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EIAMUO methodology for environmental assessment of the post-war housing estates renovation: Practical application in Seville (Spain)

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ABSTRACT

This paper reports on the environmental impact assessment of a specific urban fabric: the housing estate. This urban-growth typology arose in the second half of the twentieth century to supply the existing needs of the time. It involved short-term processes, reduced costs, and lower comfort standards, which are far from present European guidelines. Currently, they represent situations of unsustainability in cities worldwide that are undergoing improvement.

Here, the environmental impact assessment and minimization for urban organisms (EIAMUO) methodology is presented. This consists of a system of eco-indicators created specifically for estimating the impacts associated with these fabrics. Through its practical application, a snapshot of the current situation is achieved and the targets designed to minimize the environmental impact are proposed.

1. Introduction

Due to the urban development process, 80% of the European population lives in urban zones, while the percentage remains at 54 (in 2014) for the world population. This is estimated to rise to two-thirds of the world population by 2050 (United Nations, 2015).

Urban zones provoke imbalances in the cycles of water, energy, and materials, and produce atmospheric, noise, and light pollution in the urban systems they create (Castro-Bonaño and Salvo-Tierra, 2001). Thus, urban systems are partly responsible for global environmental problems. Furthermore, cities are major CO_2 emitters due to their characteristic concentration of population and activities. In Spain, 40% of all CO_2 emissions are produced in urban environments, 40% of which is due to energy consumption in the domestic sector and building-related activities (IDAE, 2011).

In many of these urban zones, a specific urban growth process can be identified from the twentieth century: the housing estate. This process is characterized by the planning and simultaneous implementation of parceling, urbanization, and construction, which creates closed packages of urban fabrics (de Solà-Morales, 1997). The housing estate is a worldwide phenomenon that spread from Europe after the Second World War (Kabisch and Grossmann, 2013). It was designed to meet the housing needs of middle and low income groups.

In Spain, the estates were mainly built as neighborhoods of open building form typologies. They are especially common in medium and large cities, which were the subject of significant growth from the middle of the century. Nowadays, their situation reflects the needs of housing at the time of construction — meaning short-term processes and reduced costs, poor industrialized production, and lower comfort standards than the present day (Rubio del Val, 2010).

Housing estates are subject to intervention designed to mitigate their urban obsolescence (Hernández Aja et al., 2013). Complex issues affect these urban areas: architectural (typological disconnections, technical deficiencies, physical deterioration); urban (isolation, functional deficiencies, degradation of public space); and social (unemployment, segregation, conflict) (Universidad de Sevilla, 2016).

Abbreviations: AC, Acoustic comfort; AGP, Accessibility to a green point; DGP, Distance to the green point from the housing access; ERR, Energy from renewable resources; LE_{UO}, Light emission per urban organism; EIAMUO, Environmental impact assessment and minimization for urban organisms; EIA, Environmental impact assessments; ESS, Energy self-sufficiency; LP_{SS}, Light pollution per street section; lpd, Liters per person and day; NCont, Number of containers; NInh, Number of inhabitants; $NInh_{<65\,dB}$, Population affected by sound lower than 65 dB(A); PGP, Proximity to the green point; PPWR, Percentage of purified wastewater that is reused; PSWCC, Provision of separate waste collection containers; PWC, Proximity to the waste collection point from the housing access; S_{SS}, Surface area of the street section; SC, Separate collection; SRI, Solar reflectance index; TCP_{YEAR}, Time the clean point remains open per year; TEC, Total energy consumption; UO, Urban organism; VPW_{BT}, Volume of purified wastewater reused per built typology; $VSCW_{YEAR}$, Volume of separate collected waste per year; VUW_{INH}, Volume of urban solid waste per inhabitant; VUW_{YEAR}, Total volume of urban solid waste per year; WC_{INH}, Water consumption in liters per person and day; WC_{BT}, Water consumption per built typology; ΣD, Sum of distances of access of the total population to the nearest collection point

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Therefore, recent research has considered sustainability and environmental impact assessments (EIA) in urban areas.

The investigations consider, on the one hand, the creation of indicator systems for specific cases (monitoring the housing sustainability in urban ecosystems) (Dizdaroglu, 2015) or for specific locations (a Mediterranean city in Spain) (Braulio-Gonzalo et al., 2015). On the other, they consider projects for development and conservation using sustainability indicators (Agol et al., 2014); reviews of the incorporation of sustainability to the strategic environmental assessment (White and Noble, 2013); and sustainability assessment tools for neighborhoods (Sharifi and Murayama, 2013). The reviews show that there is a lack of information regarding the development of the indicator systems at the micro-urban level (Dizdaroglu, 2015). Moreover, the use of sustainability indicators is appropriate for EIA (Agol et al., 2014), but most tools do not sufficiently cover the social, economic, and institutional aspects of the sustainability (Sharifi and Murayama, 2013). Research also considers international evaluation methods for the building and neighborhood scale. These tools lack of the ability to address the interaction of buildings with their infrastructure (Dawodu et al., 2017). Additionally, some methods such as BREEAM-C and LEED-ND may lead assessors to secure the certification of non-sustainable areas (Wangel et al., 2016), because the impacts related to construction are disregarded, since those methods are focused on internal sustainability while indicators for procedure carry greater weight than indicators that assess performance. The literature review conclusion is that existing systems cannot refer to the housing estates as they do not contemplate neighborhoods built immediately or the interaction of the buildings with the urban fabric they create.

The objective of this study was to create a method for the EIA of housing estates. This method, which is original and unpublished, is called the environmental impact assessment and minimization for urban organisms (EIAMUO) methodology. It provides a system of eco-indicators to assess the environmental impact of the urban organism (UO) (original research term). These are urban fabrics created by a single action, which combines planning, design, master-planning, project development, and construction based on the repetition of one or more buildings (Garrido-Piñero, 2015). The system has been outlined previously (Mercader-Moyano et al., 2015), and it is presented here along with targets to minimize the environmental impact in accordance with the framework set by current strategies.

In addition to this, the system of eco-indicators should have political significance and be useful for users; it must include analytical considerations, be measurable, documented with sufficient quality information, and regularly updated as proposed by the Organization for Economic Cooperation and Development (OECD) (OECD, 1993).

The rest of this paper is organized as follows: Section 2 explains the methodology developed for the research and presents the materials used; Section 3 establishes the indicator systems; Section 4 presents the case study and applies the system of indicators developed; Section 5 contains a discussion of the results obtained; and Section 6 concludes the research.

2. Methodology and materials

2.1. Methodology

To achieve this objective, the following methodology is proposed. First, a critical study of indicator systems is conducted. The choice of these is based on the characteristics of the UO, which is the object of study. Through this review, the most important factors for developing environmental renovation are determined, the evaluation criteria are obtained, and the evaluation areas are established that have the greatest impact on the EIA for the UO case. From this review and critical study, the system of indicators is proposed. The case study is then established and the system developed is applied. As a result, the imbalances produced are identified and valued, and actions to minimize them are proposed. The research methodology is explained in detail in our previous work (Garrido-Piñero, 2015).

2.2. Materials

The materials used are divided into two groups: those necessary for the development of the methodology and those necessary for its application. Methodology development materials include the characteristics of the UO, existing indicator systems of sustainability, and EIA. Methodology application materials include data obtained from energy simulations, surveys, field research, and official sources.

2.2.1. Methodology development materials

The UO characteristics given are dates of construction, use, and formalization. Dates of construction range from 1950 to 1979. This period covers the building sector recovery in Spain after 1950 (Cascales Barrio and Márquez Pedrosa, 2007) to the appearance of the first minimum thermal criteria introduced with the publication of the basic rule on thermal conditions in buildings (in Spanish, NBE-CT-1979) in 1979. Secondly, the use of the UO is residential. More than 40% of final energy consumption in the European Union comes from existing building stock, and 63% of total energy consumption in the building sector is accounted for by residential use (European Parliament, 2012). Finally, the UO is formalized in the open-block housing estate, forming a residential complex of urban character. In Spanish cities, this type of urban growth was used to offset the significant quantitative needs of existing housing at the end of mid-twentieth century wars (Rubio del Val, 2010).

Fig. 1 provides examples of UOs with the characteristics previously described. These are “El Tardón” Estate, Montbau and Leipzig-Grünau.

“El Tardón” is in Seville in Spain, and was built in 1952. It has an area of 6.56 ha and its population density is 6.08 dwellings/ha (Valero-Ramos, 2007). Montbau is also in Spain, in Barcelona, and was built in the late 1950s. It has an area of 15.6 ha and a density of 111.25 dwellings/ha in the south-west unit and 148 dwellings/ha in the north-east unit (Rieradevall i Pons, 2014). Finally, Leipzig-Grünau was built between 1976 and 1987 in Leipzig, Germany. Between 41,000 to 45,000 inhabitants live in the 8.7 km^2 area (Kabisch, 2016; Kabisch and Grossmann, 2013).

The study analyzed existing indicator systems of sustainability and EIA, both at the urban and building level. The selection of systems is based on their influence, their applicability to the case of UO, and their adaptability. Furthermore, they are currently used at national and global levels.

The selected systems (displayed by scope) are:

- International: ISO 37120:2014 Sustainable development of communities — Indicators for city services and quality of life (ISO, 2014); certification tools: BREEAM, LEED, CASBEE, SbTOOL, VERDE Certification, Demarchè HQE, Green Star, DGNB, CFSH, Green Globes, Protocol ITACA, BEAM (Mercader-Moyano et al., 2014). The certification tools are only considered in the analysis of the greater impact evaluation criteria.
- National: White Paper on Sustainability in Urban Planning in Spain (Fariña Tojo and Naredo, 2010); System of indicators and conditions for large- and medium-sized cities (BCNecologia, 2010a); Municipal system of sustainability indicators (BCNecologia, 2010b).
- Regional: Basis for a system of indicators in the Urban Environment in Andalusia, international experiences in measuring sustainability in cities (Castro-Bonaño and Salvo-Tierra, 2001); Special plan for environmental sustainability indicators of urban development in Seville (BCNecologia, 2007); Plan of urban sustainability indicators of Vitoria-Gasteiz (BCNecologia, 2010c); Guide to sustainable building for housing in the autonomous community of Basque Country (EVE, 2006); System of sustainability indicators for residential construction in Andalucía (López de Asiaín, 2007).