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RESEARCH ARTICLE

Land management criteria for green building certification systems in Turkey

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Abstract
The issue of energy holds significant implications for nations heavily reliant on it, such as Turkey. In recent times, legislative measures, including the Energy Efficiency Law and the Energy Performance Regulation of Buildings, have been enacted in Turkey. Despite the implementation of the Energy Performance Certificate for buildings, the absence of a national green building certification system remains conspicuous. To address this gap, an examination of globally recognized certification systems and relevant components concerning land management, pertinent to Turkey's context, was undertaken. This involved a comprehensive literature review to establish the foundation for survey inquiries. Subsequently, interviews were conducted with subject matter experts in Turkey to glean valuable insights and perspectives. Utilizing the Analytic Hierarchy Process (AHP) methodology, the responses from these experts were collated and analyzed to delineate the criteria and sub-criteria germane to land management. This study delves into the discourse surrounding the establishment of a green building certification system within Turkey, specifically within the domain of land management, a sector of paramount importance, particularly within the purview of survey engineering. Through a structured survey, the criteria pertinent to land management were identified and subjected to rigorous analysis. Furthermore, the sub-criteria within the land management category were delineated, and their respective weights were computed, thereby providing a comprehensive framework for the envisioned green building certification system in Turkey.

Keywords Energy · Sustainability · Green building · Green building certification systems

Introduction

In Europe during the eighteenth and nineteenth centuries, the advent of transformative inventions like steam-powered machinery revolutionized industrial capabilities, enabling increased agricultural productivity and consequently fostering urbanization, population growth, and diverse employment opportunities across various industrial sectors (Tokat 2010; Akgül 2010; İnanç 2010).

Following the devastation wrought by the Second World War, concerted efforts aimed at reconstruction and economic recovery inadvertently catalyzed unchecked urban expansion, exacerbating waste management challenges. While waste accumulation was historically manageable, its unchecked proliferation has escalated over time, posing a significant threat to the global ecosystem (Harris 2000; Sırkıntı 2012).

The late nineteenth and early twentieth centuries witnessed remarkable strides in technological advancement, particularly in information and communication infrastructure, facilitating ubiquitous access to data and information regardless of temporal or spatial constraints. This unprecedented accessibility underscored the extent of human-induced ecological degradation, prompting a concerted response from Non-Governmental Organizations (NGOs) and world leaders. International agreements such as the Montreal Protocol, Kyoto Protocol, and Stockholm Convention were forged to address issues ranging from air and water pollution to soil and radioactive contamination, signaling

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a collective commitment to environmental stewardship. In contemporary times, there has been a notable escalation in environmental awareness, leading to the emergence of environmentally conscious architectural practices within the construction industry. Termed as "green buildings," these structures are meticulously crafted with design principles aimed at minimizing energy and water consumption, while also mitigating the environmental impact of construction materials throughout their life cycles. The advent of green buildings has undoubtedly constituted a crucial component of the collective response to the escalating challenges posed by the intensifying phenomena of global warming and climate change.

However, while the proliferation of green buildings has yielded commendable environmental benefits, ensuring the authenticity and efficacy of these initiatives necessitates stringent oversight mechanisms. Hence, the imperative for certification systems becomes evident. Certification systems serve as indispensable tools for verifying compliance with established environmental standards and best practices, thereby ensuring that the purported benefits of green buildings are substantiated and realized in a controlled and accountable manner (Yıldırım 2014; Sırkıntı 2012).

The transition towards green buildings has evolved from being perceived as a luxury to being recognized as a fundamental necessity, owing to their profound impact on both human health and the broader environment. As green buildings are required to adhere to specific standards to deliver benefits across environmental, social, and economic dimensions, the emergence of certification systems has become imperative to ascertain the fulfillment of green credentials.

Green building qualifications serve as the foundational framework for various certification programs, categorizing environmental considerations into relevant domains (Hou and Wu 2021; Sartori et al. 2021). These certification systems play a pivotal role in overseeing the construction process, commencing from the design phase, and subsequently evaluating the green performance of buildings by assigning scores to predefined parameters.

Across the globe, diverse countries have embraced distinct certification systems tailored to their unique contexts. Notable examples include the Building Research Establishment Environmental Assessment Method (BREEAM) in the UK, Leadership in Energy and Environmental Design (LEED) in the USA, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan, and the Green Star Certification system in Australia (Olubunmi et al. 2016; Shan and Hwang 2018; He et al. 2018). In instances where countries lack indigenous certification frameworks, they often adopt and adapt existing systems from other nations to suit their specific needs and regulatory environments.

Problems such as global warming, depletion of natural resources, and climate change have put countries in a difficult situation of having to address multiple challenges. Against this backdrop, the imperative for green buildings—structures that generate their own energy, incorporate wastewater management systems, and prioritize sustainability, comfort, and efficiency—has become increasingly pronounced. Numerous countries have implemented diverse green building certification systems to assess the environmental performance of such structures. However, Turkey currently lacks a national certification system for green buildings, necessitating reliance on foreign frameworks for evaluation. This approach often fails to yield contextually relevant outcomes tailored to Turkey's unique environmental and socio-economic landscape.

In light of this disparity, the development of a national certification system for green buildings in Turkey has emerged as an urgent imperative. This paper seeks to bridge this research gap by addressing the following key research questions:

(1) What are the intrinsic advantages associated with green building technology?
(2) To what extent does land selection contribute to the effectiveness of green buildings?
(3) What criteria should be prioritized when selecting land for the construction of green buildings?
(4) How do regional variations impact the efficacy of the green building certification system?

By exploring these questions, this study aims to provide comprehensive insights into the benefits of green building technology, the significance of land selection, and the requisite criteria for land assessment in green building endeavors. Additionally, it seeks to evaluate the impact of regional disparities on the efficacy of green building certification systems, thereby facilitating the development of contextually appropriate solutions tailored to Turkey's specific needs and circumstances.

The overarching goal of green building technologies is to safeguard the environment and natural resources, mitigate the impacts of climate change, and remediate past environmental degradation. By prioritizing human health, minimizing costs, mitigating secondary pollutants, and promoting the utilization of renewable energy sources and materials, these technologies represent a significant stride towards fostering healthier and more sustainable living environments. In the context of Turkey, efforts are directed towards fostering a culture of conscientious resource utilization, reducing environmental pollution, and instilling awareness regarding the adoption of sound energy policies, thereby promoting the well-being of current and future generations.

This study holds particular significance for Turkey as it marks the pioneering exploration into the domain of land management within the context of green building certification systems. Land management, encompassing a spectrum of policies and practices aimed at efficient resource utilization, environmental protection, and sustainable urban development, has emerged as a pivotal sub-criterion across various international certification frameworks. Yet, its prominence within Turkey's regulatory landscape is nascent, necessitating focused attention and research.

The central focus of this study is to delineate the criteria under the rubric of "land management" within the context of green building certification systems, an aspect increasingly acknowledged within both foreign and domestic jurisdictions. By delving into the nuances of land management, this study aims to propose a comprehensive certification framework tailored to Turkey's unique socio-economic and environmental landscape. Moreover, the study seeks to identify sub-criteria pertinent to the proposed certification system and subsequently determine their respective weights through empirical investigation.

A critical facet of green building projects is land selection, encompassing a gamut of activities ranging from land use planning to zoning regulations and infrastructure development. While global research has predominantly focused on material utilization, renewable energy integration, and waste management within green building projects, scant attention has been afforded to land management practices. This study endeavors to rectify this disparity by shedding light on the significance of land management and advocating for the establishment of a dedicated certification system in Turkey.

Ultimately, this study underscores the multifaceted benefits of green buildings and certification systems, not only in terms of environmental conservation but also in bolstering economic growth and enhancing societal well-being. Furthermore, it reiterates the urgent need for the establishment of a national certification system tailored to Turkey's unique environmental and socio-economic imperatives. Through its comprehensive exploration of land management principles and proposed certification frameworks, this study lays the groundwork for future research endeavors and policy initiatives aimed at promoting sustainable development in Turkey.

Sustainability

Our world has thrived within a delicate balance of intricate cycles for billions of years, sustaining diverse ecosystems and life forms. However, over the past three decades, several of these equilibrium states have deteriorated alarmingly, precipitating visible climatic shifts, seasonal variations, and ecological degradation. The escalation of global greenhouse gas emissions has catalyzed a myriad of challenges, including pervasive issues like global warming and energy scarcity, prompting a global awakening towards green and sustainable development practices. Consequently, sustainability has emerged as a pervasive concept, with scholars and scientists from diverse disciplines endeavoring to explore and devise solutions to address these pressing environmental concerns (Kaya 2021; Costanza and Patten 1995; Ignatius et al. 2016; Jorgenson et al. 2019; Shafique et al. 2018).

The demographic landscape has undergone a seismic transformation since the Industrial Revolution, with urban populations surging from a mere 10% of the global populace in the early nineteenth century to over 50% today. This unprecedented urbanization wave, fueled by rural-to-urban migration, has engendered rapid, haphazard urban expansion characterized by substandard infrastructure, exacerbating environmental woes. Concomitant issues such as dwindling natural resources, ecological imbalance, and the specter of global warming, underscored by a spate of recent natural disasters, have assumed critical significance on the global stage, confronting nations with the formidable challenge of navigating a rapidly evolving world. The UN International Strategy for Disaster Reduction has identified cities as increasingly vulnerable to a spectrum of natural calamities, including droughts, floods, heatwaves, and extreme precipitation events (McPhillips et al. 2018).

Sustainability represents an environmental ethos advocating for regional development predicated on the preservation of nature's balance and judicious utilization of environmental resources. It advocates for an equitable and judicious approach to resource utilization, mindful of the needs of present and future generations, while simultaneously fostering economic prosperity (Keleş 1998). Additionally, sustainability embodies the notion of maintaining ecological functions, processes, and productivity for future generations, ensuring the resilience and longevity of ecological systems (Pamuk and Kuruoğlu 2016). Moreover, sustainability endeavors to promote social equity, enhance quality of life, and optimize economic efficiency, all while preserving and enhancing environmental quality (Akgül 2010; Mileti 1999; Komeily and Srinivasan 2015; Lazar and Chithra 2021).

In the realm of energy consumption, sustainability entails a conscientious approach to resource utilization, emphasizing the importance of protecting energy reservoirs, employing them judiciously, and considering the needs of future generations (Yılmaz 2019). By integrating sustainability principles into energy management practices, societies can foster greater sensitivity towards energy conservation and efficiency, thereby fostering a more sustainable energy future.

Green buildings

The relentless urbanization witnessed in developing nations alongside the burgeoning building construction industry worldwide has precipitated a surge in global energy consumption, thereby unsettling the delicate balance of the natural environment. This heightened awareness has underscored the imperative of sustainable and healthy development practices (Cordero et al. 2019; Li et al. 2019a; Berardi 2017). At the heart of this existential crisis lies the pervasive issue of global warming, primarily driven by the exponential increase in atmospheric CO_2 levels. While direct emissions from production processes play a significant role in exacerbating this crisis, indirect emissions stemming from energy-intensive production methods must also be considered. Remarkably, the construction sector alone accounts for a staggering 36% of global energy consumption and 39% of global CO_2 emissions (He et al. 2018, Sartori et al. 2021; Doan et al. 2017), cementing its status as a primary contributor to environmental degradation. The construction industry, being the principal consumer of natural resources, has precipitated myriad environmental and ecological challenges (Thakur et al. 2018; Shan et al. 2020), thereby thrusting green buildings into the spotlight as a beacon of sustainable development within the construction sector (Wang et al. 2021a, b; Liao and Lin 2022).

According to the World Green Building Council (WorldGBC), a green building is one that engenders positive impacts throughout its entire lifecycle—from design and construction to operation—while mitigating negative impacts on the climate and natural environment (WorldGBC). As environmental concerns garner increasing attention, buildings are increasingly designed to incorporate principles of environmental protection and sustainability (Meng et al. 2021). Green buildings not only foster harmonious integration with nature but also prioritize the health of occupants, enhance worker productivity, promote efficient resource utilization, and minimize environmental degradation. Key strategies for achieving these objectives include harnessing renewable energy sources like solar and wind energy, optimizing daylight utilization, implementing effective thermal insulation, establishing robust solid waste management systems, and utilizing locally sourced materials to imbue structures with an environmentally friendly esthetic (WorldGBC). Beyond energy efficiency and emission reduction, green building initiatives also encompass economic and social sustainability considerations, playing a pivotal role in fostering global economic green development while garnering significant attention from governmental bodies and industry experts (Wang et al. 2021a, b; Chan et al. 2017; Lopez-Behar et al. 2019; Shen et al. 2017). Recognized as a crucial step towards enhancing the sustainability of the construction industry, green buildings have garnered widespread governmental support and policy initiatives worldwide (Shen et al. 2017; Li et al. 2021). Notably, countries like the USA, England, Singapore, Hong Kong, Australia, and Italy have taken significant strides in promoting green building practices (Darko and Chan 2016; Rajabi et al. 2021).

While terms like green building, high-performance building, and sustainable building are often used interchangeably, they encapsulate nuanced distinctions. Green building emphasizes user health, comfort, and sustainable resource utilization during construction, while high-performance building focuses on structural performance aspects such as thermal efficiency, acoustics, and lighting, which directly impact user well-being and productivity. In contrast, sustainable building represents the most comprehensive paradigm, encompassing environmental, economic, and social dimensions of sustainable development (Kaya 2021) (Figs. 1 and 2).

Green buildings are costly to maintain from construction to demolition and most costs lie in the design and construction stages (Olubunmi et al. 2016). The design for new buildings should be optimized to realize green buildings. The design process can be complex and involve many design variables as well as multiple and conflicting objectives in terms of lifecycle costs, energy consumption, and user satisfaction (Zhang et al. 2019).

Green building certification systems

In recent times, there has been a growing recognition of the need for comprehensive approaches to sustainability that address all facets of development in order to yield successful outcomes (Ameen et al. 2015). Understanding the profound impact of change and transformation on global sustainability, leaders in the construction industry have spearheaded various initiatives, including revisions to building codes and the establishment of Green Building Councils (GBCs). GBCs, dedicated to incentivizing stakeholders within the sector to produce buildings that surpass regulatory requirements in terms of performance, have played a pivotal role in fostering the adoption and proliferation of green building certification systems (Ade and Rehm 2019a).

The emergence of Green Building Certification Councils (GBCCs) around the world since the early 1990s has garnered significant attention from researchers across diverse fields, leading to a surge in academic inquiries over the past decade (Darko and Chan 2016; Lazar and Chithra 2020; Li et al. 2017; Doan et al. 2017). Green building certification systems have been specifically devised to offer a framework for building design and construction that ensures compliance with performance targets related to land use, energy and water efficiency, indoor quality of life, and other pertinent factors. These systems provide a verifiable method

	Functionality	Energetic Quality	Use of Resources	Impact on the Environment	Health and Comfort	Construction and Operating Costs	Yield	Value: Stability and Trend
Low-energy/Passive House		X						
Carbon Neutral Building		X		X				
Green Building		X	X	X	X			
High Performance Building	X	X			X			
Sustainable Building	X	X	X	X	X	X	X	X

Fig. 1 Characteristics of green buildings and sustainable buildings (Reed et al. 2017; Kaya 2021)

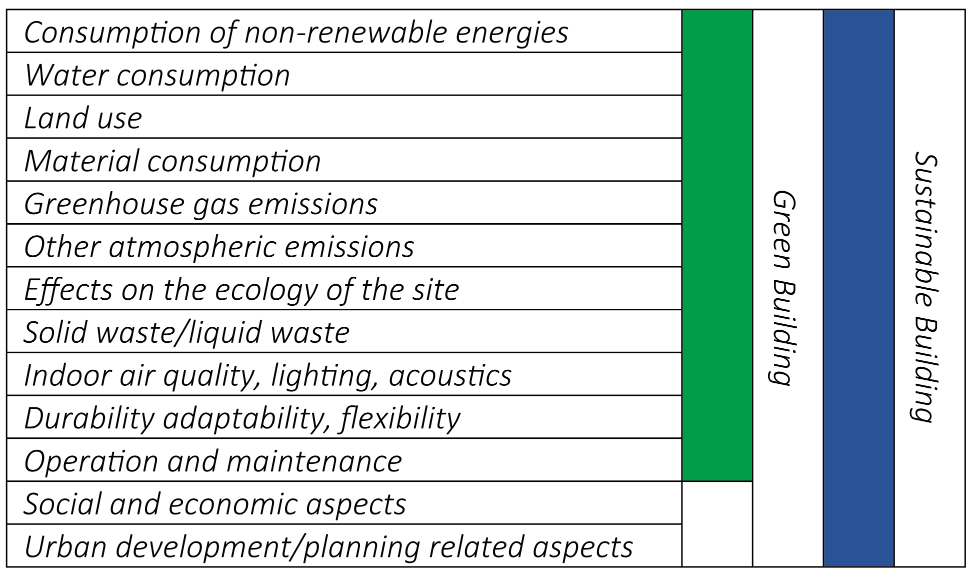

Fig. 2 Comparison between green buildings and sustainable buildings (Reed et al. 2017; Kaya 2021)

and framework to facilitate the sustainable design, construction, renovation, and management of buildings, certifying adherence to performance goals and validating the strategies employed throughout the construction process (National Research Council of The National Academies 2013).

Several green building certification systems are currently in use worldwide, with the pioneering system being the Building Research Establishment Environmental Assessment Method (BREEAM), introduced by the Building Research Establishment (BRE) in 1990 (Ade and Rehm 2019b). In addition to BREEAM in the UK and LEED in the USA, other prominent certification systems include Canada's Sustainable Building Tool (SBTOOL), recognized internationally; HKBEAM and CEPAS in Hong Kong; GREEN STAR in Australia; and CASBEE in Japan. These certification systems play a vital role in promoting sustainable building practices on a global scale, fostering environmental stewardship and advancing the principles of sustainable development within the construction industry.

Material and method

In this study, a survey was conducted to highlight the importance of the category of land management, one of the criteria of the green building certification systems, and to identify sub-criteria under this title more objectively. Worldwide valid certification systems and parts of the certification systems regarding land management that are tried to be established in Turkey were examined to determine the survey questions, and in line with this, a literature review was performed. A comprehensive array of criteria was derived from the responses obtained through questionnaire inquiries. Subsequently, by considering these criteria alongside the specific domain of investigation, experts were engaged in interviews to further refine and finalize the selection of specific criteria. The experts in Turkey were interviewed to gather ideas and insights. By listing the answers from these experts using the AHP method, the criteria and sub-criteria of the land method were determined and are shown in Table 1.

The Analytic Hierarchy Process (AHP) provides a structured and methodical approach for addressing decision-making problems by delineating, measuring, and interrelating various elements within the decision framework (Saaty 1980; Li et al. 2019b). This method employs a hierarchical structure comprising goals, criteria, sub-criteria, and alternatives, allowing decision-makers to assign weights to these elements based on their preferences elicited through pairwise comparisons. Subsequently, these weights are aggregated into holistic priorities using a linear-additive model, facilitating the ranking of alternatives based on their priority values (Çınar 2004).

Importantly, AHP does not advocate for a rigid decision-making methodology; instead, it empowers decision-makers to leverage their own expertise and insights, thereby facilitating informed decision-making processes (Çelikyay 2002).

AHP application consists of five steps (Çelikyay 2002; Canada et al. 1996):

(i) Structuring decision hierarchy,
(ii) Collecting data with one-to-one comparisons,
(iii) Checking the consistency of objective judgements,
(iv) Using the eigenvector method to calculate weights, and
(v) Combining weights to determine the order of decision alternatives.

The hierarchical structure inherent to AHP serves as an effective tool for managing complexity within decision-making systems, facilitating organization, information control, and communication. This functional versatility renders AHP a valuable instrument for addressing multifaceted decision problems (Topcu 2000). Figure 3 illustrates a simplified AHP model, depicting the hierarchical arrangement of decision elements and their interrelationships.

Criteria that make up the hierarchy is scored according to a certain scale through binary comparisons. Table 2 shows the rating scale used in AHP.

The survey questions were meticulously crafted in alignment with the identified criteria, and they were distributed to a cohort of 3270 instructors across all architecture, urban and regional planning, and civil engineering departments in Turkey. Out of this pool, 148 respondents provided meaningful insights. Given the nascent prominence of green building concepts and

Table 1 The criteria established through a comprehensive review of relevant literature were subsequently reinforced by expert opinions, thus enhancing the robustness of the research findings

B. Building features
B1. Being functional
B2. Project design
B3. Establish health and comfort
B4. Appropriate to urban esthetics
B5. Being environment friendly
B6. Being energy efficient
B7. Providing water-saving
B8. Having waste management
B9. Using renewable energy
B10. Having material management
B11. Being economical
B12. Using recycled material
B13. Being innovative
E. Protection of ecological values and properties of the land
E1. Protection of underground and surface waters
E2. Protection of biodiversity
E3. Protection of wetlands and coastal regions
E4. Reuse of the land
A. Land properties
A1. Ambient air quality
A2. Solar energy potential
A3. Renewable energy source potential
A4. Land constraints
A5. Ecological structure of the region
A6. Climate conditions of the region
A7. Wind energy potential
A8. Cultural heritage of the region
A9. Topography of the land
A10. Geological structure of the land
A11. Geothermal energy potential
A12. Zoning status of the land
A13.Demographic structure of the region
A14. Market value
K. Proximity to urban equipment and transportation networks
K1. Proximity to bicycle roads and sport areas
K2. Proximity to metro and light rail systems
K3. Proximity to rest and recreation areas
K4. Proximity to public service areas
K5. Proximity to commercial facilities and living centers
K6. Proximity to health and personal care facilities
K7. Proximity to culture and art centers
R. Identification of risks
R1. Natural disaster risk
R2. Risk of human disaster
R3. Security
R4. Proximity to garbage collection points
R5. Proximity to treatment plants
R6. Proximity to animal shelters

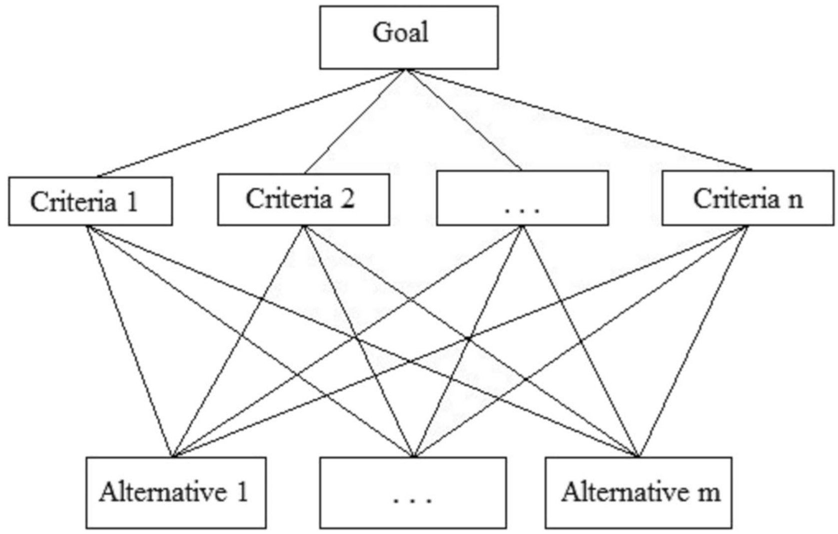

Fig. 3 A simple AHP model (Saaty 1980)

Table 2 AHP rating scales

Level of importance	Definition	Interpretation
1	Equally preferred	Two activities contribute equally to the objective
3	Moderately	Experience and judgment slightly favor one activity over another
5	Strongly	Experience and judgment strongly or essentially favor one activity over another
7	Very strongly	An activity is strongly favored over another and its dominance demonstrated in practice
9	Extremely	The evidence favoring one activity over another is of the highest degree possible for affirmation
2,4,6,8…	Intermediate values	Used to represent a compromise between preferences listed above

certification systems in Turkey, the pool of instructors capable of offering informed responses was relatively limited.

Recognizing the imperative of imbuing land management with a societal dimension, efforts were made to delineate the requisites of factors shaping the demographic fabric of society and the standards requisite for a high quality of life. This endeavor aimed at fostering social equity by striking a balance among social norms. To this end, two distinct survey methodologies were employed to gauge national needs, ascertain the level of awareness regarding green buildings, and discern criteria pertinent to land management.

The first survey, conducted employing the Delphi technique—a systematic information gathering method—aimed to evaluate specific questions or issues. However, the survey could not be concluded due to the paucity of specialists in the field and the reluctance of competing specialist groups to share information. Subsequently, a second survey was conducted, wherein participants were tasked with assigning scores ranging from 1 to 5 to survey questions formulated based on criteria gleaned from the literature. The weights of these criteria were then computed based on the collected data.

The frequencies and percentages of responses to the survey questions, categorized into five distinct levels of importance—ranging from unimportant to very important—were utilized to ascertain the weights of sub-criteria within the category of land management. Subsequent steps involved calculating the averages and standard deviations of the responses, facilitating the sorting of main criteria and sub-criteria based on their respective weights. Within this scope, averages and standard deviations were calculated as follows:

$$K_{\mathrm{o}} = \frac{N}{n} \tag{1}$$

K_o = criteria mean.

N= the total of scores given by the participants to the relevant criteria.

n= the number of participants.

The standard deviation is calculated by taking the square root of the variance.

$$\mathrm{S} = \sqrt{\frac{\sum (N_{\mathrm{i}} - K_{\mathrm{o}})^2}{n-1}} \tag{2}$$

S= standard deviation.

N_i= the score given by participant to the i question.

K_o= criteria mean.

n = number of participants.

The calculated mean, standard deviation, weight, and sorting are shown in Table 3. The main criteria for sorting

Table 3 Mean, standard deviation, sorting, scoring, and paired comparison methods of survey data

Main criterion	Sub-criterion (order)	Mean	Standard deviation	Main criterion weight	Sorting method	Scoring method	Paired comparison method
Building features	Being economical (11)	4.1689	0.81973	4.4563	0.3333333	0.3846154	0.3599995
	Being functional (1)	4.8311	0.41055				
	Appropriate to urban esthetics (4)	4.6486	0.59321				
	Being environment friendly (5)	4.6284	0.60923				
	Using recycled material (12)	3.9932	0.95829				
	Being innovative (13)	3.8446	0.98777				
	Being energy efficient (6)	4.6149	0.6072				
	Providing water-saving (7)	4.5541	0.6312				
	Having waste management (8)	4.4459	0.78492				
	Project design (2)	4.7838	0.50225				
	Using renewable energy (9)	4.4257	0.72928				
	Having material management (10)	4.2095	0.8186				
	Establish health and comfort (3)	4.7568	0.51668				
Protection of ecological values and properties of land	Reuse of land (4)	4.2973	0.88417	4.3851	0.2666667	0.2692308	0.2800010
	Protection of wetlands and coastal regions (3)	4.3784	0.88376				
	Protection of biodiversity (2)	3.3851	0.87694				
	Protection of underground and surface waters (1)	4.4797	0.82865				
Land features	Land constraints (5)	4.3581	0.83308	4.0589	0.2	0.1923077	0.2000049
	Renewable energy source potential (4)	4.3581	0.76497				
	Ambient air quality (1)	4.6622	0.62329				
	Market value (14)	3.2838	1.18402				
	Zoning status of the land (12)	3.7297	1.12845				
	Topography of the land (9)	3.9392	1.17355				
	Geological structure of the land (10)	3.9257	1.05683				
	Climate conditions of the region (6)	4.3041	0.98048				
	Cultural heritage of the region (8)	4.0338	1.13937				
	Demographic structure of the region (13)	3.4595	1.13316				
	Ecological structure of the region (3)	4.3243	0.92004				
	Solar energy potential (2)	4.4595	0.86801				
	Wind energy potential (7)	4.1622	1.01723				
	Geothermal energy potent (11)	3.8243	1.10482				

Table 3 (continued)

Main criterion	Sub-criterion (order)	Mean	Standard deviation	Main criterion weight	Sorting method	Scoring method	Paired comparison method
Proximity to urban equipment transportation networks	Proximity to public service areas (6)	3.3243	1.26822	3.6108	0.1333333	0.1153846	0.1199992
	Proximity to metro and light rail systems (4)	3.9122	1.15428				
	Proximity to rest and recreation areas (5)	3.5135	1.18084				
	Proximity to bicycle roads and sport areas (3)	3.9865	1.03655				
	Proximity to commercial facilities and living centers (7)	3.3176	1.07562				
	Proximity to culture and art centers (1)	4.4932	0.90724				
	Proximity to health and personal care facilities (2)	4.3378	1.05337				
Identification of risks	Natural disaster risk (1)	3.8108	1.32661	3.3345	0.0666667	0.0384615	0.0400008
	Risk of human disaster (5)	2.7838	1.18115				
	security (3)	2.8649	1.14671				
	Proximity to garbage collection points (2)	3.2568	1.28371				
	Proximity to animal shelters (6)	2.277	1.12981				
	Proximity to treatment plants (4)	2.8514	1.37205				

according to calculated weights were found to be building features, protection of ecological values and properties, land properties, proximity to urban equipment and transportation networks, and identification of risks. The weight of the main criterion building features was calculated as 4.4543, that of protection of ecological values and properties of land as 4.3851, that of land properties as 4.0589, that of proximity to urban equipment and transportation networks as 3.3861, and that of identification of risks as 3.5045. The sub-criteria were also aligned by their own weights.

The percentages of the 5 different responses (not important, less important, moderately important, important, very important) given to the questionnaire were calculated to be used to determine the weight of the criteria and sub-criteria of land management.

The percentage of each sub-criterion within all criteria is calculated as follows:

$$K_i = \left(\frac{n_i}{\sum n_i}\right) * 100 \tag{3}$$

K_i: I. percentage of criterion.
n_i:I. average of criterion.

Results and discussions

The exponential rise in global population has precipitated a slew of environmental challenges, including waste management crises, climate change, depletion of natural resources, and biodiversity loss. While waste management posed minimal societal threats in the past, its accumulation has burgeoned over time, now posing existential risks to the global ecosystem. Environmental advocates have thus championed the notion of sustainability, which has been adopted across various domains, notably within the construction sector, under the auspices of sustainable development principles.

The staggering statistic that buildings account for 40% of overall energy consumption has galvanized the construction industry towards adopting more sustainable and eco-friendly practices, giving rise to the concept of green buildings. As green building initiatives gained traction, corresponding certification systems were devised to assess the environmental footprint of such structures and to document their energy efficiency credentials.

Among the myriad criteria evaluated by green building certification systems, land management emerges as a focal point. A comprehensive understanding and application of this concept within green building projects are imperative for their success. Effective land management entails integrating social, economic, and ecological components within the sustainable development framework.

In order to imbue land management with an economic dimension, it is essential to devise systems tailored to socio-economic structures, thereby optimizing efficiency while mitigating costs. This entails harnessing recycled materials, promoting energy efficiency, leveraging renewable energy sources, and managing materials judiciously to strike a harmonious balance between economic imperatives and environmental stewardship.

Land management strategies aimed at preserving biodiversity, wetlands, and coastal areas are pivotal in upholding ecological integrity and curbing environmental degradation. Criteria pertaining to ambient air quality, waste management, and protection of water bodies further augment the ecological dimension of land management frameworks.

The burgeoning significance of green buildings and certification systems both globally and within Turkey has catalyzed a series of meetings and seminars aimed at fostering awareness and innovation since 2012. The annual Green Buildings Summit, inaugurated in 2012 and recurrent ever since, serves as a barometer of Turkey's evolving consciousness regarding green construction practices. The inaugural summit, in particular, spotlighted urban transformation and sustainability as pivotal themes, resonating the prevailing sentiment that green buildings have transcended luxury to become an imperative of modern living. A pivotal declaration at the summit underscored the imperative for green building projects to be integral to urban revitalization efforts, notably emphasizing energy efficiency in the transformation of informal settlements, with a directive to repurpose structurally sound dwellings. Moreover, the summit underscored the economic parity between green and conventional building costs, accentuating the substantial savings and economic benefits afforded by green constructions, advocating for legislative support for green housing certifications.

Subsequent iterations of the International Green Buildings Summit have delved deeper into the symbiotic relationship between green transformations and the resolution of environmental, economic, and societal challenges. The 2013 summit underscored the imperative of public engagement in green initiatives, particularly emphasizing energy efficiency retrofits in existing buildings as a pathway to amplified savings. Similarly, the 2014 summit echoed the ethos of sustainability and livability as linchpins of urban metamorphosis, advocating for behavioral shifts as prerequisites for realizing sustainability goals.

The 2016 Green Building Summit pivoted its focus to sustainable efficiency and building management, accentuating the inexorable trajectory towards energy efficiency. Deliberations at the summit underscored the pivotal role of building management in cost optimization, advocating for universal adoption of energy-saving practices across generations.

The formulation of criteria for land management was informed by the resolutions emanating from these summits, expert opinions, and local imperatives within Turkey. Drawing insights from the land-related components of esteemed certification systems such as BREEAM, LEED, SBTOOL, and ÇEDBİK, the sub-criteria for land management were meticulously delineated to encompass building features, preservation of ecological integrity, land attributes, urban connectivity, and risk identification. Subsequently, survey questions were crafted and disseminated among instructors specializing in green building certification systems, with responses subjected to rigorous analysis using the SPSS program. The reliability of the survey was validated through a Cronbach Alpha test, affirming its robustness. As a result of this analysis, the Cronbach Alpha value was found to be 0.921. Further analysis employing sorting, scoring, and paired comparison methodologies facilitated the assignment of weights to criteria, with functional viability emerging as a salient sub-criterion within the building features domain.

While green buildings aim to create healthy and comfortable environments for inhabitants, their design and implementation must be tailored to the specific needs and conditions of individual countries. Given the diverse growth levels and geographical landscapes across nations, green buildings are customized to address each country's unique priorities. For instance, in China, green buildings are primarily focused on reducing pollution across their entire lifecycle while conserving vital resources such as energy, soil, water, and materials. The escalating concerns over air pollution and global warming in recent years have fueled a rapid expansion of green building construction worldwide. In 2015 alone, numerous national or regional temperature records were shattered, exacerbating heat-related fatalities in countries like France and India. These alarming trends underscore the urgent need for decisive action, further underscoring the imperative of green building initiatives.

The effectiveness of green building concepts hinges on their alignment with the needs of local communities and the prevailing environmental conditions. To this end, a survey was conducted in collaboration with experts to glean insights into key considerations. Notably, the dwindling availability of water resources is a global trend observed not only in Turkey but also across the world. Consequently, the most crucial criterion under the "Protection of Ecological Value and Properties of the Land" category is identified as the safeguarding of underground and surface water sources.

Moreover, given Turkey's location along the North Anatolian Fault Line, the region is predisposed to heightened seismic activity, thereby elevating the risk of natural disasters. Consequently, the paramount criterion within the risk assessment framework pertains to mitigating the impact of natural calamities. By prioritizing these criteria and tailoring green building strategies to local circumstances, it becomes possible to maximize the efficacy and resilience of green building initiatives, ensuring their alignment with broader environmental and societal objectives.

Conclusions and suggestions

The burgeoning presence of green buildings in Turkey necessitates the development of a localized certification system to accurately assess their attributes. Consequently, various working groups have endeavored to formulate distinct certification frameworks tailored to the Turkish context. Among the crucial categories for inclusion in such a national certification system is land management, which was the focal point of this study. Through a meticulous literature review, the criteria under this category were identified as building features, protection of ecological values and land properties, land characteristics, proximity to urban amenities and transportation networks, and risk identification. Subsequently, survey studies were conducted to determine the sub-criteria and their respective weights within each category, employing sorting, scoring, and paired comparison methodologies.

In line with the findings of this study, the primary criterion of utmost importance emerged as the architectural features of buildings, with functionality being identified as the most critical sub-criterion within this domain. Furthermore, the preservation of ecological value and land properties was highlighted as a pivotal criterion, with safeguarding underground and surface waters identified as the foremost sub-criterion. Additionally, attention was drawn to land characteristics, particularly ambient air quality and solar energy potential. The proximity of buildings to urban amenities and transportation networks also featured prominently, with proximity to cultural and art centers identified as the most significant sub-criterion. Finally, the identification of risks, particularly natural disaster risk, was deemed crucial within this framework.

In Turkey, construction activities are regulated by the Energy Efficiency Law, with the primary objective being to curtail energy consumption. However, there remains a pressing need for a more comprehensive certification system to bolster the national economy and foster the development of green cities. Incentives such as tax exemptions and reductions can be instrumental in incentivizing the construction of green buildings, thereby promoting a healthier and more sustainable environment for future generations. Moreover, widespread public awareness and education initiatives are essential to ensure broad-based support for green building initiatives.

The advent of building management systems, which prioritize centralized control and information dissemination for building operations, holds immense promise for enhancing the efficiency and sustainability of green buildings. By integrating these systems into green building projects, significant gains in energy efficiency and productivity can be realized, contributing to the overall success of green building initiatives.

Given Turkey's diverse geographical regions, each characterized by distinct climate conditions and living standards, it is imperative to tailor green building certification systems to accommodate regional disparities. For instance, harnessing rainwater in projects in the high-precipitation Black Sea region or leveraging solar energy in the sun-drenched Mediterranean region can yield more tailored and effective outcomes. This underscores the importance of a nuanced understanding of sustainability principles and the formulation of region-specific policies to drive meaningful progress.

In essence, this study underscores the imperative of adapting green building certification systems to accommodate regional variations, laying the groundwork for the implementation of context-specific projects such as urban transformation initiatives tailored to the geographical peculiarities of each region.

Author contribution Sevim Bilge Erdede: conceptualization, methodology, literature review, writing of draft, statistical analysis and conclusion. Sebahattin Bektaş: reviewing, editing and supervision.

Data availability Please contact the authors for data requests.

Declarations

Ethics approval and consent to participate We declare that we have no human participants, human data or human issues.

Consent for publication We do not have any individual person's data in any form.

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