

## Can another sustainability rating system replace LEED-ND certification for multi-family housing projects?

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### ABSTRACT

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Built facilities consume significant amounts of energy during their project life cycle, and there is an increasing need to measure facility sustainability performance. To ensure high sustainability performance, sustainability rating systems have been developed and employed to proactively identify potential issues and quantitatively compare project sustainability performance. With a focus on walkable community development for multi-family housing projects, this study compared two sustainability rating systems: the Leadership in Energy and Environmental Design (LEED) for Neighborhood Development (ND); and the Walk Score. The authors selected 26 LEED-ND (v2009) certified projects and collected 20 Walk Scores within the boundary of 250-meter from the center of each LEED-ND certified project. The result shows that the Walk Score (Max: 100) has a positive and statistically significant association (the coefficient: 0.4686 at the significant level of 0.005) with the LEED-ND score (Max: 110). However, no correlation was found between the Walk Score and the LEED-ND category pertaining to walkability—the Neighborhood Pattern & Design (NPD) score (Max: 44). So, while the Walk Score was found to be an alternative rating system for measuring sustainability performance, the authors determined that LEED-ND certification could not replace the Walk Score when it comes to assessing walkability.

**Keywords:** sustainability; sustainability rating system; LEED; Walk score; neighborhood

## Introduction

Built facilities account for more than 30 percent of total energy consumption across the world, which means that energy consumption for heating, ventilation, and air conditioning (HVAC) or lightning in built facilities is very high compared to other energy-consuming sectors of the economy [1]. Thus, the sustainable development of constructed facilities, a product of the largest industry sector, has important economic and social impacts [2].

We consider three aspects critical for the sustainable development of built facilities: the environmental, economic, and social impacts of construction [1-5]. Sustainable development is defined as “social and economic development that protects and enhances the natural environment and social equity” [5] or “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [6].



Hastings and Walls categorized three system types, each with a different focus: energy, economic, and social aspects [7]. The first system type applies to the cumulative energy demand (CED) systems that monitor the energy consumption of built facilities. The second system type is the project life cycle analysis (LCA) systems that measure the environmental impact across the project life cycle. The third type is the total quality assessment (TQA) systems that examine social requirements, including the accessibility and quality of spaces [7]. Unlike the CED and LCA systems that address only one aspect, TQA systems measure sustainability with several criteria. The overall evaluation result is the sum of each criterion rating [8]. Examples of TQA systems include the Leadership in Energy and Environmental Design (LEED)–Neighborhood Development (ND) [9-11], the Building Research Establishment Environmental Assessment Method (BREEAM) [12], Green Star [13], and Greenroad Certification [14]. All TQA systems have unique specific criteria, and the collection of points is used to obtain the sustainability rating. Among the criteria of TQA systems, accessibility or walkability receives more attention because it lowers environmental impact by reducing traffic congestion and eliminating air and noise pollution [15, 16]. To increase walkability, most public projects require pedestrian and bicycle access [15]. This is why many sustainability rating systems include criteria on walkability in order to address pedestrian behaviors and to ensure that a path network connects the community [15].

The LEED certification is one of the most popular sustainable rating systems used to measure the sustainability of built environments, such as buildings, interior design, neighborhood development, and homes [9, 17-25]. Unlike other LEED certifications, the LEED-ND certification considers walkability and accessibility [9]. However, the challenges of sustainability rating systems, including some LEED-ND criteria, are that they occasion higher costs and require additional time [20, 21, 26]. To simplify the walkability measurement as a part of a sustainability rating, the Walk Score was developed to calculate a score by measuring the distance from a location to the nearest amenities [27, 28]. Previous studies identified that the Walk Score influences housing values and can lead to cost savings for property owners [26, 29]. A survey of 90,000 recent home sales across the country revealed that a one-point increase in the Walk Score positively correlates to a \$700 - 3,000 increase in home values [29]. Planned walkable communities result in significant economic benefits by increasing home values, leveraging transportation cost savings, and lower mortgage rate [26, 29].

The primary objective of this study is to understand two sustainability rating systems that can assess walkability: the LEED-ND (v2009) and the Walk Score. The U.S. Green Building Council (USGBC) announced the newest version (v4) of the LEED green building program, including the Neighborhood Development in 2013 [30]. The differences between the LEED-ND v2009 and v4 are the possible points changes; 1) increased by two points for the Green Infrastructure & Buildings category, 2) increased by one point for the Smart Location & Linkage category, and 3) decreased by three points for the Neighborhood Pattern & Design category [31]. However, the changes to the LEED-ND criteria include the revision of credit names, changes of a credit point or clarification of the requirements of the previous versions [31]. Due to the nature of construction projects, a gap exists between the LEED application and the LEED certification. Thus, the authors could not obtain a sufficient number of projects pursuing LEED-ND

v4 certification and therefore decided to use the LEED-ND v2009 instead of v4. Since LEED-ND certification requires additional time and cost [20, 21, 26, 32], this study sought to identify whether the Walk Score can replace the LEED-ND certification, to minimize the additional resources the latter necessitates. After conducting the literature review, the authors compared outcomes from two different rating systems. Data from 26 LEED-ND certified projects were gathered from the USGBC database [33]. Then, 20 Walk Scores within a 250-meter radius (0.15 miles) from the center of each LEED-ND (v2009) project were averaged to obtain a representative Walk Score for the comparison. Lastly, two rating scores were compared: 1) the entire LEED-ND score (Max: 110) was compared to the Walk Score (Max: 100); and 2) the Neighborhood Pattern & Design (NPD) criteria of the LEED-ND score (Max: 44) was compared to the Walk Score (Max: 100). To analyze the findings, the authors conducted a linear regression analysis and a correlation analysis to identify the relationship between the LEED-ND scores and the Walk Scores. Lastly, the authors summarized findings from this study and suggested topics for future studies.

This study is an extension of a previous research project conducted by the same authors, comparing the LEED-ND score and the Walk Score [34]. While the previous study examined the scores of only 11 LEED-ND certified projects without further analysis, this study compared the scores of 26 LEED-ND certified projects with their Walk Scores, and then statistically analyzed them for any associations.

## Review of Prior Studies

This section summarizes findings from previous studies that focus on such topics as sustainability, rating systems (including the LEED and the Walk Score), walkability, and the characteristics of multi-family housing, among other topics. The authors focused first on the concept of sustainability to understand how the various systems address the fundamental three aspects. Next, the authors explored walkability, which is a part of the environmental aspect. Finally, major sustainability rating systems were reviewed, to enable the authors to justify the study's focus on two rating systems, the LEED-ND and the Walk Score. At the end of the section, the authors describe the research gap between the existing body of knowledge and the work of this paper.

### Sustainability

The concept of sustainability has been defined and studied in order to promote sustainable development. As defined in the previous section, sustainability is comprised of three aspects: environmental, economic, and social effects [5, 6]. Sustainable development is defined as “. . . a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development—economic development, social development, and environmental protection—at the local, national, regional, and global levels” [35]. In order to ensure and implement sustainable development, economic, environmental, and social parameters must be balanced and managed for long-term development [36-38].

Using these fundamental definitions, previous studies have developed and identified sustainability in the built environment, considering the three parameters of sustainability. Kibert defined sustainability in the built environment as “creating and operating a healthy built environment based on resource efficiency and ecological design” [39]. Ofori defined it as “creating construction items using best-practice clean and resource-efficient techniques, from the extraction of the raw material to the demolition and disposal of its components” [40]; and R&A Team defined it as “practices that have sustainability benefits during the construction phase of a project, including those benefits that may result from decisions made during the planning and design phases of a project” [41]. Many previous studies examined sustainability in the built environment [42-46], but most of them focused on the authors’ perceptions of an individual building. Since construction projects are increased in size, there is increasing attention on sustainability in the built environment beyond individual buildings; instead, sustainability now focuses on the neighborhood or adjacent project sites [8].

### **Walkability**

Walkability is defined as “the extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people ...” [47]. Another definition, by the Wisconsin Department of Transportation, is a development that is “thoughtfully planned, designed, or otherwise retrofitted to integrate pedestrian travel into the community’s fabric. In a walkable community, walking is considered a normal transportation choice and is not a distraction or obstacle to motor vehicle traffic” [48]. Walkability or accessibility is negatively correlated to environmental impact and traffic congestion [15, 16]. If a community is walkable or accessible without a vehicle, it is considered a sustainable community with respect to the social and environmental parameters of sustainability.

Essential characteristics of a walkable community are 1) connectivity of the path network, 2) linkage with other modes including bus or subway, 3) varied land use patterns, 4) safety both from traffic or crime, 5) quality of paths (e.g., adequate width or clear marking), and 6) path context, including street design [15]. The walkable community increases focus on the pedestrian and reduce the focus on vehicles [49]. Thus, as walkability becomes the fundamental building block for the sustainable city, sustainability rating systems should be developed to assess these essential characteristics [46, 49].

This paper focuses on the sustainability assessment of multi-family housing projects. Unlike single-family housing, multi-family housing projects are open spaces, pedestrian-friendly environments, with proximity to urban amenities [50]. This research aims to identify the similarity or dissimilarity between the LEED-ND certification score and the Walk Score.

### **Sustainability Rating Systems**

To assess and control the sustainability of construction projects, sustainability rating systems and metrics have been developed and utilized [8-15, 26]. However, a rating system is needed to incorporate these concepts into

construction standards and to normalize assessment outcomes [51].

Because sustainable communities provide economically, environmentally, and socially sustainable conditions [52], most rating systems have scoring criteria that assess those three conditions of sustainability. Moreover, in three rating systems categorized by Hastings and Walls, total quality assessment (TQA) systems measure sustainability with several criteria. The overall evaluation result is the sum of each criterion rating. Following are examples of the criteria of these TQA systems:

- 1) The Leadership in Energy and Environmental Design (LEED) has different certification categories, and the LEED-Neighborhood Development (ND) has criteria that include smart location and linkage, neighborhood pattern and design, green infrastructure and buildings, innovation, and regional priority [9].
- 2) The Green Star system's categories are livability, economic prosperity, environment, design, and governance and innovation [13].
- 3) The Walk Score calculates a score based on the project's distance to the closest amenities, such as parks, theaters, and schools, in each category [27].
- 4) The Building Research Establishment Environmental Assessment Method (BREEAM) uses credit categories including energy, health and wellbeing, innovation, land use, materials, management, pollution, transport, waste, and water [53].

Each of these rating systems has its purposes and is designed to fit its objectives. Shan and Hwang identified essential criteria of the green building rating systems as “water,” “material,” “energy,” “indoor environment,” “site,” “land and the outdoor environment,” and “innovation.” Walkability, which is the primary object of this study, is relevant to site criteria that focus on location, planning, design, assessment, and regeneration and development [24]. These site criteria can be measured by eight rating systems: 1) the Comprehensive Environmental Performance Assessment Scheme (CEPAS) from Hongkong; 2) the Green Building Index (GBI) from Malaysia; 3) Green Globes (GG) from North America; 4) the Global Sustainability Assessment System (GSAS) from Qatar; 5) the Built Environmental Assessment Method (BEAM) from Hongkong; 6) the Indian Green Building Council (IGBC) rating system; 7) the International SBTtool (ISBT); and 8) LEED system from the US [9, 17, 22, 24, 54].

Among these rating systems, the LEED certification is the most popular rating system in North America, where the Walk Score also available. These two rating systems, the LEED and the Walk Score, can be utilized to measure sustainability, with a focus on a project's walkability to the adjacent community or land development.

### **LEED-ND**

According to the USGBC, the LEED-ND certification was developed in 2007 to provide “independent, third-party verification that a development's location and design meet accepted high levels of environmentally responsible, sustainable development” [9]. In other words, the LEED-ND program is used to certify a single land development project, while other LEED programs are used to certify individual buildings [9, 11]. The LEED-ND

system can be utilized to identify an appropriate sustainable location for land development or a multi-family housing project, to leverage project information for sustainable development, and to proactively forewarn developers of potential sustainability-related issues [11]. Lastly, the LEED-ND rating system enables continuous sustainable development for the community [11, 26].

The goals of the LEED-ND approach are the promotion of development near existing communities and public transit infrastructure, and the encouragement of daily physical activity by walking or riding bicycles to access community resources [9]. The LEED-ND certified site should contain at least two habitable buildings, and the site area must be smaller than 6.0 km<sup>2</sup> [9]. The specific criteria of the LEED-ND system (v2009) are grouped into five categories: 1) Smart Location and Linkage (27 possible points); 2) Neighborhood Pattern & Design (44 possible points); 3) Green Infrastructure & Buildings (29 possible points); 4) Innovation (six possible points); and 5) Regional Priority (four possible points) [9]. Among the criteria, Neighborhood Pattern & Design (NPD) pertains to walkability. (Table 1 lists the NPD criteria.) Out of 110 possible points for the LEED-ND certification, available points for sustainable sites were increased from 15 percent (in version 2.2) to 23 percent (in version 2009). This increase reflects the inclusion of consideration of how land use affects pedestrian patterns and behavior [8, 55].

**Table 1.** Neighborhood Pattern & Design (NPD) Criteria on the LEED-ND Rating System

No.	Criteria	No.	Criteria
1	Walkable Streets	10	Transit Facilities
2	Compact Development	11	Transportation Demand Management
3	Connected and Open Community	12	Access to Civic and Public Space
4	Walkable Streets	13	Access to Recreation Facilities
5	Compact Development	14	Visitability and Universal Design
6	Mixed-Use Neighborhoods	15	Community Outreach and Involvement
7	Housing Types and Affordability	16	Local Food Production
8	Reduced Parking Footprint	17	Tree-Lined and Shaded Streetscapes
9	Connected and Open Community	18	Neighborhood Schools

However, the significant drawback of the LEED-ND rating system is that achieving the certification requires substantial money, time, and expert input. That is why very few projects are certified [11, 26]. Another critique is that the LEED-ND cannot be utilized to certify all neighborhood development projects [56].

### **Walk Score™**

The Walk Score is the walkability index. It was initiated in 2007 to provide the simplest and best solutions for the sustainable community [28]. The Walk Score calculates the distance to 13 categories of amenities: grocery stores, coffee shops, restaurants, bars, movie theaters, schools, parks, libraries, bookstores, fitness centers, drugstores, hardware stores, and clothing/music stores [28]. The score examines the distance to other amenities and measures accessibility to the 13 amenities on a large-scale project, including land development or a multi-family housing

project. That is why the Walk Scores in the same area or on the same street can differ, depending on the distance and density of neighborhood facilities [28].

The Walk Score is similar to the Walkable America Checklist, which asks 35 questions to assess a neighborhood's walkability [57]. However, the Walk Score can be automatically updated, which enables a savings of time, cost, and expertise [28].

### Summary of Prior Studies

As discussed above, the three parameters for sustainability and sustainable development are the economic, environmental, and social aspects [7, 35-38]. In order to assess the level of sustainability, many rating systems have been developed and utilized [7-14, 26]. Unlike other individual building projects, land development and multi-family housing projects in Asia have unique project characteristics, and walkability or accessibility determines the land use pattern or urban design [55]. The creators of a few sustainability rating systems, including the LEED-ND rating system and the Walk Score, had this practice in mind. However, the LEED-ND certification is preferred for new projects, since, according to the USGBC, "half of the total building square footage must be a new or major renovation," while the Walk Score can be utilized for existing facilities or infrastructure [11].

The drawback of the LEED rating system is that it requires significant time and resources, and previous studies examined whether the less demanding Walk Score can be used to replace LEED-ND certification [11, 26, 58, 59]. The Walk Score could be utilized to assess sustainability on par with the LEED-ND index. Koschinsky and Talen [58] examined distance to transit and destination accessibility through both Walk Scores and LEED-ND ratings. Also, Talen et al. [11] compared the LEED-ND ratings and the Walk Scores of possible appropriate locations (but not actual projects) in Phoenix, Arizona.

The walkability/accessibility can be measured by the criteria of the Neighborhood Pattern & Design (NPD) category (Max: 44 points), and the NPD score accounts for 40 percent of the total LEED-ND score [9]. This means, the total LEED-ND score heavily depends on the NPD score and the strong association between the LEED-ND score and walkability performance. This paper aims to investigate whether the LEED-ND score and the Walk Score can be used in the same way when assessing walkability.

## Methods

To measure the sustainability of multi-family housing projects, this study compared two sustainability rating systems, the LEED-ND and the Walk Score, for 26 LEED-ND certified projects. Among the list of LEED-ND (v2009) certified projects [33], the authors excluded projects located outside North America choosing only selected areas in the U.S. and Canada, since the Walk Score is only available in North America [27]. In addition, only 26 LEED-ND (v2009) certified projects were selected because these projects had detailed scores for each category that authors were able to access [31]. The findings from this study will guide the sustainability rating systems for multi-family housing projects.



## Overview of the Research Methodology

To evaluate the sustainability rating systems, the authors followed the research methodology presented in Figure 1.

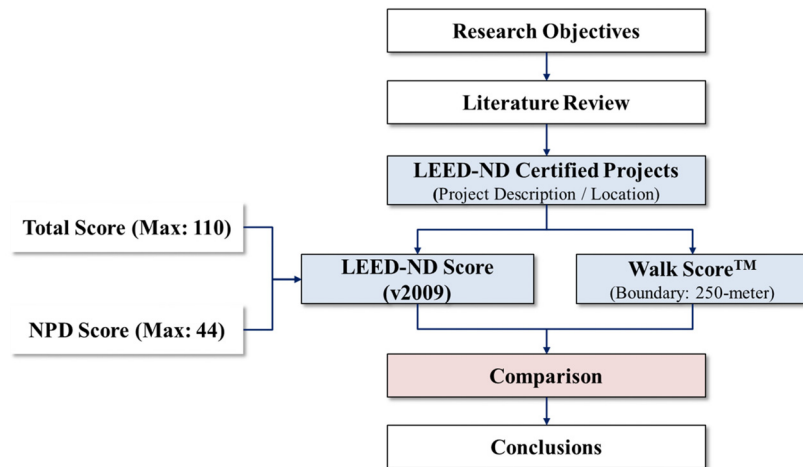


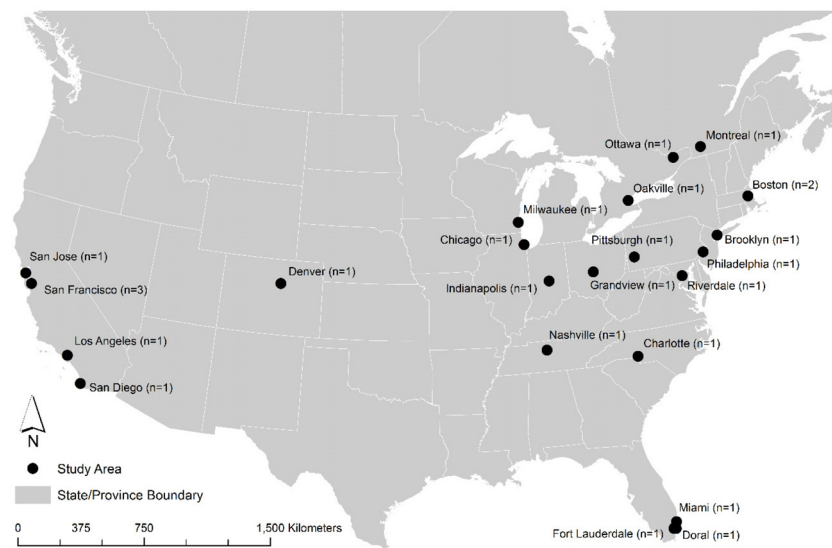
Figure 1. Research Methodology.

Once the research objective was established as a comparison of LEED-ND and Walk Scores to provide guidance for a less expensive sustainability rating system, the research scope was limited to LEED-ND certified projects. The Walk Score is available in almost every location in the U.S., while the LEED-ND score is only available for limited projects. The authors conducted a literature review in the area of sustainability, investigating sustainability rating systems that included LEED and Walk Scores, plus the characteristics of multi-family housing, to identify research gaps. The 26 LEED-ND certified projects' descriptions and location information were collected from the USGBC website [9]. Finally, one sample t-test was employed to compare means of two different groups: 1) the total LEED-ND score (Max: 110) and the Walk Score (Max: 100); and 2) the NPD score (Max: 44) and the Walk Score (Max: 100).

## LEED-ND Certified Projects

After a project is certified, the project team submits its project profile, which includes the project title, the project site address, the LEED scoring card, and the team's strategy for achieving LEED certification. If any of the project's profile, especially the LEED score, was not available from the USGBC webpage, the project was excluded from this study. In the end, the authors collected 26 LEED-ND certified projects (Table 2). The 26 project locations are illustrated in Figure 2. The projects are distributed across North America, in both the United States and Canada. Since the size of a LEED-ND certified project is bigger than that of other individual facilities, most LEED-ND certified projects are located on the West or East coasts of the U.S.





**Figure 2.** LEED-ND Certified Project Locations with the Number of Projects.

**Table 2.** List of LEED-ND certified Projects

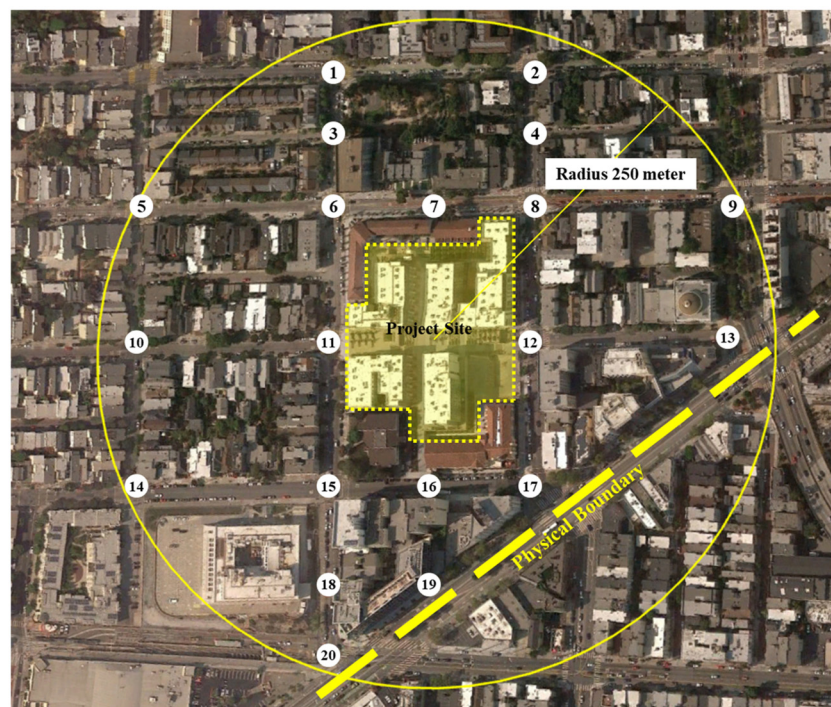
No.	Project Title	Certified Year	Location	No.	Project Title	Certified Year	Location
1	Lansdowne Park	2016	ON, Canada	14	Westlawn Revitalization	2013	WI, U.S.
2	Brightwalk	2016	NC, U.S.	15	Larimer Neighborhood	2013	PA, U.S.
3	Rebuild Potrero	2015	CA, U.S.	16	Grandview Yard	2013	OH, U.S.
4	DHA Mariposa Mixed-use Development	2015	CO, U.S.	17	Cafritz Property at Riverdale Park	2013	MD, U.S.
5	55 Laguna Street	2014	CA, U.S.	18	Rebecca Street	2013	ON, Canada
6	Seaport Square	2014	MA, U.S.	19	The Shipyard/Candle-stick Point	2012	CA, U.S.
7	Old Colony Public Housing Re-development	2014	MA, U.S.	20	Northwest Gardens	2012	FL, U.S.
8	MFCDC 20/21 Project	2014	IN, U.S.	21	Miami Design District	2012	FL, U.S.
9	Downtown Doral	2014	FL, U.S.	22	Harper Court	2012	IL, U.S.
10	North First Campus	2014	CA, U.S.	23	OneCITY	2012	TN, U.S.
11	9th and Berks Street TOD	2013	PA, U.S.	24	The Village at Market Creek	2012	CA, U.S.
12	Les Bassins du Nouveau Havre de Montreal	2013	QC, Canada	25	Navy Green	2012	NY, U.S.
13	Jordan Downs	2013	CA, U.S.	26	Sunnydale Hope SF	2011	CA, U.S.

The LEED-ND (v2009) index comprises several criteria: 1) Smart Location and Linkage (Max: 27 points); 2) Neighborhood Pattern & Design (Max: 44 points); 3) Green Infrastructure & Buildings (Max: 29 points); 4) Innovation (Max: six points); and 5) Regional Priority Credits (Max: four points) [9]. The total achieved LEED-ND score and certification level for each project was collected for further analysis.

## Walk Score™

As discussed in Section 2, the Walk Score is based on a block in a city [27]. The LEED-ND certification requires at least two habitable buildings on a site no larger than 6.0 km<sup>2</sup> [9]. Thus, a LEED-ND project had to have several intersections for the authors to be able to collect multiple Walk Scores from that LEED-ND project location. However, the USGBC webpage provides the LEED-ND project location without showing the boundary of the project site. Based on one LEED-ND certified project location, the authors set a project boundary with a radius of 250-meter from the center of the LEED-ND certified project. Then the authors collected 20 Walk Scores within the boundary and averaged all Walk Scores to get the final Walk Score for the 26 LEED-ND certified projects. Where there was a freeway, highway, lake, or oceanfront, that boundary was considered a “Physical Boundary” and, therefore, was excluded from the collection of Walk Scores, since that region was not accessible to pedestrians.

Among the 26 LEED-ND certified projects studied, one project (the 55 Laguna Street project or Alchemy by Alta) case is shown in Figure 3. Within the 250-meter boundary, the authors picked 20 intersection points to collect Walk Scores; areas beyond the physical boundary line were not considered.



**Figure 3.** Example of 20 Walk Score Points for the “55 Laguna Street Project in CA, USA” (Map image from Google Earth).

Table 3 presents the 20 individual Walk Scores, along with their average. The Walk Scores within the 250-meter boundaries of all 26 LEED-ND certified projects were collected for further analysis. To collect 20 Walk Scores at 20 points within the development, the authors identified street names at all intersections from the Google Earth map, and then found the scores from the Walk Score™ webpage [27]. (See Figure 3 and Table 3.)

**Table 3.** 20 Walk Scores of the 55 Laguna Street Project

Project	Walk Scores																				Avg.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
55 Laguna St.	96	97	98	96	96	98	96	96	96	97	98	97	99	98	98	97	97	97	98	86	96

### Statistical Analysis

The authors compared both LEED-ND and Walk Scores by employing one-way ANOVA analyses and calculated the correlation coefficient to identify the relationship between the LEED-ND scores and the Walk Scores.

## Results

Each of the profiles of the 26 LEED-ND certified projects on the USGBC website [33] includes a project title, a project site address, and a scoring card. After collecting this data, the authors collected 20 Walk Scores within the 250-meter radius from the center of each of these LEED projects and then averaged the scores to get the final Walk Score. Both the LEED scores and the Walk Scores are presented in Table 4.

**Table 4.** Comparison between LEED-ND score and Walk Score

No.	Project Title	LEED-ND score (Max: 110)	LEED (NPD) score (Max: 44)	Walk Score (Max: 100)
1	Lansdowne Park	56	23	92
2	Brightwalk	43	18	47
3	Rebuild Potrero	68	32	81
4	DHA Mariposa Mixed-use Development	62	30	85
5	55 Laguna Street	63	28	96
6	Seaport Square	63	27	83
7	Old Colony Public Housing Redevelopment	61	24	81
8	MFCDC 20/21 Project	53	18	62
9	Downtown Doral	41	21	65
10	North First Campus	41	13	31
11	9th and Berks Street TOD	82	36	89
12	Les Basins du Nouveau Havre de Montreal	62	23	91
13	Jordan Downs	57	24	59
14	Westlaw Revitalization	54	23	63
15	Larimer Neighborhood	51	21	81
16	Grandview Yard	50	21	47
17	Cafritz Property at Riverdale Park	43	22	48
18	Rebecca Street	41	14	74
19	The Shipyard/Candlestick Point	70	31	63
20	Northwest Gardens	62	16	77
21	Miami Design District	61	21	94
22	Harper Court	61	32	92
23	OneCITY	58	26	55
24	The Village at Market Creek	55	19	59
25	Navy Green	53	19	95
26	Sunnydale Hope SF	64	33	35
Average		70.9	24.0	56.7

The average of the 26 LEED-ND certified project scores is 56.7 (out of 110), the NPD score on the LEED-ND certified projects is 24 (out of 44), and the Walk Score is 70.9 (out of 100). Figures. 4 and 5 illustrate a scatter plot with the coordinates of the Walk Score (y-axis) and the LEED-ND score (x-axis) or the NPD score on the LEED rating system, respectively. Each point in the scatter plot indicates a project listed in Table 4.

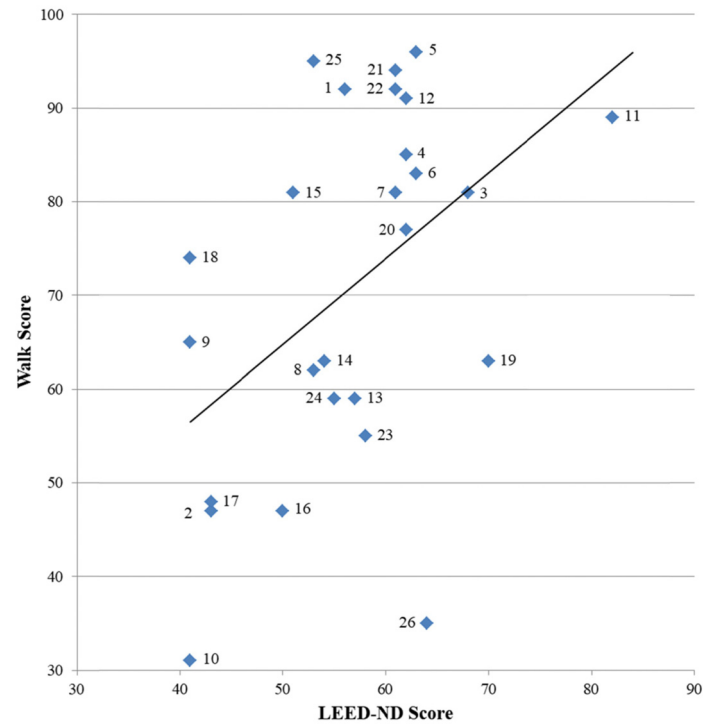


Figure 4. Scatter Plot (LEED-ND Score vs. Walk Score). Each Number Indicates a Project Number in Table 4.

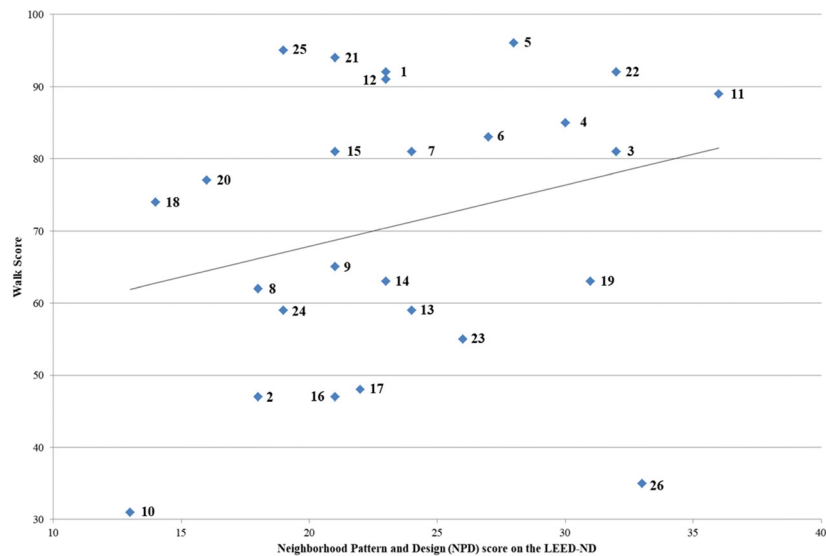


Figure 5. Scatter Plot (NPD Score on the LEED-ND vs. Walk Score). Each Number Indicates a Project Number in Table 4.

As illustrated in Figure 4, the linear regression analysis determined that the coefficient of the LEED-ND score on the Walk Score was 0.9174. This indicates that a one-point increase in the LEED-ND score is likely to increase the Walk Score by 0.92 points. The low LEED-ND score correlates to a low Walk Score, and a high LEED-ND score correlates to a high Walk Score. In addition, two-sample t-tests for equal variances,  $t(50) = -3.34$ ,  $p < .001$ , showed that the mean value for the Walk Score (70.96) is significantly larger than the mean value for the LEED-ND score (56.73). This statistical analysis confirmed that the two scores are substantially different.

The linear regression analysis plotted in Figure 5 shows that the coefficient of the LEED-ND score on the Walk Score was 0.8487. This indicates that a one-point increase in LEED-ND score is likely to increase the Walk Score by 0.85 points. As shown in Figure 4, the low LEED-ND score correlates to a low Walk Score, and a high LEED-ND score correlates to a high Walk Score. Also, the results of two-sample t-test for equal variances,  $t(50) = -11.88$ ,  $p < .001$ , show that the mean value for the Walk Score (70.96) is significantly larger than the mean value for the NPD score (24.0) on the LEED-ND rating system using. This statistical analysis confirmed that the two scores are substantially different.

The authors conducted the pairwise correlation analysis between the LEED-ND score and the Walk Score to assess any correlations. As illustrated in Table 5, the correlation coefficient was 0.4686, showing that there is a positive and statistically significant association between the LEED-ND score and the Walk Score. The analysis of the NPD score on the LEED-ND rating system and the Walk score resulted in a correlation coefficient was 0.2648, showing that there is a positive, but not the statistically significant relationship between them.

**Table 5.** Correlation between Two Samples, LEED-ND vs. Walk Score

	LEED-ND score	NPD score on the LEED-ND	Walk Score
LEED-ND score	1.000		
NPD score on the LEED-ND	-	1.00	
Walk Score	0.4686* $p = 0.0158$	0.2648 $P = 0.1911$	1.000

## Discussion

Because sustainability has gained increased attention as a way to address a variety of environmental, economic, and social issues, much previous research has examined how sustainability can be incorporated into construction projects [1-5, 60]. Specifically, some previous studies have examined sustainability rating systems, including the LEED-ND rating system and the Walk Score.

Among the rating systems designed to assess the sustainability of a construction project, the LEED certification is the most common and widespread rating system in North American and Asian countries [26]. The LEED-ND assessment requires significant resources regarding time, money, and expertise, while the Walk Score is simpler,

less expensive, and more easily replicated [26].

This study made comparisons between the LEED-ND scores and the Walk Scores of LEED-ND certified projects. The analyzed score is summarized in Figure 6, with the circled-dotted line (●) representing the LEED-ND score, the triangle-dotted line (▲) representing the NPD score on the LEED-ND, and the square-dotted line (■) indicating the Walk Score. It is worthy to note the strong similarity between the LEED-ND score and the Walk Score, as presented in Figure 6. This similarity indicates that the higher Walk Score corresponds to the higher LEED-ND score, and that the lower Walk Score corresponds to the lower LEED-ND score. However, there are no statistically significant relationships between the NPD scores (Max: 44) on the LEED-ND rating system and the Walk Score.

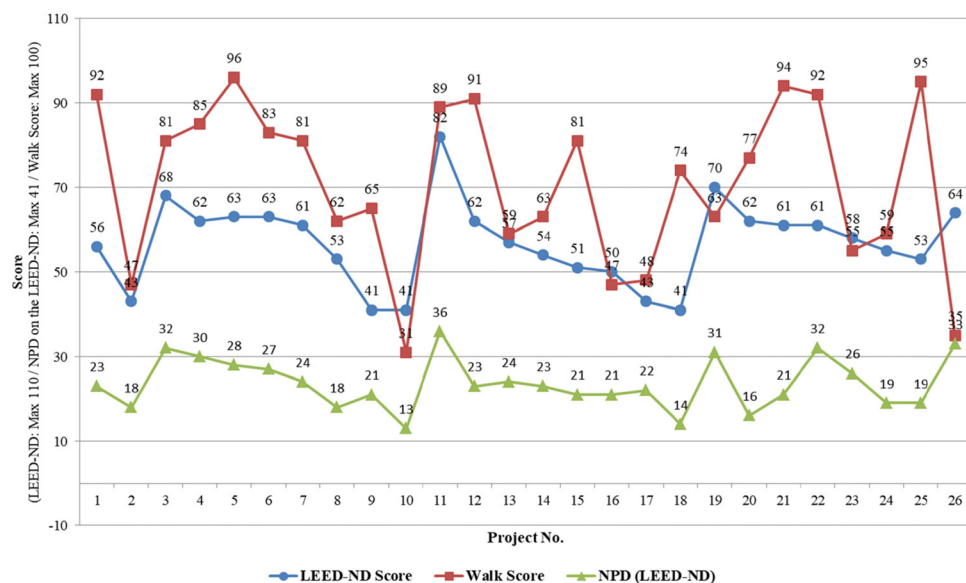


Figure 6. Comparison between the LEED-ND Score and the Walk Score of 26 Projects.

One of the reasons for the similar pattern between the Walk Score and the LEED-ND score is that they both were designed as a measure of New Urbanism (NU) development. This type of development focuses on well-connected neighborhoods, high walkability, and increased density around a community [61-63]. This trend promotes the compact city and transit-oriented development (TOD) so that many amenities can be constructed within a neighborhood [64]. Since the Walk Score is calculated by measuring the distance to 13 amenities around a community, New Urbanism development correlates highly with it. Moreover, since New Urbanism contributes to the sustainability of built facilities, it also associates with the LEED-ND score [63].

The reason that similar patterns were not found between the NPD score and the Walk Score is that the Walk Score does not consider the land use or a project's relationships with the adjacent area—one of the most important criteria of the NPD score. Future research should develop a comprehensive framework that could incorporate location factors into comparisons of multiple sustainable projects.



This study's contributions have a limitation related to the Walk Score. Even though the LEED-ND certified project has a large project boundary, the USGBC does not release the exact boundary dimensions of the project. Thus, the authors collected 20 walk scores around each LEED-ND project location and averaged them to obtain overall project Walk Scores. Therefore, the accuracy of the Walk Score should be considered in a future study. Also, the relatively small sample size should be factored into any interpretation or generalization of the findings. Moreover, some states' infrastructure and development paradigms may facilitate the pedestrian movement more than those of other states. The limited sample size of this study did not allow the researchers to consider these varying degrees of pedestrian friendliness while examining the development projects. Future research should take development environments, regulations, and policies into account when comparing projects across wide geographical areas.

Despite these limitations, this study compared two sustainability rating systems, the LEED-ND index, and the Walk Score, and identified both similar and dissimilar patterns. The findings on walkability will contribute to the existing body of knowledge and will help project stakeholders meet their sustainability goals, especially for owners and developers of multi-family housing projects. Multi-family housing projects are similar to condominium projects in the United States and are the most common building type in Asian countries [65]. The commonalities of multi-family housing in the U.S. and Asia are higher density, open spaces, pedestrian environments, and proximity to urban amenities [50]. The primary difference between multi-family housing in the U.S. and Asia consists of the type of residence constructed and its intended user [65]. Most multi-family housing projects in the U.S. are constructed for first-time buyers, small families, retirees, and single-person households [50], whereas, in Asia, multi-family housing is the most common housing type, regardless of resident status, due to government policy and the savings on construction costs [65, 66].

## Conclusions

This study compared scores from two sustainability rating systems on 26 LEED-ND certified projects: the LEED for Neighborhood Development (ND) index and the Walk Score. Statistical analysis of the two scores revealed similar patterns. However, when the authors compared only walkability or accessibility, the two scores were not associated.

The primary contribution of this study is a better understanding of sustainability rating systems. The authors examined rating systems and identified two designed for multi-family housing projects. Many previous research projects identified the impact of sustainability assessment with only one rating system and, thus, were unable to make any comparisons across systems. Other significant contributions of this study are the identification of the similarity of the LEED-ND score and the Walk Score, and the associations between the LEED-ND NPD score and the Walk Score. The LEED certification has limited application for an existing facility or a new construction project since it would require plan changes requiring additional human resources, time, and money. For such projects, sustainability can be measured by the simpler and less expensive Walk Score.



The authors recommended pursuit of the following research questions for a better understanding of sustainability in the built environment: 1) Which aspects of the LEED-ND certification lead to similar patterns with the Walk Score?; and 2) What level of the Walk Score reflects higher sustainability implementation on a construction project? In addition, efforts should be made to develop other sustainability rating systems focused on walkability, taking into considerations of site access and site design factors.

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