure equitable access to landscape benefits for all groups
	Effective participatory methods (quantitative & qualitative)	High	Social	Prevent participant fatigue, integrate multiple engagement methods
Economic	Implementation cost of sustainable management	High	Economic	Plan for upfront investment, assess long-term ROI
	Annual maintenance cost	High	Economic	Reduce costs via native plants and smart maintenance technologies
	Ecosystem service value & positive NPV	Very high	Economic & Ecological	Quantify ecosystem benefits, link to real estate, and life quality
	Optimized forestry policies & circular economy	High	Economic	Encourage resource reuse, minimize waste, and promote policy support

Conclusion

This study aimed to address the existing gap in the literature on green landscape design by proposing a comprehensive, indicator-based framework for assessing landscape sustainability. The findings indicated that, although global frameworks such as LSA, LEED, SITES, and BREEAM provide significant achievements in environmental and economic assessment, none of them simultaneously and quantitatively cover the environmental, social, and economic dimensions at the landscape design level. Therefore, the main innovation of this research lies in the inductive integration of indicators from both the literature and real-world projects, coherently structured through a deductive approach based on global frameworks and localized for Iranian conditions. This approach resulted in a structured, context-sensitive, and adaptable model suitable for diverse climatic and social settings. Unlike existing frameworks (e.g., MEA/TEEB, SITES, LSA), the present model not only aggregates indicators but also provides a dynamic structure linking objectives, indicators, and strategies, with clear potential for localization in Iran.

The results demonstrated that the success of green landscape design is only achievable through systematic and coordinated convergence of ecological, social, and economic components. Such convergence must rely on scientific data and active stakeholder participation to develop dynamic, Resiliency, and responsive design frameworks. Furthermore, understanding the multi-layered complexities of landscapes fosters participatory governance and green economy practices. The proposed framework, through the expansion of the objective–indicator–strategy chain, attempts to reflect local, natural, and cultural values in a systematic structure.

Incorporating Tehran's Ab-o-Atash Park alongside international cases revealed that the proposed framework is not only effective in analyzing prominent global projects but also in assessing the strengths and weaknesses of Iranian projects. In this park, social indicators such as community participation and social capital are prominent, whereas shortcomings exist in water resource management and habitat connectivity, highlighting the need to reconsider local design patterns and policymaking. Beyond its analytical function, this framework can serve as a strategic tool for

decision-making at the levels of design, urban management, and environmental policy. The study also has limitations, including reliance on secondary data, a limited number of case studies, and the absence of direct interaction with stakeholders. To overcome these limitations, future research is recommended to employ field-based and participatory methods (e.g., surveys, interviews, and interactive workshops) to enhance the validity and operational applicability of the framework. Overall, the primary contribution of this study is the development of a multidimensional, indicator-based, and locally adaptable model that can improve the quality of landscape design in Iran and other developing countries. By enabling simultaneous

quantitative and qualitative assessment of the three dimensions, this model serves as a launching point for future research and as an effective tool in achieving sustainable development goals. It is recommended that future studies focus on developing field-based tools for indicator measurement and localized data-driven evaluations to operationally test and assess the framework in real projects, thereby providing opportunities for its refinement and updating.

Declaration of No Conflict of Interest

The authors declare that they have no conflict of interest in conducting this research.

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