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RESEARCH ARTICLE

Designing healthy communities: A walkability analysis of LEED-ND

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Abstract
Prevailing city design in many countries has created sedentary societies that depend on automobile use. Consequently, architects, urban designers, and land planners have developed new urban design theories, which have been incorporated into the Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) certification system. The LEED-ND includes design elements that improve human well-being by facilitating walking and biking, a concept known as walkability. Despite these positive developments, relevant research findings from other fields of study have not been fully integrated into the LEED-ND. According to Zuniga-Teran (2015), relevant walkability research findings from multiple disciplines were organized into a walkability framework (WF) that organizes design elements related to physical activity into nine categories, namely, connectivity, land use, density, traffic safety, surveillance, parking, experience, greenspace, and community. In this study, we analyze walkability in the LEED-ND through the lens of the nine WF categories. Through quantitative and qualitative analyses, we identify gaps and strengths in the LEED-ND and propose potential enhancements to this certification system that reflects what is known about enhancing walkability more comprehensively through neighborhood design analysis. This work seeks to facilitate the translation of research into practice, which can ultimately lead to more active and healthier societies.
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1. Introduction

Architects, urban designers, and land planners have recognized that city design can contribute to the challenges faced by urban societies, including the trend toward urban sprawl and

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increased sedentariness (Frank et al., 2003). The U.S. Green Building Council (USGBC) created the Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) rating system to certify sustainable development and provide design guidelines that can help address urban society challenges (http://www.usgbc.org/articles/getting-know-leed-neighborhood-development). This study builds on a previous walkability study, which focused on the degree to which the built environment promoted physical activity as part of daily routine. In this study, we analyze walkability in the LEED-ND using the walkability framework (WF). We conduct quantitative and qualitative analyses of how walkability is captured in the LEED-ND and propose a walkability-enhanced version of the rating system.

1.1. The LEED initiative and LEED-ND

The USGBC is a nonprofit organization that acts as an independent entity. The USGBC verifies that sustainable practices are adopted in the design, construction, operation, and maintenance of buildings in the U.S. and internationally through its certification system known as LEED (http://www.usgbc.org/leed). LEED certification has grown to include building design and construction, interior design and construction, building operations and maintenance, neighborhood development, and homes. The certification system for neighborhood development was launched in 2009, and hundreds of certified neighborhoods currently exist worldwide (http://www.usgbc.org/projects).

All LEED certifications are based on a simple point-based rating system to ensure practicality. The rating system includes mandatory prerequisites that projects must comply with. Satisfying these prerequisites makes projects eligible to apply for certification, but points are not earned from prerequisites (http://www.usgbc.org/leed). In addition to the prerequisites, optional credits are available that may be pursued for a given project. Each credit in the LEED has an associated number of points that are awarded to a project if it complies with the credit. The total number of points earned by a project determines its LEED certification level: certification (40–49 points), silver (50–59 points), gold (60-69 points), and platinum (80 points and above). A total of 110 optional points are available.

The LEED-ND places significant emphasis on neighborhood design. Thus, the site selection, design, and construction phases can ensure that buildings and supporting infrastructure are linked, supporting the relationships among neighborhoods, landscapes, and larger local and regional contexts (Sharifi and Murayama, 2013). Moreover, rather than relying solely on regulatory requirements for sustainable neighborhood development, the LEED-ND is intended to be a voluntary, market-driven approach with the aim of being comprehensive but readily implementable (Garde, 2009).

The LEED-ND is divided into five sections: (1) smart location and linkage (SLL), (2) neighborhood pattern and design (NPD), (3) green infrastructure and building (GIB), and (4) innovation and design process, with additional points that may be earned for extra significance in the local area under the optional section (5) “Regional Priority” (http://www.usgbc.org/resources/leed-v4-neighborhood-development-checklist). Some prerequisites and credits offer several options from which the developer may choose. Other prerequisites are divided into cases, and developers must select the most appropriate case for their project. Finally, some prerequisites include several parts (e.g., a, b, and c), and the developers must comply with all of them. Some credits also include several items (e.g., a, b, and c), and the number of points earned depends on the number of items that the project complied with.

The LEED-ND integrates the sustainable development theories from new urbanism thinking and the smart growth policies that followed, as well as green building certification principles (Jackson, 2003). The LEED-ND attempts to address all of the key principles of sustainable neighborhood development, one of which is to provide compact development and integrated sustainable mobility, effectively reducing the need for automobile travel (Luederitz et al., 2013). By providing points for design elements that promote pedestrian activity, the LEED-ND indirectly encourages physical activity through enhanced walkability in neighborhoods (Lewin, 2012). Research has shown that LEED-ND projects are associated with increased physical activity in children (Stevens and Brown, 2011).

The LEED-ND appears to have been accepted by developers. Although concerns do exist within the development and building community, feedback suggests that the goal of making it practical and flexible has been met, based on surveys of developers (Garde, 2009; Knack, 2010; Sharifi and Murayama, 2014). Moreover, the LEED-ND has been adopted by several authorities to provide guidelines for urban development that support slow and incremental lifestyle changes that reduce demands on the environment (Lewin, 2012).

1.2. LEED-ND and walkability

The manner in which the LEED-ND addresses walkability is viewed as one of the strengths of the rating system; however, this strength may come at the expense of other categories. Sharifi and Murayama (2014) compared the LEED-ND with conceptually similar neighborhood sustainability assessment tools used in the United Kingdom and Japan and determined that LEED-ND addressed walkability well and that walkability played a pivotal role in receiving LEED-ND certification when applied by developers. However, the low cost of implementing the walkability criterion has a relatively high weight in the LEED-ND. The concern is that other important categories that have lower weights and/or involve greater costs are less frequently implemented in projects that receive certification (Garde, 2009; Knack, 2010; Sharifi and Murayama, 2014).

Encouraging results have been obtained in LEED-ND walkability research; LEED-ND-certified neighborhoods are correlated with increased physical activity. Stevens and Brown (2011) observed higher levels of moderate-to-vigorous physical activity (MVPA) in LEED-ND neighborhoods than that in other communities. Gallimore et al. (2011) compared a LEED-ND-certified neighborhood and an uncertified suburban neighborhood in terms of walking routes to school and determined that the LEED-ND-certified neighborhood provided better walking conditions for children. However, this finding does not mean that children would actually

walk to school. Napier et al. (2011) noted that demographic and municipal policy trends in the U.S. were leading to fewer and larger schools. This finding indicates that fewer children will realistically be able to walk to school, even if the LEED-ND calls for safer routes, because they will likely live far from the school.

Since the advent of the LEED-ND, considerable research has been conducted on the effects of the built environment on walkability and physical activity in research domains outside urban design and architecture, including physical activity, thermal comfort, land planning and transportation, health and the built environment, and greenspace. The LEED-ND is considerably helpful to architects, land planners, and urban designers who wish to design sustainable neighborhoods because it provides specific design guidelines (Knack, 2010). However, this certification has not integrated the findings on walkability from other research domains. This study aims to address this gap and to integrate the findings from other research domains into the LEED-ND in a manner that adheres to the strengths of the certification system (relatively easy to implement and flexible), such that the suggested enhancements can be considered not only for their scientific value but also for their applicability to the current LEED-ND structure.

1.3. Walkability framework

The first stage of this research involved synthesizing findings on neighborhood design elements that are related to walkability from multiple research domains (Zuniga-Teran, 2015). This synthesis also treated the neighborhood design elements found in the LEED-ND as a representative of the architecture and urban design domain. As a result of this synthesis, we developed a conceptual framework, i.e., the WF, that comprises nine categories: (1) connectivity, (2) land use, (3) density, (4) traffic safety, (5) surveillance, (6) parking, (7) experience, (8) greenspace, and (9) community. Each category describes a set of neighborhood design elements that affect physical activity and human health (Table 1). Some neighborhood design elements are interrelated, such that they can be considered in several categories. For example, a strip of vegetation along the sidewalks provides safety from traffic (part of the traffic safety category) and reduces fumes and noise (part of the experience category).

Some categories include multiple neighborhood design elements that can clearly be grouped into subcategories. The traffic safety category was further divided into four subcategories, namely, pedestrians, bicycles, transit systems, and traffic-calming treatments. Similarly, the experience category was divided into seven subcategories, namely, streetscape proportions, aesthetics, thermal comfort level, wayfinding considerations, slope, presence of fumes/noise, and presence of dogs.

Current research shows that all walkability categories are related to physical activity. Woldeamanuel and Kent (2016) reported that the availability and quality of sidewalks (*traffic safety* category) and the connectivity of the street network (*connectivity* category) were significantly associated with people accessing and using public transportation in San Fernando Valley, Los Angeles, U.S.A. Similarly,

Table 1 Walkability framework (WF). The neighborhood design elements associated with physical activity are grouped into nine categories that together form the WF.

WF categories	Subcategories	Main aspect of the category
Connectivity		Provide a street network that gives multiple, direct, and short routes.
Land use	• Pedestrians • Bicycles • Transit systems • Traffic-calming treatments	Locate a variety of small businesses within a 10 min walk (1/2 mile) from homes.
Density		Require a high residential and retail density. High-rise towers must consider the pedestrian scale at street level to avoid oppression.
Traffic safety		Slow the traffic and give pedestrians and bikers safe places to travel. In addition, provide safe and comfortable bus stops and a frequent and reliable bus service.
Surveillance		Design buildings such that pedestrians traveling on the street can be seen from the surrounding homes and businesses.
Parking		Decrease parking availability and locate parking away from streets.
Experience	• Streetscapes • Aesthetics • Thermal comfort • Wayfinding • Slope • Fumes/noise • Dogs	Provide a pleasant walking and biking experience by addressing streetscape proportions, aesthetics, wayfinding considerations, thermal comfort level, slope, presence of fumes, and presence of dogs/wildlife.
Greenspace		Include a variety of greenspace in size and proximity with easy access and vegetation throughout the neighborhood.
Community		Provide spaces for social interactions among neighbors and encourage the participation of neighbors in the decision-making processes of the community.

Stockton et al. (2016) developed a walkability model for London, where they measured connectivity, residential density, and land use mix, and observed a radial decay in walkability. People who lived in the center of London, which scored higher in walkability, were more likely to walk more than 6 h/week than those who lived in the peripheries of the city, which scored lower in walkability. In an effort to examine how the relationship between built environment and physical activity varied in low-income and middle-income countries, Adlakha et al. (2016) adopted the Neighborhood Environment Walkability Scale questionnaire in India. This tool was developed by Cerin et al. (2006) and measures connectivity, density, traffic safety, safety from crime (*surveillance* category), land use mix, aesthetics (*experience* category), parking, and infrastructure for walking and bicycling. According to Adlakha et al. (2016), this tool measured walkability in India acceptably and reliably.

With regard to *greenspace* category, Ward et al. (2016) reported that children who were exposed to greenspace in Auckland, New Zealand were positively related to MVPA and emotional well-being. Similarly, Veitch et al. (2016) observed that Australian women who lived close to parks were more likely to meet physical activity recommendations and less likely to be obese than women who do not live close to parks. In addition to greenspace, Soltero et al. (2015) examined the relationship between physical activity and its resources (i.e., parks and plazas) in Puerto Vallarta, Mexico. Soltero (2015) determined that plazas (*community* category) attracted more users than parks, particularly women, and their discussion suggested that the quality of amenities and incivilities were determinants of their use.

2. Methods

In applying the WF to the LEED-ND, identifying the prerequisites and credits in the LEED-ND that are related to walkability and human health and determining the percentage of points in the LEED-ND that are related to walkability are necessary. Then, we compared the LEED-ND with the design elements found in each of the nine WF categories. We added a column to the tables from the synthesis study (Zuniga-Teran, 2015) and identified which prerequisites and credits from the LEED-ND were related to the design elements for each category. This analysis identified walkability gaps and strengths in the LEED-ND (Tables 4-12 in the Appendix).

Then, we determined the walkability score for LEED-ND for each category by calculating the percentage of neighborhood design elements included in the LEED-ND from the total number of neighborhood design elements in the WF for each category (Tables 4–12 in the Appendix). Calculating these percentages allowed us to compare how well the LEED-ND supported walkability between categories.

The synthesis of findings from the first stage of this research yielded a summary table of the main aspects of each category (Table 1). This summary table was used to analyze LEED-ND qualitatively.

We scored the LEED-ND by comparing how the certification system addressed the main focus of each category in two ways: (i) by looking at the percentage of neighborhood design elements included in the LEED-ND and (ii) by evaluating how well the main focus of the category (Table 1) is enforced in the prerequisites. The first part of this analysis was based on the academic and professional experience of the team of coauthors. The team included two architects, who are LEED-accredited professionals with experience in the design of sustainable and walkable neighborhoods, and academic researchers with interdisciplinary backgrounds, including architecture, physical activity, landscape architecture, and spatial analysis. As a team, we established 50% as the threshold for neighborhood design elements to be included in the LEED-ND. The second part of the scoring was an evidence-based binary variable (yes/no). The variable examined whether the main focus of the categories was included in the LEED-ND as prerequisites for certification. This assessment included the review of all LEED-ND prerequisites and their relationship with walkability categories.

We assigned three scores, i.e., strong, moderate, and weak. *Strong* scores were given to the categories in which the main focus (as described in Table 1) was addressed in a prerequisite for certification and in which the LEED-ND includes 50% or more of the neighborhood design elements from the WF (Zuniga-Teran, 2015). *Moderate* scores were given to the categories in which the LEED-ND did not address the main focus of the category in a prerequisite, but in which more than 50% of the neighborhood design elements identified in the WF was included. Finally, *weak* scores were given to the categories in which the LEED-ND did not address the main focus of the category in a prerequisite and in which less than 50% of the neighborhood design elements from the WF was included.

On the basis of the outcomes of this analysis, we developed a walkability-enhanced LEED-ND that integrated the main aspects of the categories included in the WF. We called this proposed certification system the LEED-ND walkability plus (LEED-NDW+).

3. Results

In this study, we determined that walkability was addressed mainly in the first and second LEED-ND sections (i.e., SLL and NPD), with some credits appearing in the GIB section. The tally across all categories revealed that the LEED-ND in its current form considered walkability in 78 of the available 110 points (70.9%).

LEED-ND analysis through the lens of the nine categories of the WF provided a measure of how well walkability is represented in the LEED-ND in each category (Fig. 1; Table 2)..

The results show that the LEED-ND received a strong score in the *density* category, which includes more than 50% of the neighborhood design elements (53.3%), and some of these elements are required. For example, the *NPDp2—Compact Development* offers two options to achieve compliance: *Option 1—Projects in Transit Corridors* (locate the project within walking distance from a transit service and use a density of seven units per acre or more for those areas not within walking distance from a transit service) and *Option 2—All Other Projects* (must include a minimum density of seven units per acre). Both options are related to density. Therefore, an LEED-ND-certified neighborhood

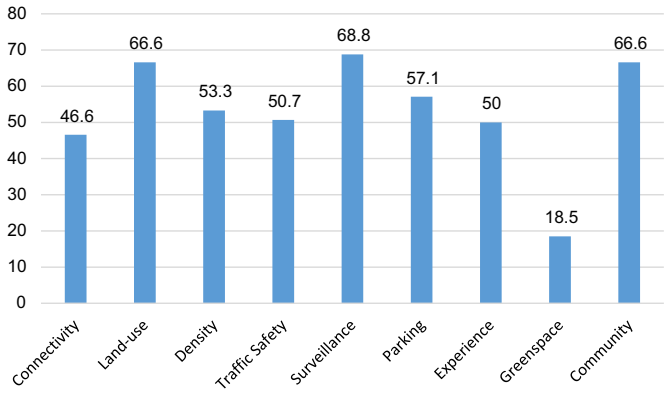

Fig. 1 Percent of design elements included in the LEED-ND. Percent of design elements related to walkability found in the literature that is addressed in the LEED-ND, according to the nine WF categories (see Tables 4-8 in Appendix).

Table 2 Results of the analysis between WF and LEED-ND. *Strong* indicates that more than 50% of the WF design elements is addressed in the LEED-ND and that at least one design element is a prerequisite. *Moderate* indicates that more than 50% of the WF design elements is addressed, but none is required. *Weak* indicates that less than 50% of the WF design elements is addressed and none is required. Results for subcategories are shown in parentheses.

WF categories	WF subcategories	Percent of design elements in the LEED-ND	Number of design elements required by the LEED-ND	Correspondence with the LEED-ND prerequisites
Connectivity		46.6	6	**Strong**
Land use		66.6	8[a]	Moderate
Density		53.3	6	**Strong**
Traffic safety		50.7	5	Moderate
	Pedestrians	(61.5)	(3)	(Strong)
	Bicycles	(52.6)	(0)	(Moderate)
	Transit systems	(66.7)	(2)[a]	(Moderate)
	Traffic-calming treatments	(22.2)	(0)	(Weak)
Surveillance		68.8	2	**Strong**
Parking		57.1	0	Moderate
Experience		50.0	3	Moderate
	Streetscape	(50)	(1)	(Strong)
	Aesthetics	(46.2)	(0)	(Weak)
	Thermal comfort	(88.8)	(2)	(Strong)
	Wayfinding	(0)	(0)	(Weak)
	Slope	(50)	(0)	(Moderate)
	Fumes/noise	(0)	(0)	(Weak)
	Dogs	(0)	(0)	(Weak)
Greenspace		18.5	0	Weak
Community		66.6	0	Moderate

[a]Prerequisites that offer several options to achieve compliance, but not all options are related to the category.

would necessarily address the main focus of the density category.

Similar to density, *surveillance* also received a strong score. This category includes more than 50% of the neighborhood design elements (68.8%), and some of these elements are required. For example, *NPDp1—Walkable Streets* have four sections (a–d) that are not optional; thus, the developer must comply with all of them. Surveillance is represented in section "a" (front façades of 90% of the buildings face a public street) and section "b" (a minimum building height-to-street width ratio of 1:3 for 15% of the street frontage, which ensures a short building setback and locates people inside the buildings who are close to the street).

Connectivity also received a strong score in this analysis. Although the percent of neighborhood design elements included in the LEED-ND is slightly less than 50% (46.6%), several prerequisites address this category, which ensures

Table 3 LEED-NDW+. Changes to the LEED-ND that consider the results of the quantitative and qualitative analyses for walkability. These changes enhance walkability in the LEED-ND by addressing the gaps identified in this study.

Walkability category		Changes to the LEED-ND	Description
Connectivity		NPDc1—Walkable streets	Include two points for a grid street network in at least 50% of the neighborhood.
Land use		NPDp4—Mixed-use developments	Include at least 30% of the building footprint as mixed use, where the ground floor is used for retail, including corners.
		NPDc15—Child care facilities	Include a child care facility within 1/4 mile (400 m) of homes.
Density		NPDp9—Pedestrian scale	Push away high-rise towers (more than five stories high) from the street line and maintain a four to six stories height at the street level.
Traffic safety	Pedestrians	No change	Subcategory received a strong score in the LEED-ND.
	Bicycles	NPDp5—Pedestrian and bicycle infrastructure	Provide sidewalks and bike lanes throughout the neighborhood, buffered from the road by on-street parking and a vegetated strip of at least 90 cm (approx. 3 ft).
	Transit	Eliminate Option 2 in NPDp2 - Compact Development	By having Option 1 as the only option to comply with this pre-requisite, access to transit systems is ensured.
	Traffic-calming treatments	NPDc16—Traffic-calming treatments	Include any five traffic-calming treatments for one point and seven traffic-calming treatments for two points (see the list in Table 7.4 in the Appendix).
Surveillance		NPDc1—Walkable streets	Include front porches, balconies, and outdoor cafes.
		GIBp5—Lighting	Provide lighting along the streets that follow light pollution guidelines.
Parking		NPDp10—Parking location	Locate parking in the rear of buildings or in basements, but away from the front of the buildings (on-street parking is encouraged).
Experience	Streetscape	No change	Subcategory received a strong score in the LEED-ND.
	Aesthetics	NPDp8—Tree-lined streets	Provide trees along all of the streets of the neighborhood on both sides of the streets at intervals of 12 m or less.
		NPDc1—Walkable streets	Include street furniture (e.g., benches and waste bins).
	Thermal comfort	NPDc1—Walkable streets	Include water bodies (fountains).Note: NPDp8- Tree-lined streets (above) is also related to thermal comfort.
	Wayfinding	NPDc17—Street design	Include signage, awnings, marquees, balconies, arcades, and galleries along the streets. An extra point can be earned for a landmark.
	Slope	No change	Site specific.
	Fumes/noise	GIBc16—Solid waste management	Locate waste containers away from the street.
	Dogs	NPDc13—Vegetated streetscapes	Provide a strip of vegetation of at least 1.5 m wide along the streets that buffers the sidewalks and bike lanes from the road. Vegetation must include grassy areas of at least 1.4 m^2 every 30 m and include dog infrastructure (waste bags and waste containers), following green infrastructure design described in GIBc8.
Greenspace		NPDp7—Greenspace	Include a small greenspace (2 ha or 4.9 acres) within walking distance of homes (1/4 mile or 400 m), and encourage small shops on its boundaries, including food trucks.
		GIBc17—Green play space	Provide a grassy play space (0.40 ha or 1 acre) safeguarded from traffic with dwelling units overlooking the space within 100 m from homes.
Community		NPDp8—Access to civic and public spaces	Provide a civic space (plaza) located in a central location also surrounded by small retail.

that some degree of connectivity is guaranteed. For example, *NPDp3—Connected and Open Community* offers two options to achieve compliance: *Option 1—Projects with Internal Streets* (projects must have at least 140 intersections per square mile) and *Option 2—Projects without Internal Streets* (adjacent connectivity is at least 90 intersections per square mile). Both options are related to connectivity. In addition to this prerequisite, connectivity is also required within options for other prerequisites (Table 4 in the Appendix). We gave this category a strong score because the main focus of the category was guaranteed to be addressed in an LEED-ND project.

The overall averaged result for the *traffic safety* category (average of the percentages of the four subcategories and sum of prerequisites) indicates that this category can have a strong rating. The category includes more than 50% of the neighborhood design elements (50.7%), and some of these elements are required. In addition, the pedestrian subcategory received a strong score. However, we gave this category an overall moderate score because the remaining subcategories received moderate or weak scores. For example, the bicycle subcategory received a moderate score because, although more than 50% of the neighborhood design elements (52.6%) was included in the LEED-ND, no prerequisite was required. Similarly, the transit system subcategory received a moderate score because the prerequisites offered several options to achieve compliance and not all options addressed this subcategory. Thus, a LEED-ND-certified neighborhood that completely ignores bicyclists and transit systems can be built. Finally, the traffic-calming treatment subcategory received a weak score because it included less than 50% of the neighborhood design elements (22.2%), and none of these elements are required. This finding indicates that overall traffic safety is not ensured in a LEED-ND neighborhood. We gave this category an overall moderate score because it has room for improvement.

The evaluation of the *experience* category was similar to the traffic safety evaluation described previously. The overall percentage and requirements would suggest a strong score; however, we obtained several weak and moderate scores. Therefore, the overall score of the *experience* category was moderate.

Land use was given a moderate score because, although the LEED-ND included more than 50% of the neighborhood design elements for this category (66.6%), the prerequisites did not ensure that this aspect of walkability was represented in the final product. For example, *SLLp1—Smart Location* offers four options to achieve compliance, and *Option 4—Nearby Neighborhood Assets* refers to land use (includes the residential component and locates the project close to services). However, a developer may choose one of the other three options that are unrelated to land use (i.e., *Option 1—Infill Site*, *Option 2—Adjacent Site with Connectivity*, and *Option 3—Transit Corridor or Route with Adequate Transit Service*). Thus, we gave this category a moderate score.

Finally, *greenspace* received a weak score because few neighborhood design elements are included in this category (18.5%), and none of these elements are required. Greenspace does not have specific prerequisites or credit points. For example, the LEED-ND awards up to four points for including services close to homes in *NPDc3—Mixed-use Neighborhood Centers*, where a developer can choose from a list of 27 services (or diverse uses) to include in the neighborhood within walking distance from homes. In this list, a public park is an option. However, developers may choose one of the other 26 services on the list. Similarly, *NPDc9—Access to Civic and Public Spaces* offers one credit point for an open space and includes a park as an option, which can be substituted by a square, paseo, or plaza (open spaces without vegetation). This credit does not specifically ensure that a greenspace will be included. In addition, *NPDc10—Access to Recreation Facilities* offers one credit point for including a recreation facility, which can be indoor or outdoor, within walking distance from homes. In summary, greenspace does not have direct credit points or prerequisites in the LEED-ND.

4. Discussion and conclusion

This study determined that walkability was widely considered in the LEED-ND; 70.9% of the credit points available were related to walkability. However, when the LEED-ND treatment of walkability was compared with the WF, important gaps and strengths became evident. *Connectivity, density,* and *surveillance* were clear strengths of the LEED-ND because the certification system addressed the main aspects of these categories as prerequisites for certification and offered additional credits (Table 2).

However, we observed important gaps in *land use, traffic safety, parking, experience*, and *community*. Although many neighborhood design elements related to these categories were included in the LEED-ND, no requirement was set to ensure that these aspects of walkability were included in a LEED-ND-certified neighborhood.

The most significant gap identified in the LEED-ND involved the *greenspace* category, which received a weak score. We considered all of the empirical evidence of the benefits of the presence of greenspace in cities to well-being (Jackson, 2003; Chu et al., 2004; Herrick, 2009; Clark et al., 2010; Sandifer et al., 2015), including its role as a catalyst for physical activity (Herrick, 2009). We determined that this aspect of the LEED-ND, along with the other categories that received moderate scores, urgently needs to be addressed. The LEED-ND is a practical tool used by developers, urban designers, and architects who wish to build sustainable and walkable neighborhoods. Thus, we decided to propose a modified version of the LEED-ND, called the LEED-NDW+(Table 3), to address the gaps identified in this study.

Although *connectivity* received a strong score in this analysis, we decided to make a slight change to *NPDc1—Walkable Streets*. Considering that the WF consistently shows the grid street network as more walkable, we decided to add an optional credit point for this category that includes a grid street network for at least 50% of the land area.

For *land use* category, which received a moderate score in this study because of the lack of enforced prerequisites, we added the prerequisite *NPDp4—Mixed-use Developments*. This prerequisite ensures that a LEED-ND-certified neighborhood contains services (e.g., shops and restaurants) close to homes that provide destinations for walking.

NPDc15—Child Care Facilities is also added because, similar to schools, this service is used daily by young families.

Density received a strong score in this study; however, the oppressive feeling of tall buildings has been well documented (Jacobs, 1961; Montgomery, 2013; Gifford, 2014). Therefore, we decided to include the prerequisite *NPDp9—Pedestrian Scale*, which ensures that high-rise towers (more than five stories high) are pushed away from the street line, while maintaining the four-story height at the street level.

The *traffic safety* category showed gaps in the bicycle, transit, and traffic-calming treatment subcategories. Therefore, we included the prerequisite *NPDp5—Pedestrian and Bicycle Infrastructure* to ensure that bike lanes and sidewalks protected from traffic are present throughout the neighborhood. We also eliminated Option 2 from the NPDp2 - Compact Development, which is not related to transit systems. In addition, we added the credit *NPDc16—Traffic-calming Treatments*; developers may earn up to two points for including several of the traffic-calming treatments listed in Table 7.4 in the Appendix.

Although the *surveillance* category received a strong score in this analysis, the LEED-ND could be further strengthened by incorporating additional design elements from WF. Thus, design elements related to surveillance were added to *NPDc1—Walkable Streets*, which now included front porches, balconies, and outdoor cafes. These types of design elements facilitate observation of the streets, which increases surveillance. In addition, we decided to move *GIBc17—Light Pollution Reduction* to a prerequisite position that we called *GIBp5—Lighting* because lighting is essential for surveillance at night. This prerequisite follows the same light pollution guidelines from GIBc17, but it now ensures that all of the streets of a LEED-ND neighborhood are equipped with lighting fixtures.

Parking received a moderate score in this study because this category has no prerequisite. Therefore, we added the prerequisite *NPDp10—Parking Location*, which requires parking to be located in the rear of buildings or in basements, and thus away from sidewalks. On-street parking is recommended because it provides safety to pedestrians from traffic.

Even though the streetscape and thermal comfort subcategories of the *experience* category received strong scores, we still proposed minor edits to these subcategories. We added the option to include a fountain or water body in *NPDc1—Walkable Streets*, which addresses thermal comfort. For the aesthetics subcategory, we moved *NPDc14—Tree-lined and Shaded Streets* from a credit to a prerequisite position (*NPDp6—Tree-lined Streets*) to ensure that the streets of a LEED-ND-certified neighborhood contains trees. In addition, we included street furniture to *NPDc1—Walkable Streets* as an additional item to choose from. For the wayfinding subcategory, we included a new credit, *NPDc17—Street Design*, which offers a credit point for signage, awnings, marquees, balconies, arcades, and galleries along the streets. An additional point can be earned in this credit for a landmark. For slope, we did not make any changes because this subcategory is site specific, and the negative aspects of slopes are already addressed in *SLLc6—Steep Slope Protection*. With regard to fumes/noise, we added a specification to the existing *GIBc16—Solid Waste Management* to locate waste containers away from the streets, which would remove garbage fumes from the space used by pedestrians and cyclists. In addition, we created a new credit, *NPDc14—Vegetated Streetscape*, by moving the former *NPDc14—Tree-lined and Shaded Streets* to a prerequisite position (described previously). This new credit offers a point for providing a strip of vegetation along the sidewalks that buffers pedestrians and cyclists from the road. This credit enhances the experience of walking (in addition to making streets safer, which is part of the traffic safety category) because vegetation is known to remove pollutants from the air. Finally, for dogs, we included grassy areas and dog infrastructure (waste bags and containers) as guidelines for the same *NPDc14—Vegetated Streetscape*.

An important gap was identified in the *greenspace* category, which was the only category to receive a weak score in this analysis. To address this gap and the findings that indicate that having access to a diverse range of greenspaces is essential for well-being, we propose the prerequisite *NPDp7—Greenspace*, which ensures that a greenspace (2 ha or 4.9 acres) is available within walking distance from homes (Handley et al., 2003). The prerequisite also calls for small and diverse shops along the greenspace boundary, particularly food trucks, because having vendors around makes a greenspace safer (Jacobs, 1961; Zuniga-Teran, 2015). In addition, we included *GIBc17—Green Play Space*, which offers one credit point for including a grassy play space (1 acre or 0.40-ha) safeguarded from traffic and with dwelling units overlooking the space. This space provides a safe area for children to play while adults continue their duties. This type of space has been observed to be used more frequently than traditional playgrounds (e.g., *lots for tots*) because children can play without the need of a chaperone (Jacobs, 1961; Mahdjoubi, 2014).

Finally, the *community* category received a moderate score in this study because it did not have a prerequisite in the LEED-ND. Thus, we moved *NPDc9—Access to Civic and Public Spaces* from a credit to a prerequisite. This change ensures that a civic space will be placed in a central location within a LEED-ND-certified neighborhood. Similar to greenspace, this space should be surrounded by small and diverse retail.

The proposed LEED-NDW+ captures the main aspects of what our previous study has shown to be essential for facilitating physical activity and supporting human health (Table 13 in the Appendix). The proposed LEED-NDW+ maintains the sustainable integrity of LEED-ND because the existing prerequisites and number of points are preserved. If implemented, the LEED-NDW+ has the potential to increase physical activity and improve human health, as the LEED-ND has been adopted by municipalities as a design guideline for development (Lewin, 2012).

Important caveats should be considered regarding the proposed changes to the LEED-ND. The proposed LEED-NDW + may be more expensive and difficult to implement by developers because more prerequisites are included that cannot be ignored, and some of these prerequisites may result in loss of profit and/or additional costs. Getting a project LEED-ND certified is difficult. Lewin (2012) indicated that the rigidity of the prerequisites in the LEED-ND is already an impediment for certification for many projects. The proposed LEED-NDW+, which contains even more prerequisites, may discourage developers from pursuing certification.

Incorporating walkability into neighborhood design has been argued to enhance property values; however, the financial benefit comes mainly if low development costs are involved. Pivo and Fisher (2011) observed associations between walkability and higher office, retail, and apartment property values, but warned that developers benefit from this increased value only if it is not exhausted by expenses related to development. The LEED-ND certification process has been described as complex, time-consuming, and expensive for small projects (Lewin, 2012); thus, the proposed LEED-NDW+ may be regarded as such to a greater extent.

Although the proposed LEED-NDW+ may be more expensive to implement, and developers may be reluctant to pursue certification, the benefits of some of the proposed prerequisites may translate into elevated property values that may bring profit to developers. The new prerequisite for greenspace (*NDPp7—Greenspace*) means that a piece of land will be set aside for public use and will not bring in direct revenue to the developer in the form of dwelling units or commercial space to sell. However, evidence indicates that proximity to greenspace is correlated with increased property values (Troy and Grove, 2008; Sander and Zhao, 2015). In addition, the proposed LEED-NDW+ requires trees along the streets of the neighborhood (*NPDp6—Tree-lined Streets*). Although the benefits of trees (e.g., reduced air pollution and noise; increased safety and aesthetics) are not experienced directly by the developer, the presence of trees in a neighborhood is also correlated with increased property values (Sander and Zhao, 2015), which may ultimately benefit developers.

Despite the potential reductions in revenue realized by developers, design guidelines for walkable neighborhoods should be documented and more research on this topic should be conducted. Once the public health benefits of walkable neighborhoods are more evident, and this knowledge is reflected in the market and in public health-driven regulations, having a practical tool, such as the LEED-NDW+, will be useful to guide development toward healthy communities.

The integration of landscape connectivity findings into the LEED-NDW+ should be the next step for this research. Greenspaces in cities should be connected to allow species to move across the urban matrix because urbanization has caused habitat fragmentation that threatens biodiversity (Andersson and Bodin, 2008). The LEED-ND must reflect this effect of neighborhood design on the environment, and future revisions should consider prerequisites for connected greenspace (e.g., greenways), which can also promote walkability.

Appendix

See Tables 4-13.
See Tables 7.1-7.4.

Table 4 Connectivity. The design elements for connectivity provide multiple direct and short routes to destinations throughout the city. LEED-ND includes 7 out of 15 neighborhood design elements found for this category (46.6%), with 6 prerequisites for certification ([a]).

	Design elements for connectivity category	LEED-ND Code
1	There must be at least 140 intersections per 2.6 km^2 (~1 sqmi) or small blocks allowing intersections to occur at 91 m (~100 yd) or less. Intersections must be 4-way	SLLc1 NPDp3 (case1)[a] NPDc6
2	Adjacent sites must have a connectivity of 90 intersections per 2.6 km^2 (~1 sqmi)	SLLp1 (opt. 2)[a] NPDp3(case 1)[a]
3	Avoid gated communities	NPDp3 (case 1)[a] NPDc6
4	There must be at least one through-street every 122 m (~400 ft) in the boundary	NPDp3 (case 2)[a] NPDc6
5	If there are any cul-de-sac, connect it to pedestrians and bicycles by streets or trails (without barriers)	NPDc6
6	The neighborhood should be served by adequate transit system	SLLp1 (opt. 3)[a] SLLp4 (opt. 3)[a]
7	Avoid cul-de-sac/ dead-end streets	SLLp1(opt. 2)[a]
8	Avoid freeways, railway lines, rivers	
9	Provide easy access to highways vs. avoid highways	
10	Avoid fences and allow access to the general public	
11	The street layout should be a grid	
12	Grid street networks in high-intensity streets must include visual interruptions like "T" junctures, bridges connecting buildings, slope, and short blocks	
13	In case of a grid, lay a diagonal across	
14	In case of a grid, add slight bends that follow topography	
15	In case of a grid, include a variety of street types and widths	
	RATIO	**7/15**

[a]Prerequisites for certification

Table 5 Land use. The design elements for land-use category propose a mix land uses that provide multiple destinations at a walking distance. LEED-ND includes 16 out of 24 neighborhood design elements found in this category (66.6%), with 8 prerequisites for certification ([a]).

	Design elements for land-use category	LEED-ND Code
1	Provide number of fulltime jobs within 800 m (1/2 mile) of the geographic center of the project that is equal to or greater than the number of dwelling units in the neighborhood	SLLc5
2	For office and residential buildings, the ground floor should be retail and must face at least 60% of the street	NPDc11
3	Services on the ground floor must have direct access from sidewalk along a public space, not a parking lot	NPDp1-a[a] NPDc11
4	Include at least 4 types of services within 5 min walk (400 m) and at least 7 services within 10 min walk (800 m) from most dwelling units*	SLLp1(opt. 4)[a] SLLc4 NPDc3
5	Services must include food retail with fresh produce	SLLp1(opt. 4)[a] SLLc4 NPDc3
6	Ensure that at least 50% of the dwelling units are within 400 m (1/4 mile) from a bus or streetcar stop	SLLp1(opt. 3)[a] SLLc3
7	For neighborhood centers, entries to services must be within 91 m (~300 ft) from a single common point	NPDc3
8	There must be a farmers market within a 10 min walk or 800 m (1/2 mile) from the project's center	SLLp1(opt. 4)[a] SLLc4 NPDc3 NPDc13
9	There must be an elementary and middle school within a 10 min walk or 800 m (1/2 mile) from 50% of the homes	NPDc15
10	There must be a high school within 1.6 km (~1 mile) from 50% of the homes	NPDc15
11	Schools must be compact and not exceed an area of 6.ha (~15 acres) for high schools; 4 ha (~10 acres) for middle schools; and 2 ha (~5 acres) for elementary schools	NPDc15
12	Include a variety of restaurants	SLLp1(opt. 4)[a] SLLc4 NPDc3
13	Include mixed-use buildings that include residential/office and retail on the ground floor in all the streets of the neighborhood	NPDc1-l
14	Include child care services close to homes	SLLp1(opt. 4)[a] SLLc4 NPDc3
15	No more than 1 bank per block	SLLp1(opt. 4)[a] SLLc4 NPDc3
16	Avoid large sized services	NPDc1-d,e
17	Services must have different working hours	
18	Provide a variety of shops along the routes to school	
19	Avoid fast-food restaurants, corner markets, and liquor stores	
20	Open corridors between housing buildings must include a variety of uses	
21	Corners must have retail on the ground level	
22	Insure zoning for deliberate diversity that limits the amount of the same service within a certain area	
23	Insure that public buildings stay staunch even if property values increase	
24	In the case of "borders" such as waterfronts, railways, freeways, and other massive single uses (e.g., hospitals, university campuses), locate services that make direct use of the border itself	
	RATIO	**16/24**

[a]Prerequisites for certification.

Table 6 Density. The design elements for density recommend a high residential and retail density that maintains the pedestrian scale at street level. LEED-ND includes 8 out of 15 neighborhood design elements found for this category (53.3%), with 6 prerequisites for certification ([a]).

Type of density		Design elements for density category	LEED-ND Code
Residential	1	*Suburbs* must have a residential density of at least 17 dwelling units per ha (7 units per acre)	NPDp2(case 2)[a]
	2	*Semi-suburbs* must have a residential density of 25–49 dwelling units per ha (10–20 units per acre)	NPDp2(case 1)[a] NPDc2
	3	*Urban neighborhoods* must have a residential density of at least 247 dwelling units per ha (100 units per acre)	
	4	High-rise buildings must not be too close to one another	
Retail	5	*Suburbs* must have a retail density of at least 0.50 FAR	NPDp2(case 2)[a]
	6	*Semi-suburbs* must have a retail density of 0.8–3.0 FAR	NPDp2(case 1)[a] NPDc2
All	7	Locate the project on an infill site	SLLp1 (opt. 1)[a] SLLp4 (opt. 2)[a] SLLc1
	8	Locate the project in a redeveloped brownfield	SLLc2
	9	Locate the project in a designated receiving area for development rights	SLLp4 (opt. 4)[a]
	10	Building frontage should maintain the pedestrian scale (low rise buildings/podium) pushing high-rise towers away from pedestrian sight	
	11	High-rise buildings must not be too close to one another	
	12	Space between buildings must have clear private and public spaces	
	13	Buildings should not cover more than 70% of the buildable land	
	14	Maintain a homogenous density of 37-74 dwelling units per ha (15–30 units per acre) throughout the city	
Schools	15	Design compact schools: elementary – 2 ha (5 acres), middle school - 4 ha (10 acres), high-school – 6 ha (15 acres)	NPDc15
		RATIO	**8/15**

[a]Prerequisites for certification.

Table 7.1 Traffic Safety - Pedestrians. The design elements for the pedestrian section of the traffic safety category refer to the street infrastructure necessary to maximize safety for pedestrians in order to increase physical activity. LEED-ND includes 8 out of 13 neighborhood design elements found for this category (61.5%), with 3 prerequisites for certification ([a]).

	Design elements for the pedestrian section of the traffic safety category	LEED-ND Code
1	Provide continuous sidewalks along both sides of 90% of the streets	NPDp1-c[a]
2	Sidewalks on residential areas must be at least 1.2–1.5 m (4–5 ft) wide	NPDp1-c[a] NPDc1-j
3	Sidewalks on retail or mixed use blocks must be 2.4–3 m (~8–10 ft) wide	NPDc1-j
4	Provide on-street parking on 70% of both sides of the streets	NPDc1-i
5	No more than 20% of the street frontage are faced by garage openings and service bays	NPDp1-d[a]
6	Minimize at-grade crossings of sidewalks with driveways	NPDc1-p
7	Guaranteed ride home	NPDc8
8	Universal design: Design homes and streets that can be used by a wide spectrum of people regardless of ability or age	NPDc11
9	Provide a strip of vegetation with large trees that separates the sidewalks from the roads	
10	Provide maintenance to the sidewalks to ensure evenness	
11	Provide pedestrian-only streets	
12	Widen sidewalks at intersections	
13	Provide pedestrian lights with countdown timers	
	RATIO	**8/13**

[a]Prerequisites for certification.

Table 7.2 Traffic Safety - Bicycles. The design elements for the bicycles section of the traffic safety category refer to the street infrastructure necessary to maximize safety for cyclists in order to increase physical activity. LEED-ND includes 10 out of 19 neighborhood design elements found for this category (52.6%), with no prerequisites for certification.

	Design elements for the bicycles section of the traffic safety category	LEED-ND Code
1	Include a bicycle network and pedestrian trail within 400 m (1/4 mile) of the project	SLLc4
2	For residential projects, a bicycle network is within 400 m (1/4 mile) of boundary and connects to a school or employment center within 4.8 km (3 miles)	SLLc4
3	Include a bicycle network within 400 m (1/4 mile) of boundary that connects at least 10 diverse uses within 3.21 km (3 miles)	SLLc4
4	Residential: provide bicycle parking and storage capacity of at least 1 space/dwelling unit	SLLc4 NPDc5-a
5	Retail: provide bicycle parking and storage capacity of: 1 space/465 m^2 (5,000 sqft) of retail space. Bicycle storage must be located within 30 m (~100 ft) of main entries	SLLc4 NPDc5-b
6	Non-residential other than retail: provide 1 storage for 10% occupancy and visitor rack on-site of 1 space per 930 m^2 (~10,000 sqft), and no less than 4 spaces per building	SLLc4 NPDc5-c
7	Provide at least 1 on-site shower with changing facility for any development with 100 workers	SLLc4 NPDc5-b
8	Bicycle racks must be located in visible areas from main entries of buildings, served with lighting.	SLLc4 NPDc5-c
9	Guaranteed ride home	NPDc8
10	Provide continuous bike lanes throughout the neighborhood	NPDc15
11	Give bicycles priority at intersections	
12	Maintain bike lanes with smooth surfaces and remove loose gravel	
13	Devote space on the streets for bicycle and car-sharing businesses	
14	Include a bike lane on every street buffered from the road	
15	Elevate bike lanes and crossroads a few inches	
16	Include signalized intersections (stop-controlled)	
17	Provide lighting	
18	Color-pavement markings	
19	Avoid steep slopes for bike routes	
	RATIO	**10/19**

Table 7.3 Traffic Safety - Transit Systems. The design elements for transit systems section of the traffic safety category refer to the provision of safe and comfortable infrastructure and the implementation of a convenient transit system that incentivizes people to use transit systems. LEED-ND includes 8 out of 12 neighborhood design elements found for this category (66.7%), with 2 prerequisites for certification ([a]).

	Design elements for the transit systems section of the traffic safety category	LEED-ND Code
1	Dwelling units must be located within a 10 min walk (800 m) from transit stops and 5 min walk (400 m) from bus stops	SLLp1(opt.3)[a]
2	There are short and direct routes from homes to bus stops (<400 m) and transit stops (<800 m)	SLLp1(opt.3)[a]
3	Provide safe, convenient, and comfortable transit waiting areas and safe and secure bicycle storage for transit users	NPDc7
4	Provide kiosks, bulletin boards or signs that displays transit schedules and route information at each public transit stop	NPDc7
5	Provide information about the journey on screens at each public transit stop or on smartphone apps	NPDc7
6	Provide annual transit passes at a reduced price to residents and occupants of the buildings in the project	NPDc8

Table 7.3 (*continued*)

	Design elements for the transit systems section of the traffic safety category	LEED-ND Code
7	Provide private transit service (vans, shuttles, buses) from a central point of the neighborhood to transit facilities or other important destinations sponsored by the developer	NPDc8
8	Guaranteed ride home	NPDc8
9	Buses must show-up every 15 min or less	
10	Boost the status of public transit by creating state-of-the-art public transit stops and units	
11	Provide bus-only lanes and intersection priority to transit systems	
12	Designate buses, taxis and trucks-only streets	
	RATIO	**8/12**

[a]Prerequisites for certification.

Table 7.4 Traffic Safety - Traffic-Calming Treatments. The design elements for the traffic-calming treatments section of the traffic safety category aim to reduce speed in motorized vehicles in order to increase physical activity. LEED-ND includes 4 out of 18 neighborhood design elements found for this category (22.2%), with no prerequisites for certification.

	Design elements for the traffic-calming treatments section of the traffic safety category	LEED-ND Code
1	Speed limit on residential areas is 30 km/h (~19 mph) or less	NPDc1-n
2	Speed limit on non-residential or mixed-use streets is 40 km/h (~25 mph) or less	NPDc1-o
3	Include medians and crossroads every 244 m (~800 ft) on busy streets and access lanes with a speed limit of 40 km/h (~25 mph)	NPDc1-o
4	Provide a combination of traffic control and calming measures on routes from dwelling units to schools	NPDc15
5	Include brightly painted crosswalks raised a few inches above the roadway on street intersections	
6	Widen sidewalks at the intersections	
7	Designate pedestrian zones/streets	
8	Toll on cars entering the city core	
9	Install speed bumps along streets	
10	Narrow streets	
11	Place a small park at the end of streets	
12	Use cobblestone for street paving	
13	Place trees and other elements (e.g., monuments) in the middle of the roads	
14	Small corner radii to force cars to slow down when turning	
15	Create woonerf streets	
16	Place roundabouts at street intersections	
17	Provide a shoulder lane on intersections between arterials and secondary roads	
18	Avoid multiple lane boulevards (more than 4 lanes)	
	RATIO	**4/18**

Table 8 Surveillance. The design elements found for surveillance category refer to the design that allows people from inside the buildings to watch pedestrians on the street. LEED-ND includes 11 out of 16 neighborhood design elements found for this category (68.8%), with 2 prerequisites for certification ([a]).

	Design elements for surveillance category	LEED-ND Code
1	A principal entry faces a public space, not a parking lot	NPDp1-a[a]
2	All ground level retail uses that face a public space must have clear glass on at least 60% of their facades between 0.91 and 2.4 m (3–8 ft) above grade	NPDc1-f
3	For residential, the ground floor of at least 50% of the units must have an elevation of more than 60 cm (24 in) above the sidewalk	NPDc1-k
4	Ground floor of buildings must have retail, live/work or dwelling units that have access to public space	NPDc1-l
5	Avoid wide streets with low-rise buildings. Building height-to-street-width ratio of 1:3	NPDp1-b[a]

Table 8 (*continued*)

	Design elements for surveillance category	LEED-ND Code
		NPDc1-m
6	Avoid blank walls (no windows or doors) longer than 15 m (50 ft)	NPDc1-g
7	Setbacks of 8 m (~25 ft) or less for 80% of street-facing buildings	NPDc1-a
8	Locate buildings close to the streets. Setbacks of 5 m (~18 ft) or less for 50% of street-facing buildings	NPDc1-b
9	Setbacks of 0.3 m (~1 ft) for at least 50% of mixed used and non-residential street-facing buildings	NPDc1-c
10	Building entries occur at an average of 9–23 m (~30–75 ft) or less along mixed or non-residential buildings	NPDc1-d NPDc1-e
11	Include trees	NPDc14
12	Setbacks of 3 m (10 ft) that include a front yard allow a semi-private space between homes and public space	
13	Garage doors facing the street should be avoided	
14	Include outdoor cafes on the streets	
15	Provide lighting on the streets and outdoor spaces	
16	Orient the buildings toward the street: front porches, windows, storefronts, balconies, entries	
	RATIO	**11/16**

[a]Prerequisites for certification.

Table 9 Parking. The design elements for parking category aim to de-incentivize the use of the automobile and increase physical activity by reducing the amount of available parking. LEED-ND includes 8 out of 14 neighborhood design elements found for this category (57.1%), with no prerequisites for certification.

	Design elements for parking category	LEED-ND Code
1	Reduce parking footprint. Either do not build off-street parking or build parking lots at the side or rear of buildings leaving frontages free of surface parking	NPDc5
2	Do not allow more than 20% of footprint area is used for off-street parking	NPDc5
3	Do not allow parking lots greater than 0.8 ha (~2 acres)	NPDc5
4	For non-residential, provide carpool and/or shared-use vehicle parking spaces for 10% of parking, with signage and within 60 m (~200 ft) of building entries	NPDc5
5	Parking spaces are sold or rented separately from the dwelling units or square footage of non-residential	NPDc8
6	Provide on-street parking on 70% of both sides of the streets	NPDc1-i
7	Include at least one vehicle from a vehicle-sharing program within a 5 min walk of the dwelling units	NPDc8
8	Integrate parking in the building base	NPDc5
9	Downtown parking should be 200 spaces per 1000 workers	
10	If parking lots/garages cannot be avoided, surround these by small blocks (intersections occurring every 48 m or 160 ft)	
11	Surrounding areas of parking lots must have diverse services (e.g., shops, restaurants)	
12	Sharing parking between uses can significantly reduce the parking area requirements	
13	Screen or hide parking behind landscaping	
14	Locate parking and drop-off areas along secondary streets but within blocks of primary streets	
	RATIO	**8/14**

Table 10 Experience. The design elements for experience category aim to make the walking and biking experience pleasant in order to increase physical activity. LEED-ND includes 16 out of 32 neighborhood design elements found for this category (50%), with 3 prerequisites for certification ([a]).

	Design elements for experience category	LEED-ND Code
	Streetscape	
1	Building-height-to-street-width ratio of 1:3	NPDp1-b[a]
2	Avoid gaps in the street wall (empty lots or low rise buildings in high-rise street)	
	Aesthetics	
3	Include trees along most of the length of the sidewalks at intervals of no more than 12 m (50 ft)	NPDc14
4	Maximize store-front transparency to create visual interest and void shutting windows at night.	NPDc1-h
5	Include a diversity of building types and ages. Provide affordable housing.	SLLc1 NPDc4 GIBc5
6	Preserve historic resources	GIBc6
7	Provide 2 units of soil per 1 unit of tree height to allow trees to grow big and tall	NPDc14
8	Include a green infrastructure and a diversity of tree species to reduce risk of flooding	GIBc8
9	Include landscaping along sidewalks and other outdoor areas	
10	Insure clean streets (e.g., cleaning programs) to avoid trash and graffiti	
11	For high-intensity streets, add "unifiers" such as trees spaced uniformly, pavements with strong patterns, or colored awnings	
12	For low-intensity streets, avoid "sameness" by using different design of facades and different building types	
13	Add street furniture such as benches facing passing crowds	
14	Provide awnings, marquees, arcades or galleries on the streets	
15	Provide continuous maintenance to vegetation	
	Thermal comfort	
16	Provide shade on at least 50% of the hardscape (e.g., plants that provide shade)	GIBc9
17	Provide shade on the hardscape with a light colored roof finish (or SRI of at least 29)	GIBc9
18	Use paving materials that are light-colored (SRI of at least 29)	GIBc9
19	Low-slope roofs must have an initial SRI of 78 and steep-slope roofs must have an initial SRI of 29	GIBc9
20	Include vegetated roofs on at least 50% of the total roof area	GIBc9
21	Include water bodies in outdoor spaces. Limit development within 15 m (~50 ft) of existing wetlands and 30 m (~100 ft) of existing water bodies	SLLp3(opt.1)[a] SLLc7 SLLc8 SLLc9
22	Include shading devices such as awnings in sidewalks	NPDc14
23	Include high-rise buildings to provide shade to the streets	NPDp1-b[a]
24	Include deciduous trees	
	Wayfinding	
25	Include landmarks or artworks at key vista points or axial termini and corners	
26	Include radically different uses to increase landmarks and focal points	
27	Include appropriate signage, clear edges, distinctive buildings, and pathways	
	Slope	
28	Low slopes (<15%) are desirable	SLLc6
29	Include hilly streets	
	Fumes/noise	
30	Include large areas of vegetation on heavy-traffic streets to improve air quality and reduce noise and fumes	
	Dogs	
31	Include high fences in dog areas away from children's areas and busy roads	
32	Provide dog-related infrastructure (e.g., dog litter bags, bins, signage, accessible water sources)	
	RATIO	**16/32**

• Prerequisite for certification

Table 11 Greenspace. The design elements for greenspace category refer to the provision of and access to greenspace at a walking distance from homes in order to increase physical activity. LEED-ND includes 5 out of 27 neighborhood design elements found for this category (18.5%), with no prerequisite for certification.

Design elements for greenspace category		LEED-ND Code
1	Leave a portion of the site of 10%–20% that has not been developed undisturbed in order to maintain native vegetation and pervious surfaces	GIBc7
2	Provide an accessible greenspace to all homes	NPDc3 NPDc9
3	Locate an outdoor or indoor public recreational facility of at least 0.40 ha (1 acre) for outdoors and 0.23 ha (1/2 acre) for indoors within 0.80 km (1/2 m) of 90% of the dwelling units	NPDc10
4	Outdoor facility must include tot-lots for children, swimming pools and sports fields	NPDc10
5	Provide an accessible 2 ha (4.9 acres) greenspace no more than 300 m (984 ft) from 100% of dwelling units.	NPDc3 NPDc9
6	Provide at least 1 accessible 20 ha (49.4 acres) greenspace within 2 km (1.24 miles)	
7	Provide at least 1 accessible 100 ha (247.1 acres) greenspace within 5 km (3.1 miles)	
8	Provide at least 1 accessible 500 ha (1235.5 acres) greenspace within 10 km	
9	Greenspace must be surrounded by a variety of shops and include inside vendors; all working different hours	
10	Avoid “superblocks” in surroundings of greenspace by including multiple public intersections with accesses to houses and stores	
11	Greenspace must promote a variety of uses by changing the rise in the ground, the grouping of trees and the openings leading to various focal points	
12	Design the greenspace so that it includes a center as a main crossroad	
13	Greenspace must have a variety of sun exposure (shaded vs. sunny areas)	
14	Greenspace must include spaces for cultural events	
15	Greenspace must include spaces for several activities like biking (washing, renting, repair), kite-flying (buying, repair), bar-*b*-ques, and ice-skating (cold weather)	
16	There must be vegetation (nature) throughout the entire neighborhood and accessible to all homes	
17	Promote businesses that sell products related to uses inside the greenspace and locate these vendors along the borders of the greenspace (e.g., bike rentals, kite shops, food trucks)	
18	Regulate the low-height of buildings on the south side of greenspace to allow the sun during winter months	
19	Include sheds for vendors’ carts on bordering streets of parks	
20	Locate a neighborhood park at the end of streets to discourage automobile-use	
21	Locate a greenspace close to high-rise towers so that all units have a view of nature	
22	Avoid playgrounds or locate them where parents can do alternative activities while watching the kids	
23	Link the greenspaces together by integrating nature into the neighborhoods	
24	Include greenspace with high biodiversity	
25	Provide continuous maintenance to vegetation	
26	Provide dog-related infrastructure	
27	Include well-fenced areas for off-leashed dogs, away from children’s play areas	
	RATIO	**5/27**

Table 12 Community. The design elements for community category aim to increase sense of community and physical activity. LEED-ND includes 10 out of 15 neighborhood design elements (66.6%), with no prerequisite for certification.

Design elements for community category		LEED-ND Code
1	Include a diversity of housing types	SLLc1 NPDc4
2	Include affordable housing	NPDc4
3	Increase the proportion of areas usable by people of diverse abilities	NPDc11
4	Advertise an open community meeting and solicit their input on the design	NPDc12
5	Conduct a charrette of at least 2 days open to the public to get input on the design	NPDc12
6	Dedicate space for food production within the neighborhood	NPDc13
7	Provide an accessible civic space of at least 0.67 ha (1/6 acre) within 1/4 mile of 90% of the homes. For projects larger than 10 acres must have a space of at least 0.4 ha (1 acre)	NPDc9
8	The proportion of the civic space must not be narrower than 1 unit of width to 4 units of length	NPDc9
9	Include trees	NPDc14
10	Provide public spaces (e.g., community center, churches, parks, recreational facilities)	SLLc4 NPDc3 NPDc10
11	Promote a self-governing body or neighborhood association	
12	Add irregularities to the building line along sidewalks to create niches that allow incidental play for children	
13	Avoid blacklisting neighborhoods for renovation credits	
14	Include a variety of dwelling units sizes in high-rise buildings (2 & 3 bedroom units) that can accommodate families	
15	Include shared outdoor spaces (e.g., shared facilities, open space)	
	RATIO	**10/15**

Table 13 LEED-NDW+ Checklist incorporates findings from the literature that enhance walkability. Shown in bold are changed items.

Code	Type	Design Element	Possible points for certification	Changes
Smart Location & Linkage (SLL)				
SLLp1	Prereq	Smart Location	Required	
SLLp2	Prereq	Imperiled Species and Ecological Communities	Required	
SLLp3	Prereq	Wetland and Water Body Conservation	Required	
SLLp4	Prereq	Agricultural Land Conservation	Required	
SLLp5	Prereq	Floodplain Avoidance	Required	
SLLc1	**Credit**	**Preferred Locations**	**2**	**−8**
SLLc2	Credit	Brownfield Remediation	2	
SLLc3	Credit	Access to Quality Transit	7	
SLLc4	Credit	Bicycle Facilities	2	
SLLc5	Credit	Housing and Jobs Proximity	3	
SLLc6	Credit	Steep Slope Protection	1	
SLLc7	Credit	Site Design for Habitat or Wetland and Water Body Conservation	1	
SLLc8	Credit	Restoration of Habitat or Wetlands and Water Bodies	1	
SLLc9	Credit	Long-Term Conservation Management of Habitat or Wetlands & Water Bodies	1	
Total			**20**	

Table 13 (*continued*)

Code	Type	Design Element	Possible points for certification	Changes
Neighborhood Pattern & Design (NPD)				
NPDp1	Prereq	Walkable Streets	Required	
NPDp2	Prereq	Compact Development	Required	Eliminate Option 2
NPDp3	Prereq	Connected and Open Community	Required	
NPDp4	**Prereq**	**Mixed-use Development**	**Required**	**Prerequisite added**
NPDp5	**Prereq**	**Pedestrian and Bicycle Infrastructure**	**Required**	**Prerequisite added**
NPDp6	**Prereq**	**Tree-lined Streets**	**Required**	**Prerequisite added**
NPDp7	**Prereq**	**Greenspace**	**Required**	**Prerequisite added**
NPDp8	**Prereq**	**Access to Civic & Public Space**	**Required**	**Prerequisite added**
NPDp9	**Prereq**	**Pedestrian Scale**	**Required**	**Prerequisite added**
NPDp10	**Prereq**	**Parking Location**	**Required**	**Prerequisite added**
NPDc1	**Credit**	**Walkable Streets**	**12**	**+3**
NPDc2	Credit	Compact Development	6	
NPDc3	Credit	Mixed-Use Neighborhoods	4	
NPDc4	Credit	Housing Types and Affordability	7	
NPDc5	Credit	Reduced Parking Footprint	1	
NPDc6	Credit	Connected and Open Community	2	
NPDc7	Credit	Transit Facilities	1	
NPDc8	Credit	Transportation Demand Management	2	
NPDc9	Credit	Access to Recreation Facilities	1	
NPDc10	Credit	Visitability and Universal Design	1	
NPDc11	Credit	Community Outreach and Involvement	2	
NPDc12	Credit	Local Food Production	1	
NPDc13	**Credit**	**Vegetated Streetscapes**	**2**	**+1**
NPDc14	Credit	Neighborhood Schools	1	
NPDc15	**Credit**	**Child Care Facility**	**1**	**+1**
NPDc16	**Credit**	**Traffic-Calming Treatments**	**2**	**+2**
NPDc17	**Credit**	**Street Design**	**2**	**+2**
Total			**49**	
Green Infrastructure & Buildings (GIB)				
GIBp1	Prereq	Certified Green Building	Required	
GIBp2	Prereq	Minimum Building Energy Performance	Required	
GIBp3	Prereq	Indoor Water Use Reduction	Required	
GIBp4	Prereq	Construction Activity Pollution Prevention	Required	
GIBp5	**Prereq**	**Lighting**	**Required**	**Prerequisite added**
GIBc1	Credit	Certified Green Buildings	5	
GIBc2	Credit	Optimize Building Energy Performance	2	
GIBc3	Credit	Indoor Water Use Reduction	1	

Table 13 (*continued*)

Code	Type	Design Element	Possible points for certification	Changes
GIBc4	Credit	Outdoor Water Use Reduction	2	
GIBc5	Credit	Building Reuse	1	
GIBc6	Credit	Historic Resource Preservation and Adaptive Reuse	2	
GIBc7	Credit	Minimized Site Disturbance	1	
GIBc8	Credit	Rainwater Management	4	
GIBc9	Credit	Heat Island Reduction	1	
GIBc10	Credit	Solar Orientation	1	
GIBc11	Credit	Renewable Energy Production	3	
GIBc12	Credit	District Heating and Cooling	2	
GIBc13	Credit	Infrastructure Energy Efficiency	1	
GIBc14	Credit	Wastewater Management	2	
GIBc15	Credit	Recycled and Reused Infrastructure	1	
GIBc16	Credit	**Solid Waste Management**	1	**Added specification for location**
GIBc17	**Credit**	**Green Play Space**	**1**	**+1**
Total			31	
Innovation & Design Process (IDP)				
IDPc1	Credit	Innovation	5	
IDPc2	Credit	LEED® Accredited Professional	1	
Total			6	
Regional Priority Credits (RP)				
RPc1	Credit	Regional Priority Credit: Region Defined	1	
RPc2	Credit	Regional Priority Credit: Region Defined	1	
RPc3	Credit	Regional Priority Credit: Region Defined	1	
RPc4	Credit	Regional Priority Credit: Region Defined	1	
Total			4	
TOTAL			110	

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