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SUSTAINABLE BUILDING RENOVATION PRACTICES: Simple additive weighting

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Research Article

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Abstract

The concept of sustainability has become a priority in the decisions made by all disciplines today. In the field of architecture, sustainable decisions are incorporated at all stages, such as new construction, life cycle, demolition, and renovation. The reuse of buildings is considered a sustainable approach in this sense. In addition to the reuse of buildings, the renovation of existing buildings to gain sustainable identities also constitutes another step in sustainable architecture. In this study, sample buildings were evaluated based on parameters determined through a literature review within the scope of sustainable building renovation practices. The study included research and case studies on sustainable architecture, sustainable building renovation, and sustainable renovation practices. Sustainable building renovation methods were compiled using research studies conducted on the subject. After determining the parameters of sustainable building renovation through a literature review, structures with sustainable renovation practices were evaluated within the scope of this study. The sustainable renovation qualities of the buildings evaluated in the study were scored using the Simple Additive Weighting method. The aim of this study is to reveal the diversity of renovation processes based on the parameters determined through the studies conducted and to develop new proposals based on the structures examined. As a result of the study, sustainable renovation practices were evaluated based on the characteristics of the structures. In line with the findings obtained, the advantages of sustainable renovation processes in the life cycle of buildings have been emphasized, and recommendations have been developed within the scope of renovation.

Keywords: Sustainability, architectural design, reuse of buildings, sustainable renovation of buildings

SÜRDÜRÜLEBİLİR BİNA YENİLEME UYGULAMALARI: Basit toplamlı ağırlıklandırma

Özet

Sürdürülebilirlik, günümüzde tüm disiplinlerin alacağı kararlarda öncelikli olan bir kavram haline gelmiştir. Mimarlık disiplininde de yeni inşa, yaşam döngüsü, yıkım, yenileme gibi tüm aşamalarda sürdürülebilir kararlara yer verilmektedir. Binaların yeniden kullanılması bu anlamda başlıca sürdürülebilir bir yaklaşım olarak karşılanmaktadır. Binaların yeniden kullanılmalarının yanı sıra mevcut binaların sürdürülebilir kimlikler kazanmak üzere yenilenmesi de bir diğer sürdürülebilir mimarlık adımını oluşturmaktadır. Bu çalışmada sürdürülebilir bina yenileme uygulamaları kapsamında literatür taraması yapılarak belirlenen parametreler doğrultusunda örnek yapılar değerlendirilmiştir. Çalışmada sürdürülebilir mimarlık, binaların sürdürülebilir yenilenmesi, sürdürülebilir yenileme uygulamaları kapsamında araştırmalar yapılarak örnek çalışmalara yer verilmiştir. Konu kapsamında yapılan araştırma çalışmalarından yararlanılarak sürdürülebilir bina yenileme yöntemleri bir araya getirilmiştir. Literatür taraması ile sürdürülebilir bina yenileme parametrelerinin belirlenmesinin ardından çalışma kapsamında sürdürülebilir yenileme uygulamaları bulunan yapılar değerlendirilmiştir. Çalışmada değerlendirilen yapıların sürdürülebilir yenileme nitelikleri, Basit Toplamlı Ağırlıklandırma (Simple Additive Weighting) yöntemi kullanılarak puanlandırılmıştır. Çalışmada amaçlanan, yapılan çalışmalar doğrultusunda belirlenen parametreler ile yenileme süreçleri için çeşitliliğin ortaya konması ve irdelenen yapılar üzerinden yeni önerilerin geliştirilmesidir. Çalışmanın sonucunda yapıların özelliklerine göre yapılan sürdürülebilir yenileme uygulamaları değerlendirilmiştir. Elde edilen bulgular doğrultusunda binaların yaşam döngüsünde sürdürülebilir yenileme işlemlerinin avantajı vurgulanarak yenileme işlemleri kapsamında öneriler geliştirilmiştir.

Anahtar Kelimeler: Sürdürülebilirlik, mimari tasarım, binaların yeniden kullanımı, binaların sürdürülebilir yenilenmesi

1. INTRODUCTION

Sustainability means meeting the needs of today while not preventing future generations from meeting their needs (WCED, 1987). Sustainability is an important concept that should be considered in conjunction with socio-cultural, ecological, and economic terms, encompassing a wide range of areas from political and economic policies to energy resources, production, social structures, and architecture. It is possible to say that many events and situations that have affected the world from the past to the present have played a role in the emergence of the concept of sustainability, which can be defined as the conservation of resources and their transfer to future generations (Beşiroğlu & Özmen, 2022). As a result of rapidly increasing consumption activities in many areas today, the importance of this concept must be constantly remembered. Disciplines that contribute to all aspects of life are responsible for creating sustainable solutions.

Sustainable architecture aims to minimize environmental impact throughout all phases of building design, construction, use, and demolition. Creating human-centered designs and preventing the consumption of natural resources throughout the building's lifecycle constitute the fundamental principles of sustainable architecture. There are multiple sustainable practices within the scope of architecture. Sustainable steps include considering energy efficiency in the design and construction of new buildings, identifying and renovating existing buildings for their environmentally damaging qualities, ensuring recycling during the demolition process, and managing waste disposal. Reusing an existing building rather than demolishing it is also a key sustainable step.

Reusing buildings protects the existing building stock and prevents the energy and material consumption required for new construction. Studies on the preservation of buildings, particularly focusing on cultural heritage structures, highlight the potential of these traditional buildings as examples of sustainable approaches. Their reuse will extend their lifecycles, contribute to their social and economic well-being, and maintain their exemplary qualities by utilizing the embodied energy (Dayaratne, 2018; Othman & Elsaay, 2018). Furthermore, renovating existing buildings destined for reuse and enhancing their sustainability is considered a positive development.

Cristina et al. (2017) compared two scenarios: one involving low-cost modifications and renovations of an existing building, and another involving renovations with energy-efficient solutions. Despite high initial investment costs, they concluded that energy-efficient renovations are a more positive approach because they make buildings more usable, save energy in living activities, and create a more integrated design by enabling energy production. Identifying and renovating environmentally detrimental features in existing buildings intended for reuse will increase the building's sustainability. Planning a design appropriate for the new function, evaluating natural light opportunities, monitoring and regulating energy use, and paying attention to thermal insulation will ensure the building's sustainability. This renovation process eliminates the harms of the building's demolition process, avoids constructing a new building, and prevents natural resource consumption through energy efficiency measures, suggesting a new, human-centered use of the building.

The study included research and case studies on sustainable architecture and sustainable building renovation practices. In line with these concepts, the study employed a qualitative research method and conducted a literature review. Sustainable renovation methods were compiled using studies conducted on the subject. Furthermore, examples of sustainable renovation practices were selected globally, including buildings with existing or green certifications, and the sustainable renovation practices were evaluated. Structures were analyzed and compared using the Simple Additive Weighting (SAW) method, one of the Multi-Criteria Decision Making (MCDM) methods, in line with the main principles of "Efficiency," "Environmental Impact," and "Socio-Cultural and Economic Factors." This method is widely used in the literature, is mathematically simple, and provides objective results (Churchman & Ackoff, 1954). The sustainable renovation qualities of the structures evaluated using this method were scored. Findings were obtained by comparing the structures, and recommendations were developed for sustainable building renovation.

2. SUSTAINABLE RENOVATION OF BUILDINGS

The concept of sustainability, defined as the state of being sustainable (TDK, 2024), has impacted all aspects of life and the foundation of development. Developments such as rapid urbanization, increased consumption, and increased energy needs following the industrial revolution have led to the uncontrolled depletion of resources (Beşiroğlu & Özmen, 2022). This rapid increase and uncontrolled consumption have led to negative consequences such as air pollution, environmental pollution, ecological damage, and climate change.

Sustainability has become a concept that requires significant attention across many disciplines, particularly regarding the efficient use of resources and their transfer to the future, given the negative conditions resulting from increased consumption. "Sustainable development," which refers to a development model that aims to meet the needs of today without hindering the ability of future generations to meet their needs, identifies sustainability as a common denominator in countries' economic and social development goals (URL-1). All disciplines have responsibilities in line with the objectives identified within the scope of sustainable development. The discipline of architecture also contributes to sustainable development goals through sustainable architectural approaches.

Sustainable architecture signifies prioritizing quality of life in the processes of building production and designing spaces, and being environmentally conscious in accordance with social, cultural, and aesthetic needs. The Charter for Architectural Education, prepared by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1996, outlined the goals that should be adopted in the architectural discipline to create future living environments as ensuring a quality of life worthy of humanity in residential areas, implementing technical practices that respect the social and cultural needs of individuals, and ensuring the ecological sensitivity of the built environment, with everyone accepting and valuing it as their responsibility (Özmehmet, 2007). These goals constitute the concept of sustainable building.

In addition to sustainable building construction, ensuring the sustainability of existing buildings is another sustainable architecture approach. A building's operational phase is defined as the period during which it can withstand normal use, which can range from a minimum of 50 years to several hundred years. This long service life is the phase during which a building has the greatest environmental impact (Sonebi, et al., 2016). Buildings are considered the largest energy consumers in Europe, and their renovation plays a crucial role in achieving energy and climate targets (European Commission, 2024). The construction of a building, its manufacturing process, the use of materials, its lifespan, and its demolition at the end of its life cycle all create environmental burdens (Fahlstedt et al., 2024). Renovation projects, whether repurposed or designed to maintain its functionality, aim to preserve the existing building stock. Numerous studies have been produced on this topic:

- Jensen et al. (2018), state that improving indoor climate quality as a social impact of building renovation does not directly help reduce negative environmental impacts or make an economic contribution, but improving indoor climate quality in office buildings increases productivity and reduces illnesses among employees.
- Vardopoulos (2019), states that the reuse of buildings, as one of the approaches that will contribute to sustainable development, is an important factor in not depleting the city's resources.
- Lidelöw et al. (2019), state that energy consumption and user behavior are more sensitive in traditional buildings. Sustainable renovations will allow for cultural continuity and improved user awareness.
- Serbest Yenidünya and Limoncu (2020) state that determining sustainable renovation processes in buildings that need to be renovated in line with environmental, economic and social criteria will contribute to the country's economy, sustainability of resources and user comfort.
- Ürük (2020), states that by reusing buildings, they revitalize the areas where they are located, add social and economic value and are included in social life.
- Souza (2021), states that the renovation wave initiative launched by the European Commission highlights the global importance of the issue, stating that 75% of buildings in the EU are not energy efficient and that the renovation of public and private buildings will constitute the main action.
- Rakhshan et al., (2021) focused on developing a model on the technical reusability of the structural elements of an existing building in case it completes its lifespan and as a result of the study, they encouraged suggestions that would ensure the circularity of these elements instead of demolition projects.
- Jiménez-Pulido et al. (2022), state that renovation processes have an important place in addition to building construction in line with Europe's goal of becoming carbon neutral by 2050 and recommend the development of innovative technologies in this context.
- Apostolopoulos et al. (2023), state in their study that the renewal of building stocks is an indispensable approach to achieving sustainability goals due to the high energy consumption rates of the building sector, in which they reach concrete results that can support sustainable decision-making in the improvement of buildings.

- Riuttala, et al. (2024), investigated the reuse of concrete building components in their study, stating that building component reuse is a critical tool for achieving sustainability goals in the construction industry by reducing resource consumption, waste production, and associated emissions.
- Leichter and Piccardo (2024), in their systematic literature review of 44 articles evaluating renovation and reconstruction scenarios, conclude that most of their studies evaluate the impacts related to global warming potential and that renovation is preferable.
- Caruso et al. (2024), in their study investigating solutions that effectively minimize the environmental, economic, and social impacts of the building life cycle, state the necessity of increasing the resistance of building improvement interventions against natural disasters, reducing energy needs, and using low-impact construction materials during improvement.

Research on the reuse of buildings shows that being sensitive to reuse and renovation processes represents a sustainable approach. However, this applies not only to structures that have lost their function, but also to the renovation of existing buildings through sustainable processes, ensuring they are more environmentally conscious throughout their lifespan. Based on the literature review and the thesis study in which the recommendations were investigated (Balçık, 2026), the procedures that can be applied for the sustainable renovation of a building are compiled in Figure 1. These applications are categorized into eight areas: energy efficiency, water efficiency, material selection, waste management, indoor environmental quality, environmental quality, socio-cultural factors, and economic factors.

Energy Efficiency	Use of renewable energy sources
	Improvement of the building envelope
	Effective energy consumption of heating and cooling systems
	Effective energy consumption of lighting equipment
	Users' efficient use of energy
Water Efficiency	Reducing clean water consumption
	Grey water recycling
	Management and reuse of surface water
	Rainwater collection and use
Interior Quality	Ensuring air and humidity quality through natural ventilation
	Taking advantage of natural lighting
	Ensuring thermal comfort
	Ensuring acoustic comfort
Material Selection	Use of renewable materials
	Use of local materials
	Reducing environmental impacts in the life cycle
	Effective use of materials
Waste Management	No demolition waste is created
	Reducing waste generation
	Ensuring proper management and recycling of waste
Environmental Quality	Minimizing greenhouse gas emissions
	Limitation of environmental impacts (resource consumption/waste)
	Reducing light, air and noise pollution
Sociocultural Factors	Protection of historical values of buildings
	Ensuring resilient urban revitalizationp
	Awareness and active participation of designers/users
Economic Factors	Ensuring durability
	Reduction in the investment cost of the building
	Reduction in usage costs in the building
	Extending the building life cycle

Figure 1. Design scenario in sustainable renovation (Balçık (2026) was used as a reference).

Although practices within the scope of sustainable building renovation are brought together, there is no single solution for this process. The most effective solution in this regard will be to test the many suggestions that emerge and to determine the most appropriate techniques and applications by considering the general and individual form of the building as well as its historical context (Berardinis, Rotilio, & Capannolo, 2017). Zhang et al. (2021) also state that methods should be developed according to the age and construction characteristics of the buildings in building renovation processes. Since the existing characteristics and potentials of buildings differ from each other, renovation applications vary. Environmentally friendly renovation solutions are produced in line with the qualities of the buildings.

3. SUSTAINABLE BUILDING RENOVATION PRACTICES

"The greenest building is the one that's already built."

Carl Elefante (2012)

Sustainable architecture aims to ensure the continuity of life, the efficient use of existing natural resources, spatial and environmental comfort, and the proper management of waste (Çiğan & Yamaçlı, 2020). In addition to reusing buildings and utilizing embodied energy, these goals also include the efficient use of energy and water resources, the creation of renewable solutions, prioritizing material selection, reducing and managing waste generation, ensuring spatial and environmental quality, reducing building investment and usage costs, increasing user awareness, and preserving cultural values. The sustainable building renovation parameters determined as a result of the research were examined on examples from around the world. The sample buildings were selected from those that have been renovated for reuse, used for different functions, and particularly possess characteristics of sustainable renovation. Among the evaluated examples were certified buildings, as well as buildings with a focus on sustainability. Table 1 lists the names, images, locations, former and current functions, renovation dates, and green building certification characteristics of the evaluated structures.

Table 1. Evaluated buildings and their properties (Prepared by authors).

 **Zala 1 Office Building** (USGBC, 2023) **Latvia, 2016** **Old/New Function:** Industrial/ Commerce **Certification**: LEED Gold (Existing Buildings)	 **Charity Lotteries Office Building** (URL-4) **Netherlands, 2018** **Old/New Function:** Commerce/ Commerce **Certification:** BREEAM Outstanding	 **Adobe SF 601 Townsend Office Building** (USGBC, 2012) **USA, 2023** **Old/New Function:** Commerce/ Commerce **Certification:** LEED Gold
 **Valtorta 52 Offices** (URL-6) **Italy, 2022** **Old/New Function:** Commerce/Commerce **Certification**: LEED (Core and Shell)	 **USGBC HQ Building** (USGBC, 2023) **USA, 2023** **Old/New Function:** Commerce/Commerce **Certification**: LEED (Commercial interiors)	 **TU Delft Faculty of Architecture** (URL-8) **Netherlands, 2011** **Old/New Function:** Training/ Training **Certification: -**
 **International Institute for Geo-Information Sciences** (URL-10) **Netherlands, 2023** **Old/New Function:** Training/ Training **Certification: -**	 **Schoenenkwartier Shoe Museum** (URL-11) **Netherlands, 2023** **Old/New Function:** Public/Culture **Certification: -**	 **İşbank Painting Sculpture Museum** (URL-12) **Türkiye, 2023** **Old/New Function:** Housing/Culture **Certification: -**

3.1. Zala 1 Office Building, Riga, Latvia

Zala is located in the center of Riga, the capital of Latvia. Originally built in 1899 by A.G. Rutenberg as a tobacco factory, the building was repurposed as an office building in 2009, preserving its historical value and adding two glass floors in a contemporary style. The office features a modern interior design and integrated technologies.

During the renovation, special attention was paid to the quality of construction materials and building technologies, ensuring greater comfort and commensurate user fees. The work was completed in 2010, and the flexible offices were quickly and efficiently equipped to meet specific business needs. In 2016, the office building earned gold certification from the international LEED (Leadership in Energy and Environmental Design) program for Existing Buildings. The certification confirms the building's sustainability.

To achieve sustainable results in this renovated structure, the following were achieved:

- The existing structure was reused, extending its life cycle. Reuse ensures the building's economic, cultural, and environmental sustainability,
- Eliminates demolition waste,
- Reduces water consumption and ensures water efficiency,
- Sustainable site selection and development,
- Responsible material selection,
- Waste management,
- Improved interior and environmental quality,
- Energy-efficient practices (URL-2), (Table 2).

Table 2. Zala1 Office Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	Productivity	Energy Efficiency	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	Material Selection	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	No demolition waste is created
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
			Reducing light, air and noise pollution
	Social, Cultural, and Economic Factors	Sociocultural Factors	Protection of historical values of buildings
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

3.2. Charity Lotteries Office Building, Amsterdam, Netherlands

Originally built as an office, the building was renovated for use as an office by employers who consider sustainability one of their core values. The iconic roof, designed with approximately 7,000 polished aluminum leaves added to the structure, allows the building to be used by individuals outside the office, giving it a transparent and accessible identity. A slender, tree-shaped beam supports the roof and does not burden the existing structure (URL-3). The building holds the title of most sustainable office renovation, earning a BREEAM Outstanding rating (URL-4).

The renovated office building reused materials from the demolished sections of the old building. All newly used materials were tested for sustainability and were designed to be repurposed in the future if necessary (URL-3). 949 solar panels provide energy on the building's roof. Rainwater is collected to irrigate the roof gardens and provide water for the flush systems. The office building has become not only energy neutral but also energy positive (URL-3). This renovated building incorporates practices that achieve sustainable outcomes, such as: Utilizing the existing structure, avoiding demolition waste, recycling and selecting waste materials responsibly, ensuring energy production, reducing rainwater collection and freshwater use, sustainable site selection and development, enhanced indoor environmental quality (Table 3). It also creates accessible, transparent public spaces, fostering public participation and awareness of the building's cultural value and sustainability.

Table 3. Charity Lotteries Office Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices			
	Productivity	**Energy Efficiency**	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	**Material Selection**	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	No demolition waste is created
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
			Reducing light, air and noise pollution
	Social, Cultural, and Economic Factors	**Sociocultural Factors**	Protection of historical values of buildings
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

3.3. Adobe SF 601 Townsend Office Building, San Francisco, USA

The Baker & Hamilton Building, built in 1905, is a three-story brick office building for the Steel and Hardware Company. It is on the National Register of Historic Places and is one of the few buildings of its kind remaining in the city before the 1906 earthquake. In 2000, the building was converted for office use, preserving the facade with its Beaux Arts brick veneer and arched windows. It was awarded LEED Platinum status in 2010. Acquired by Adobe in 2007, the building underwent renovations to the facade, including course fill and damaged brickwork. The building has a LEED Gold certificate as of 2023 (URL-5).

The key sustainable features of this renovation project (USGBC, 2012):

- The existing structure was reused.
- No demolition waste was generated.
- A web-based monitoring system was installed that allows for detailed monitoring and adjustment of energy and water use, as well as reporting total CO_2 emissions, resulting in the building achieving the highest possible score of 100 in the Energy Star rating system.
- Electricity use was effectively reduced by 63% over a seven-year period.
- Water use was reduced by more than 62%.
- Diversion of solid waste from landfills through composting and recycling was increased from 23% to 98%.
- The company is requiring all products to be purchased with high recycled content.
- "Green" products are preferred, minimizing hazardous chemicals, noise, indoor air pollution, and worker injuries.

- The building's facade, with its Beaux Arts brick veneer and arched windows, has been preserved.
- Cleaning is done during the day to minimize the need for lights at night and to allow janitors to be home with their families in the evenings.
- Adobe encourages public transportation with bike racks and locker rooms with showers and electric vehicle charging stations, as well as shuttle services to the local train station and coupons for use on buses and trains. 74% of the building's employees use alternative transportation to get to work.
- To further reduce CO_2 emissions and achieve grid independence, alternative energy sources like biogas-powered fuel cells have also been implemented (Table 4).

Table 4. Adobe SF 601 Townsend Office Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	Productivity	Energy Efficiency	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of Energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	Material Selection	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	No demolition waste is created
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
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			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

Practices such as employees' use of alternative transportation, the elimination of nighttime lighting, and waste management demonstrate the importance of user awareness, as well as the sustainability of buildings. In a city striving to move the country towards an environmentally responsible future, this modest and elegant structure sets a precedent for existing legacy buildings.

3.4 Valtorta 52 Offices Building, Milan, Italy

Located in a significantly revitalized area in northern Milan, a 1960s-era office building was partially salvaged and renovated. The building is now back in its original office function. The façade and interior were completely redesigned, and a robust renovation was implemented using innovative materials. The renovation was carried out using materials that connect with the surrounding environment. The existing structural members were completely replaced, and a fourth floor was added, set back from the façade, to the existing three floors. This created additional Office space and a green terrace along the building's perimeter.

Located on a corner site, the office building features spacious and bright offices on all four floors, along with two open spaces: a green terrace on the first floor and a hanging garden extending around the perimeter of the top floor. The project is registered under the LEED building sustainability certification protocol, Core and Shell.

The building's sustainable qualities include: Utilizing the existing structure, avoiding demolition waste, selecting innovative and environmentally compatible materials, providing green space with a roof terrace, providing natural lighting, and ensuring interior quality (URL-6), (Table 5).

Table 5. Valtorta 52 Offices Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	Productivity	Energy Efficiency	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	Material Selection	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	No demolition waste is created
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
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	Social, Cultural, and Economic Factors	Sociocultural Factors	Protection of historical values of buildings
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

3.5. USGBC HQ Building, Washington, DC, ABD

The renovated U.S. Green Building Council headquarters serves as a showcase for everything the organization does. Ribbon walls gently embrace the public space, symbolizing the connection between sustainability, resilience, biophilia, and human well-being. People will come here to exchange ideas and collaborate on a positive future. For this reason, the building is divided into two spaces: one renovating the existing office staff workspace and the second a new public collaboration space that represents an evolution of the U.S. Green Building Council brand. The building also doubles as an educational tool, providing visitors and staff with the opportunity to learn about sustainable and human-centered design, where all materials are housed in an information center (URL-7).

In this sense, the sustainable features of the renovated headquarters structure are:

- Utilizing the existing structure
- Avoiding demolition waste
- Reusing materials and circularity
- Sustainable and efficient operations (measuring and monitoring energy consumption, water consumption, and indoor air quality data, analyzing and improving the headquarters' carbon output)
- Carbon reduction strategies
- Waste reduction strategies (Table 6).

The former workspace served as a material resource, providing the design team with a wealth of products and materials for reuse and repurposing. Ninety-five percent of the original construction materials, including ceiling tiles, ceiling grid, drywall, glass panels, hardware, millwork, and mosaic tiling, were reused. Sixty percent of the furniture and materials were reused. To minimize waste generation, staff were offered furniture, and items were donated or sold. Retaining the existing office spaces in place reduced demolition waste. The site achieved a 94.3% waste diversion rate by reusing furniture, equipment, and materials from the previous site, reducing both operational and embodied carbon. The building received LEED Commercial Interiors certification in 2023.

Table 6. USGBC HQ Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	Productivity	Energy Efficiency	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	Material Selection	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	No demolition waste is created
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
			Reducing light, air and noise pollution
	Social, Cultural, and Economic Factors	Sociocultural Factors	Protection of historical values of buildings
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

3.6. TU Delft Faculty of Architecture, Delft, Hollanda

Following a fire in 2008 that completely destroyed the TU Delft Faculty of Architecture building, the faculty was forced to relocate to the university's former main building. The large, monumental building, constructed in the 1920s using brick, required rapid renovation. The renovated building has been transformed into a modern and inspiring student city and research center. Architect Liesbeth van der Pol, who oversaw the renovation, described the building's use as follows: "The building has been transformed from a place students avoided into a real magnet for students." The new faculty building was soon renamed BK City. It was decided that the Faculty of Architecture would remain in this building for the longer term, and therefore BK City needed to be made more efficient and sustainable to meet future needs (URL-8).

The renovation project, which aims to create a building that places sustainability at the center of education for future generations of architects, providing an inspiring environment, functional qualities, and cost savings, was addressed in four different areas: energy and materials; ecosystems and species; culture and economy; and health and happiness (URL-9).

The sustainable features of the renovated building;

- Utilizing the existing structure,
- Avoiding demolition waste,
- Saving 67% of heat through wall, roof, and window insulation,
- Saving on electrical equipment and lighting, and achieving energy efficiency with photovoltaic panels embedded in glass,
- Connecting to campus biogas energy production,
- Considering future energy innovations,
- Designing an indoor atrium garden,
- Creating an ecosystem with greenhouses, plant-based air conditioning, and green roofs,
- Ensuring water self-sufficiency in ecosystem areas,
- Adopting an open-source and participatory framework design,
- Creating a holistic campus where technology and ecology meet,
- Ensuring long-term economic stability,
- Using an elevated heat recovery ventilation system,
- Designing recreational and natural areas, and

- Having a sustainable, healthy, low-energy food system (Table 7).

The renovation of the building has an extremely instructive and exemplary environmental quality as an indoor plant ecosystem and operationally sustainable water use, and as a feasible and progressively realizable plan.

Table 7. TU Delft Faculty of Architecture Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	**Productivity**	**Energy Efficiency**	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	**Material Selection**	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	No demolition waste is created
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
			Reducing light, air and noise pollution
	Social, Cultural, and Economic Factors	**Sociocultural Factors**	Protection of historical values of buildings
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

3.7. International Institute for Geo-Information Sciences, Enschede, Netherlands

It is a faculty at the University of Twente that stands out as a symbol of sustainability. It is a building where students gather with world-class researchers to explore sustainable solutions. Instead of building a new faculty structure, the conversion of a former laboratory built in 1972 was chosen. The existing structure, with its remarkable dimensions of 220 meters long and 38 meters deep, features a low ground floor and a high upper floor. Four atriums carved into the structure provide greenery, fresh air, and natural light (URL-10). The building is situated on a campus site surrounded by modern buildings within a lush green landscape. The designed atriums connect the interior with the exterior. Gardens create habitats for flora and fauna, contributing to clean air and a stress-free working environment, and creating small ecosystems with established plants and trees. One of the atriums serves as the new entrance at the center of the building.

The architectural design essentially symbolizes the global sustainability mission by preserving the existing structure. Reused sunshades on the south side of the building prevent overheating in summer. Atriums serve as the building's lungs and support natural ventilation. Natural materials, such as oak facades and bamboo flooring, provide warmth to the design. The materials are durable and have been used in their native colors without the use of paint. The wood joinery supports the building's new purpose. The sustainable features of the renovated building include:

- Utilizing the existing structure,
- Avoiding demolition waste,
- Supporting green spaces with atriums,
- Utilizing natural ventilation,
- Ensuring ecosystem development and sustainability,
- Controlling heating through the use of sunshades,
- Selecting environmentally friendly materials (URL-10), (Table 8).

Table 8. International Institute for Geo-Information Sciences Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	Productivity	Energy Efficiency	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	Material Selection	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	No demolition waste is created
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
			Reducing light, air and noise pollution
	Social, Cultural, and Economic Factors	Sociocultural Factors	Protection of historical values of buildings
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

3.8. Schoenenkwartier Shoe Museum Building, Waalwijk, Netherlands

The Schoenenkwartier Museum is a partially renovated, converted, and expanded historic building complex from the 1930s in the center of Waalwijk, the Dutch leather and shoe city, transforming it into a new and innovative knowledge center for shoe design, shoe production, and footwear fashion. It houses a collection of 12,000 objects, various permanent exhibitions, an information center with a research library, workshop space, and auditorium, a museum café, and design and prototyping laboratories. Both the building's planning and design, as well as its interior, map out a new and inspiring future for industry, city, and society, building on the values of the past (URL-11).

Leatherworking and shoemaking, as local crafts, formed the region's culture and economy. However, today, leather and shoe production has become extinct. The Shoe and Leather Museum was established in 1954. The museum structure, acting as a center for innovation, includes exhibition rooms, a research library, various innovation and design laboratories for teaching and artist-in-residence, and various facilities for conferences and company presentations. In addition to being a museum and innovation center, the Shoe Museum also represents an open and public space for the community.

The deliberate selection of materials such as brick, steel, concrete, and wood throughout the complex enhances the atmosphere of the collection and the historic building. The selection of authentic materials and the geometric shapes used further broaden the target audience by appealing to the universal experiences of the human senses, from sight to hearing, touch to smell. Materials were chosen with sustainability in mind, with emphasis placed on durability, sustainable sourcing, and reusability (URL-11).

The sustainable features of the renovated building are listed as follows:

- Utilizing the existing structure,
- Avoiding demolition waste,
- Selecting local and reusable materials (Table 9).

Table 9. Schoenenkwartier Shoe Museum Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	Productivity	Energy Efficiency	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	Material Selection	**Use of renewable materials**
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	**No demolition waste is created**
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
			Reducing light, air and noise pollution
	Social, Cultural, and Economic Factors	Sociocultural Factors	**Protection of historical values of buildings**
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

3.9. İşbank Painting Sculpture Museum Building, İstanbul, Türkiye

The İşbank Painting Sculpture Museum is situated on İstiklal Street, one of the city's most prominent pedestrian thoroughfares, adjacent to Odakule Passage. Built in 1907 as an apartment building, its ground and first floors, formerly stores, were later converted to function as a bank. The rooms on the upper floors, originally residential, were left in their original state and used as offices. The İş Bank Painting Sculpture Museum was renovated in 2023 (URL-12). The museum building's heating and cooling system design, in line with İşbank's sustainability goals, consists of state-of-the-art, internationally tested, and certified devices (URL-13). The building utilizes natural lighting. Systems running within the suspended ceiling provide heat, air, and energy to the existing building (Cansız, 2023). The sustainable features of the renovated building are: Utilizing the existing structure, avoiding demolition waste, making sustainable choices in the heating and cooling system, providing natural lighting (Table 10).

Table 10. İşbank Painting Sculpture Museum Building sustainable renovation qualities (Prepared by authors).

Sustainable Building Renovation Practices	Productivity	Energy Efficiency	Use of renewable energy sources
			Improvement of the building envelope
			Effective energy consumption of heating and cooling systems
			Effective energy consumption of lighting equipment
			Users' efficient use of energy
		Water Efficiency	Reducing clean water consumption
			Grey water recycling
			Management and reuse of surface water
			Rainwater collection and use
		Interior Quality	Ensuring air and humidity quality through natural ventilation
			Taking advantage of natural lighting
			Ensuring thermal comfort
			Ensuring acoustic comfort
	Environmental Impact	Material Selection	Use of renewable materials
			Use of local materials
			Reducing environmental impacts in the life cycle
			Effective use of materials
		Waste Management	**No demolition waste is created**
			Reducing waste generation
			Ensuring proper management and recycling of waste
		Environmental Quality	Minimizing greenhouse gas emissions
			Limitation of environmental impacts (resource consumption/waste)
			Reducing light, air and noise pollution
	Social, Cultural, and Economic Factors	Sociocultural Factors	**Protection of historical values of buildings**
			Ensuring resilient urban revitalizationp
			Awareness and active participation of designers/users
		Economic Factors	Ensuring durability
			Reduction in the investment cost of the building
			Reduction in usage costs in the building
			Extending the building life cycle

The evaluated structures are compiled in Table 11. Comparison of the structures reveals that they vary in terms of parameters other than eliminating demolition waste and extending the building's lifecycle. Certified structures exhibit a higher prevalence of sustainable renovations. None of the structures address parameters such as graywater recycling, surface water management and reuse, ensuring acoustic comfort, ensuring durability, reducing the building's investment cost, or reducing the building's operating costs.

Table 11. Comparison of sustainable renovation practices in buildings (Prepared by authors).

Sustainable Building Renovation Practices	**Buildings**	**Zala 1 Office Building**	**Charity Lotteries Office Building**	**AdobeSF601 Townsend Office Building**	**Valtorta 52 Offices Building**	**USGBC HQ Building**	**TU Delft Faculty of Architecture**	**International Institute for Geo-Information Sciences**	**Schoenenkwartier Shoe Museum**	**İşbank Painting Sculpture Museum**
Energy Efficiency	Use of renewable energy sources		•	•			•			
	Improvement of the building envelope						•			
	Effective energy consumption of heating and cooling systems	•		•		•		•		•
	Effective energy consumption of lighting equipment	•		•		•	•			
	Users' efficient use of energy			•						
Water Efficiency	Reducing clean water consumption	•	•	•		•	•			
	Grey water recycling									
	Management and reuse of surface water									
	Rainwater collection and use		•				•			
Interior Quality	Ensuring air and humidity quality through natural ventilation	•	•		•	•		•		
	Taking advantage of natural lighting	•	•		•	•		•		•
	Ensuring thermal comfort	•	•		•	•	•			
	Ensuring acoustic comfort									
Waste Management	No demolition waste is created	•	•	•	•	•	•	•	•	•
	Reducing waste generation			•		•				
	Ensuring proper management and recycling of waste	•	•	•						
Environmental Quality	Minimizing greenhouse gas emissions			•	•	•	•	•		
	Limitation of environmental impacts (resource consumption/waste)	•	•	•						
	Reducing light, air and noise pollution				•		•	•		
Sociocultural Factors	Protection of historical values of buildings	•		•			•		•	•
	Ensuring resilient urban revitalizationp	•								
	Awareness and active participation of designers/users		•				•			
Economic Factors	Ensuring durability									
	Reduction in the investment cost of the building									
	Reduction in usage costs in the building									
	Extending the building life cycle	•	•	•	•	•	•	•	•	•
Material Selection	Use of renewable materials				•				•	
	Use of local materials								•	
	Reducing environmental impacts in the life cycle	•	•	•	•	•		•	•	
	Effective use of materials	•		•		•				

4. RESULTS AND DISCUSSION

Sustainable renovation practices were compiled as a result of studies conducted to ensure the sustainability of buildings during their renovation and reuse processes. Different practices were implemented in the buildings examined in line with these identified parameters. The practices included in the sample buildings are compiled in Table 11, and the variety of practices is compared. Furthermore, the buildings were scored using Simple Additive Weighting to determine the weights of their sustainable renovation qualities. The practices were evaluated under eight headings and divided into three categories: efficiency, environmental impact, and socio-cultural and economic factors. The strategies included 3-3-2 strategies, with 3 for efficiency, 3 for environmental impact, and 2 for socio-cultural and economic factors. When assigning values to each category, a common multiple of the strategy numbers was determined, 6. Dividing this value by the number of strategies within the category determined the total value of each strategy. Each strategy also has its own parameters. Dividing the determined strategy value by the parameter determines the value of the parameter. Table 12 shows the coefficient values of the strategies and their parameters.

Table 12. Calculating the weights of the buildings according to the sustainable renovation parameters according to the SAW method (Prepared by authors).

Sustainable Renewal Practices	Strategies	Strategy Coefficient	Number of Parameters	Parameter Coefficient	Total Weight
Productivity	Energy efficiency	2	5	0.4	6
	Water efficiency	2	4	0.5	
	Interior quality	2	4	0.5	
Environmental impact	Material selection	2	3	0.666	6
	Waste management	2	4	0.5	
	Environmental quality	2	3	0.666	
Social, cultural, and economic factors	Sociocultural factors	3	3	1	6
	Economic factors	3	4	0.75	

A comparison of the weights of the buildings using the Simple Sum Weighting method is presented in Table 13. Buildings with an "*" at the end of their names are certified for sustainability, as indicated in Table 1. Sustainable renovation percentages were determined based on the renovation practices implemented by the buildings. These percentages were calculated using the Simple Sum Weighting method, based on the score values determined for each category of the buildings' parameters.

Table 13. Comparison of the weights of the buildings according to the SAW method in line with the sustainable renovation parameters (Prepared by authors).

Simple Additive Weighting (SAW) method		Productivity			Environmental Impact			Social, Cultural, and Economic Factors		Total
		Energy Efficiency	Water Efficiency	Interior Quality	Material Selection	Waste Management	Environmental Quality	Sociocultural Factors	Economic Factors	
Sustainable Renewal Practices	Parameters	5	4	4	3	4	3	3	4	30
	Numerical Equivalent	0.4	0.5	0.5	0.666	0.5	0.666	1	0.75	18
		6			6			6		
	Percentage Equivalent	%100			%100			%100		%100
Zala 1 Office Building*	Parameters	2	1	3	2	2	1	2	1	14
	Numerical Equivalent	0.8	0.5	1.5	1.333	1	0.666	2	0.75	8.55
		2.8			3			2.75		
	Percentage Equivalent	%46.6			%50			%45.8		**%47.5**
Charity Lotteries Office Building*	Parameters	1	2	3	1	2	1	1	1	12
	Numerical Equivalent	0.4	1	1.5	0.666	1	0.666	1	0.75	6.95
		2.9			2.3			1.75		
	Percentage Equivalent	%48.3			%38.3			%29.1		**%38.6**

Table 13. Comparison of the weights of the buildings according to the SAW method in line with the sustainable renovation parameters (continued).

Adobe SF 601 Townsend Office Building*	Parameters	4	1	0	2	3	2	1	1	14
	Numerical Equivalent	1.6	0.5	0	1.333	1,5	1.333	1	0.75	7.95
		2.1			4.1			1.75		
	Percentage Equivalent	%35			%68.3			%29.1		**%44.1**
Valtorta 52 Offices Building*	Parameters	0	0	3	2	1	2	0	1	9
	Numerical Equivalent	0	0	1.5	1.333	0.5	0.666	0	0.75	4.75
		1.5			2.5			0.75		
	Percentage Equivalent	%25			%41.6			%12.5		**%26.3**
USGBC HQ Building*	Parameters	2	1	3	2	2	1	0	1	12
	Numerical Equivalent	0.8	0.5	1.5	1.333	1	0.666	0	0.75	6.55
		2.8			3			0.75		
	Percentage Equivalent	%46.6			%50			%12.5		**%36.3**
TU Delft Faculty of Architecture	Parameters	3	2	1	0	1	2	2	1	12
	Numerical Equivalent	1.2	1	0.5	0	0.5	1.333	2	0.75	7.25
		2.7			1.8			2.75		
	Percentage Equivalent	%45			%30			%45.8		**%40.2**
International Institute for Geo-Information Sciences	Parameters	1	0	2	1	1	2	0	1	8
	Numerical Equivalent	0.4	0	1	0.666	0.5	1.333	0	0.75	4.65
		1.4			2.5			0.75		
	Percentage Equivalent	%23.3			%41.6			%12.5		**%25.8**
Schoenenkwartier Shoe Museum	Parameters	0	0	0	3	1	0	1	1	6
	Numerical Equivalent	0	0	0	2	0.4	0	1	0.75	4.15
		0			2.4			1.75		
	Percentage Equivalent	%0			%40			%29.1		**%23**
İşbank Painting Sculpture Museum	Parameters	1	0	1	0	1	0	1	1	5
	Numerical Equivalent	0.4	0	0.5	0	0.5	0	1	0.75	3.15
		0.9			0.5			1.75		
	Percentage Equivalent	%15			%8.3			%29.1		**%17.5**

**Buildings with an "*" at the end of their names are certified for sustainability.*

Based on the tables that allow for comparison of buildings:

• While studies prioritize one aspect of efficiency, shortcomings are observed in their implementation. For example, while water consumption reduction is emphasized, systems such as graywater treatment or rainwater harvesting are not included.

• Renovation projects focus on some of the aforementioned strategies while ignoring others, and a holistic renovation system is lacking.

• Certification systems are not mandatory, and the most recent studies do not emphasize sustainability practices.

• However, renovation projects are diversifying with different approaches to buildings.

• It is observed that not only historical buildings but also the existing building stock is being enhanced with sustainable features, ensuring their continued use.

The evaluated buildings contained at most 14 of the 30 parameters. While this number is higher in certified buildings, non-certified buildings also exhibit high sustainable renovation percentages. The Valtorta 52 Office Building is registered in the Core and Shell category of the LEED building sustainability certification protocol and does not include energy and water efficiency applications. While the roof garden application may be considered to utilize rainwater, the goal should be to develop efficiency applications. Furthermore, the uncertified TU Delft Faculty of Architecture building had more parameters and a higher percentage. Considering that the TU Delft Faculty of Architecture building has the oldest renovation applications among the buildings, it is expected that the renovation parameters of the buildings closer to the present day will be higher in number and percentage. It appears that common parameters include avoiding the creation of demolition waste due to reuse in buildings and extending the building's life cycle. The idea of sustainability, with an emphasis on local or monumental features, is not evident in the buildings.

5. CONCLUSION

Sustainability has become a concept whose importance cannot be overstated today, and it plays a role in almost every field. The aim of reusing buildings is to utilize their energy, while also ensuring environmentally friendly consumption through renovations, ensuring spatial quality, and contributing to cultural and economic development.

The study explored the reuse of buildings and the practices they could employ as sustainable renovation methods. Based on the examples provided, renovations aimed at enhancing their sustainability were identified. Buildings were evaluated using tables based on parameters determined by considering energy and water efficiency, interior quality, material selection, waste management, environmental, sociocultural, and economic factors. The study, based on the research conducted and the buildings evaluated, highlights the advantage of incorporating sustainable renovation parameters into the decision-making process (Figure 2).

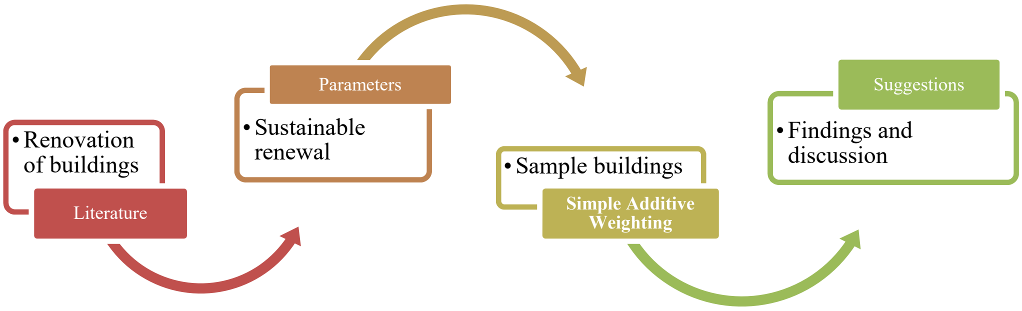

Figure 2. Diagram expressing the process of the study, (Prepared by authors).

This study, which examines sustainable renovation practices in renovated buildings, brings together guiding examples and recommendations for renovation processes. While adaptive reuse is a primary sustainable method, executing renovations while considering factors such as resource consumption, waste management, cultural considerations, and user comfort and behavior will contribute to the building's sustainability. In this sense, the study emphasizes the field of sustainable building renovation, where more research and development of practices are needed in the literature. It is recommended that studies be conducted in areas such as ensuring technological innovations in the field of sustainable building renovation, developing a certification system for holistic sustainable renovation processes, and identifying renovation projects for monumental or locally significant buildings.

Adopting a sustainable renovation approach to buildings has been shown to effectively support minimizing environmental, economic, and social impacts across all building lifecycle stages. Considering that both utilizing existing building stock and creating sustainable designs are essential today, it is recommended that legal regulations be implemented for the path to be followed in renovations, and that sustainable renovation practices and solutions aimed at improving the lifecycle be increased.

In sustainable renovation of buildings, the lifespan of the buildings should be taken into account when determining the applications; sustainability parameters should be included in decision-making processes; certification systems should be guiding for buildings to gain a holistic sustainable identity; and improvement should be carried out not only in buildings with historical value but throughout the entire existing building stock.

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Ruşen Yamaçlı: Conceptualization (supporting), methodology (equal), writing - original draft (supporting), writing - review & editing (supporting), visualization (supporting), resources (equal), investigation (supporting), formal analysis (supporting), data curation (equal), project administration (supporting), validation (supporting).

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