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Scaling up LEED-ND sustainability assessment from the neighborhood towards the city scale with the support of GIS modeling: Lisbon case study

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ABSTRACT

Cities and governments are increasingly interested in refurbishing the existing built environment as a key component in plans to reduce GHG emissions and resource efficiency strategies. In this sense, the building industry started to develop sustainability assessment tools, first to guide new or major renovation building projects, and slowly progressing toward the evaluation of neighborhoods and cities. However, scaling up sustainability is a challenge due to the increased number of parameters and stakeholders involved in the decision-making process. This paper presents a methodology to scale up LEED-ND sustainability assessment from the neighborhood towards the city scale with the support of GIS modeling. This approach was tested for the current Lisbon case study. It resulted in the identification of the priority intervention areas and parameters. The paper further highlights four policy recommendations: reduce water flood risk; increase mixed residential and non-residential developments; reinforce the adoption of energy certifications, and create similar schemes for water consumption. These findings can support decision-makers to develop urban redevelopment strategies and improve the overall city sustainability performance.

1. Introduction

Today, more than half of the world's population lives in urban areas (WHO, 2015). Cities are centers of development and economic prosperity, however, as the urban population continues to expand rapidly, the depletion of natural resources grows exponentially.

Currently, buildings account for approximately 40% of the final energy consumption worldwide (WEC, 2016), 25% in the EU (EUROSTAT, 2016), 40% in the US (EIA, 2017). They also require 14% of all accessible potable water (WRG, 2009). In addition, buildings construction and demolition waste accounts for approximately 33% of all waste generated in the EU (EC, 2016; EUROSTAT, 2014), 31% in the US (USEPA, 2016). Furthermore, the increasing demand for resources intensifies the adverse impact of the climate change and potential shortage of supplies, which pose serious implications on the world's social and economic balance (Dixton et al., 2014). Therefore, the sustainable use of resources has become a goal of official city plans and urban renewal policies at the beginning of the 21st century.

As a response to these concerns, the construction industry has been progressing toward the integration of sustainability principles and performance-based sustainable design. The early steps in that direction were made at the building scale with the development of a number of pilot projects, support tools and sustainable assessment systems such as LEED, BREEAM or CASBEE, to help decision makers improve the environmental performance of buildings (Smith, 2014).

Results from these early phase projects have led to the recognition that reaching the sustainable transformation goals would require moving beyond the assessment of buildings individually (Dixton et al., 2014), and moving towards the urban scale with a more integrated approach where buildings are seen as a component of a system. At the neighborhood scale, the built environment, public transport, and services may be considered to take full advantage of the synergies among buildings and activities, as well as cost sharing and market risk for the different stakeholders simultaneously.

Recently, the attempt to scale up the sustainability assessment led to the development of rating systems, such as LEED-ND, dedicated to neighborhood scale projects (USGBC, 2014b). Simultaneously, in the academic field, a substantial part of the literature has been focused on understanding and determining a consensual definition for urban sustainability and its main parameters (Ameen, Mourshed, & Li, 2015; Haapio, 2012). Other researchers explored the use of digital modeling and software tools (Allegrini et al., 2015; Yigitcanlar et al., 2015) and

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Table 1
LEED-ND sections and pre-requirements.

Section	SLL: Smart Location and Linkage	NPD: Neighborhood Pattern and Design	GIB: Green Infrastructure and Buildings
Pre-requirements (PR)	PR1 smart location; PR2 imperiled species & ecological communities; PR3 wetland & water body conservation; PR4 agricultural, land conservation; PR5 flood avoidance.	PR6 walkable streets; PR7 compact development; PR8 compact & open community.	PR9 certified green buildings; PR10 minimum energy performance; PR11 indoor water use reduction; PR12 construction activity; pollution prevention

the potential of using georeferenced data within Geographical Information Systems (GIS) to perform analysis on the urban scale (Lazar & Murtha, 2009; Smith & Bereitschaft,2016). These studies suggest that it is possible to scale up from the building to the neighborhood, toward a city scale, which can foster integrated sustainable urban planning. Nevertheless, scaling up sustainability assessment also increases the complexity due to the higher number of parameters and stakeholders involved in the decision-making process. Therefore, this is a growing field of research.

This paper presents a methodology to scale up LEED-ND sustainability assessment. Instead of the standard use of the LEED-ND to certify a single neighborhood (USGBC, 2014b), we use it to assess all Lisbon city subsections (3279), using GIS modeling as a support tool in this process. The goal is to identify the key parameters and priority intervention areas for strategic urban planning. The outcomes of this case study can be used to support informed policy making and foster the overall sustainable renewal of the city.

2. State of the art

2.1. LEED-ND for sustainability urban assessment

Sustainable neighborhood redevelopment projects can benefit from assessment systems that provide guidelines to the inclusion of sustainability measures along with the project development process. These systems emerged primarily to assess sustainability practices at the building scale (GRESB, 2013), but more recently, some have been moving toward the neighborhood scale (Ameen et al., 2015; Haapio, 2012; Komeily & Srinivasan, 2015), for example: CASBEE – UD from Japan (2007), BREEAM Communities from UK (2012), DGNB – New Urban Districts from Germany (2007), and LEED for Neighborhood Development from USA (2009).

Despite their relatively short history, the sustainability assessment tools at the neighborhood scale have received much attention from the industry and research community. A substantial proportion of the literature focuses on understanding the similarities and differences between the different systems (Berardi, 2013; Haapio, 2012; Reith & Orova, 2015; Sharifi, 2013). Others focuses on improving existing methodologies or creating new ones (Alqahtany, Rezgui, & Li, 2013; Yigitcanlar & Dur, 2010). There are also several studies focused on the application of these tools (Smith & Bereitschaft, 2016; Talen et al., 2013), including case studies to show how these tools have been used for assessing neighborhoods. Some authors address the challenges of using these schemes as global standards. In this respect, Sharifi & Murayama (2014), argue that assessment tools should take into account the specificities of each location, however, some of these schemes have already been applied to neighborhood developments in several countries, as is the case of LEED-ND, used in this paper.

LEED-ND, developed in 2009 by the *U.S. Green Building Council* (USGBC), is one of the most widespread assessment system for the neighborhood scale. It is a volunteer-based certification system that offers an integrated sustainability approach for land-use, transportation, and infrastructure of urban projects.

The LEED-ND scheme (USGBC, 2014b) is subdivided into three main sections: Smart Location and Linkage (SLL) which intends to minimize adverse environmental impacts and limit urban sprawl; Neighborhood Pattern and Design (NPD) which incentivizes compact, mixed-use neighborhoods with connections to surrounding communities; and Green Infrastructure and Buildings (GIB) which aims to reduce the environmental impact of buildings and infrastructures. Additionally, there are two bonus credit sections: Innovation & Design Process (IDP); and Regional Priority Credits (RC). Each of these sections comprises a set of mandatory pre-requirements (PR) and optional credits (CR). For applying to LEED certification, the projects must meet all the mandatory pre-requirements and a minimum set of points given by optional credits.

By comparing the values obtained within each neighborhood with the standard indicated in each PR or CR it is possible to score the neighborhoods on an evidence-based binary variable (yes/no if it complies with the standard). Furthermore, LEED-ND projects can qualify as Certified, Silver, Gold or Platinum, depending on the number of credits and pre-requirements achieved.

Table 1 shows the pre-requirements (PR 1–12) for each of the LEED sections, that will be analyzed in the present study.

While LEED-ND proved to bring substantial advancement for urban sustainability assessment (Talen et al., 2013), it has some constraints. Among other critics, there are five main constraints recognized in the literature.

First, LEED-ND was originally designed to assess new urban projects and is less suited to directly assess the redevelopment of existing neighborhoods, which is particularly significant in the European context, where the challenges to sustainable urban planning focus on refurbishing the existing building stock (Economidou, Laustsen, Ruyssevelt, & Staniaszek, 2011).

Second, although this scheme aims to be an international standard, there is skepticism relative to how all the evaluation criteria can be applied universaly, since each region bears its own characteristics in terms of climate, legislation, cultural or natural conditions (Säynäjoki, Kyrö, Heinonen, & Junnila, 2012).

Third, there has been some criticism that in LEED-ND, the economic and cultural aspects are only marginally accounted for (Ameen et al., 2015; Sharifi & Murayama, 2014). Fourth, time and cost investment in the calculation of LEED-ND scores for each individual project has a strong influence on low rates of adoption (Talen et al., 2013).

Finally, even though there is a recognized market need to access large scale projects (Murakami et al., 2011; Yigitcanlar, Dur, & Dizdaroglu, 2015), the high level of detail required by LEED-ND in the current version *v4* limits the size of the projects to 6 km^2 (GBCI, 2012; USGBC, 2014a,b). To take LEED-ND to its full potential as a support tool to sustainable urban planning at the city scale, these limitations need to be overcome.

In line with these arguments, sustainability rating systems such as LEED-ND were developed primarily to assess and certify single projects. In this regard, the property owners pursue a sustainability certification that gives them the recognition of high quality and sustainability value for their properties. However, this system can also potentially be used at a larger scale by municipalities to identify priority urban areas and parameters for strategic urban planning. The present case study aims to evaluate the adequacy of LEED-ND to this city scale.