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MULTI-ATTRIBUTE CLASSIFICATION OF HOUSING CONSERVATION STATUS IN URBAN REGENERATION ACTIONS

Eduardo Natividade-Jesus[13], João Coutinho-Rodrigues[23], Lino Tralhão[3], Nuno Sousa[34]

1: Professor of Civil Engineering
Department of Civil Engineering, Polytechnic Institute of Coimbra - School of Engineering
Quinta da Nora, 3030-199 Coimbra, Portugal
E-mail: ednativi@isec.pt

2: Full Professor of Civil Engineering
Department of Civil Engineering-Faculty of Sciences and Technology-University of Coimbra
Rua Luís Reis Santos, 3030-788 Coimbra, Portugal
E-mail: coutinho@dec.uc.pt

3: Researcher at INESC-Coimbra
Av. Antero Quental 199, 3000-141 Coimbra, Portugal
http://kreation.dec.uc.pt/projects

4: Invited Assistant Professor at Universidade Aberta
Delegação de Coimbra da Universidade Aberta, R. Alexandre Herculano 52, 3000-019 Coimbra
E-mail: nsousa@uab.pt

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Abstract *Urban regeneration is more and more a "universal issue" and a crucial factor in the new trends of urban planning. It is no longer only an area of study and research; it became part of new urban and housing policies. Urban regeneration involves complex decisions as a consequence of the multiple dimensions of the problems that include special technical requirements, safety concerns, socio-economic, environmental, aesthetic, and political impacts, among others. This multi-dimensional nature of urban regeneration projects and their large capital investments justify the development and use of state-of-the-art decision support methodologies to assist decision makers.*

This research focuses on the development of a multi-attribute approach for the evaluation of building conservation status in urban regeneration projects, thus supporting decision makers in their analysis of the problem and in the definition of strategies and priorities of intervention. The methods presented can be embedded into a Geographical Information System for visualization of results. A real-world case study was used to test the methodology, whose results are also presented.

1. INTRODUCTION

1.1. Sustainable development and buildings

Modern trends in sustainable development emphasize, along with the economic aspect of the problem, other fundamental aspects, like environmental, social, cultural, and political dimensions [1]. Success of sustainable development strategies requires adequate translations of these concepts into the practical dimensions of the real world. This implies the implementation of sustainable development strategies at an urban level [1], given the high percentage (75% in 2010) of urban population in the most developed countries [2].

Recent literature concerning energy expresses that the building sector is crucial for climate change mitigation worldwide [3]. The building sector represents about 32% of the world primary energy consumption (http://www.iea.org/stats/) and about 34% of carbon dioxide (CO_2) emissions [3]. Refurbishment of buildings in existing urban centres has a high potential for the increase of efficient energy use because it can significantly improve building thermal performance. It can also reduce energy use by bringing people from suburbia to city centres, reducing commuting, and is thus an opportunity for promoting more sustainable urban transportation modes [4].

1.2. Urban regeneration - the Portuguese scenario

Portugal has one of the highest rates of housing per capita in Europe, at 1.5 dwellings per household. However, a large stock of aging housing exists - about 70% are more than 20 years old. It is estimated that 50% of the older housing stock need repairs. Despite of this scenario, Portugal lags behind many its fellow EU states in the development of a more "Kyoto friendly" urban environment, particularly in the renovation of existing housing stock to meet minimum energy performance requirements adapted to the local climate. The housing renovation and maintenance (R&M) sector has a relatively low importance in total residential output (about 23% - source: www.ine.pt) in comparison with other Euroconstruct countries where the R&M markets represent about 60% of the total residential market [5].

Nevertheless, regeneration has become in the past few years an important issue in the Portuguese public and governmental agendas [6], and a higher conscience related to the importance of urban regeneration seems to exist now, especially in historic areas.

2. MULTI-ATTRIBUTE APPROACH TO CLASSIFICATION OF HOUSING CONSERVATION STATUS

Urban regeneration inherently involves multiple, conflicting, and incommensurate aspects of evaluation of the merit of possible different scenarios and alternatives, depending on the context of the study and the stakeholders involved (resident population and/or house owners, project management entities and technical development teams) [7]. Given the diversity and complexity of the factors that influence these problems, the spatial nature and volume of data involved, and the need for the use of scientific models, a spatial decision support system

(SDSS) is important for the study of this type of problems, as it can assist stakeholders in making better-founded decisions in urban regeneration problems. The SDSS used in this research is fully integrated, capable of performing spatial analysis and database management, as well as running optimisation analysis. It is thus an SDSS of level 3, as defined in [8].
To address the foregoing, we present and implement a methodology for analysing building conservation status (CS), within particular urban areas to be intervened. Such evaluation is usually one of the first stages to be considered in the analysis of urban regeneration projects.

2.1. Definition of attributes and their structure

Taking into consideration the available data and the aspects to be considered in a multi-attribute analysis, a set of 13 attributes was considered, shown on table 1 below, together with their respective weights, which were set according to the assessment method defined by Portuguese law - Portaria 1192-B/2006.

Categories	Attributes	Weight
Superstructure and facade walls	Conservation of frame/structure	14%
	Conservation of facade support walls	14%
	Conservation of wall facade finishes	5%
Roof system	Conservation of roof structure	8%
	Conservation roof coating	3%
Interior stairs, wall and ceiling	Conservation of the stairs structure	10%
	Conservation of interior stairs, wall/partitions and ceiling finishes and windows	6%
Building systems and services	Conservation of water installations	9%
	Conservation of wastewater drainage network infrastructure	6%
	Conservation of rainwater drainage installations	3%
	Conservation of electrical installation	9%
	Conservation of communication installation	5%
Fire-Safety	Fire-Safety	7%

Table 1. Attributes table and respective weights.

Six classes of building CS, including refurbishment cost to optimal level (based on the prices for construction of housing per square metre of floor area defined in Portuguese law - Portaria 1172/2010), were defined in order to obtain a convenient building classification, as represented in Table 2. These classes range from “no need of refurbishment” (class 1) to “demolition and new construction” (class 6).

Classes	Conservation status	Refurbishment levels	cost [€/m2]
Class 1	New	no need of refurbishment	0 €
Class 2	good	slight refurbishment	74 €
Class 3	medium	medium refurbishment	186 €
Class 4	poor	major refurbishment	595 €
Class 5	**unfit housing**	**exceptional refurbishment**	**1 004 €**
Class 6	in ruin	demolition and new construction	744 €

Table 2. CS classes and their refurbishment cost to optimal level.

Given a particular set of buildings and their scores in each of the 13 attributes, the SDSS yields back the class in which those buildings lie.
These classes were defined considering a set of reference profiles, which serve as a model against which the alternatives (in our case, buildings) are to be compared. The SDSS allows the decision maker to customize those profiles, which can represent hypothetical situations or real buildings in the database that can be considered representative of a given profile of the conservation status. In figure 1 below the reference profiles used are presented.

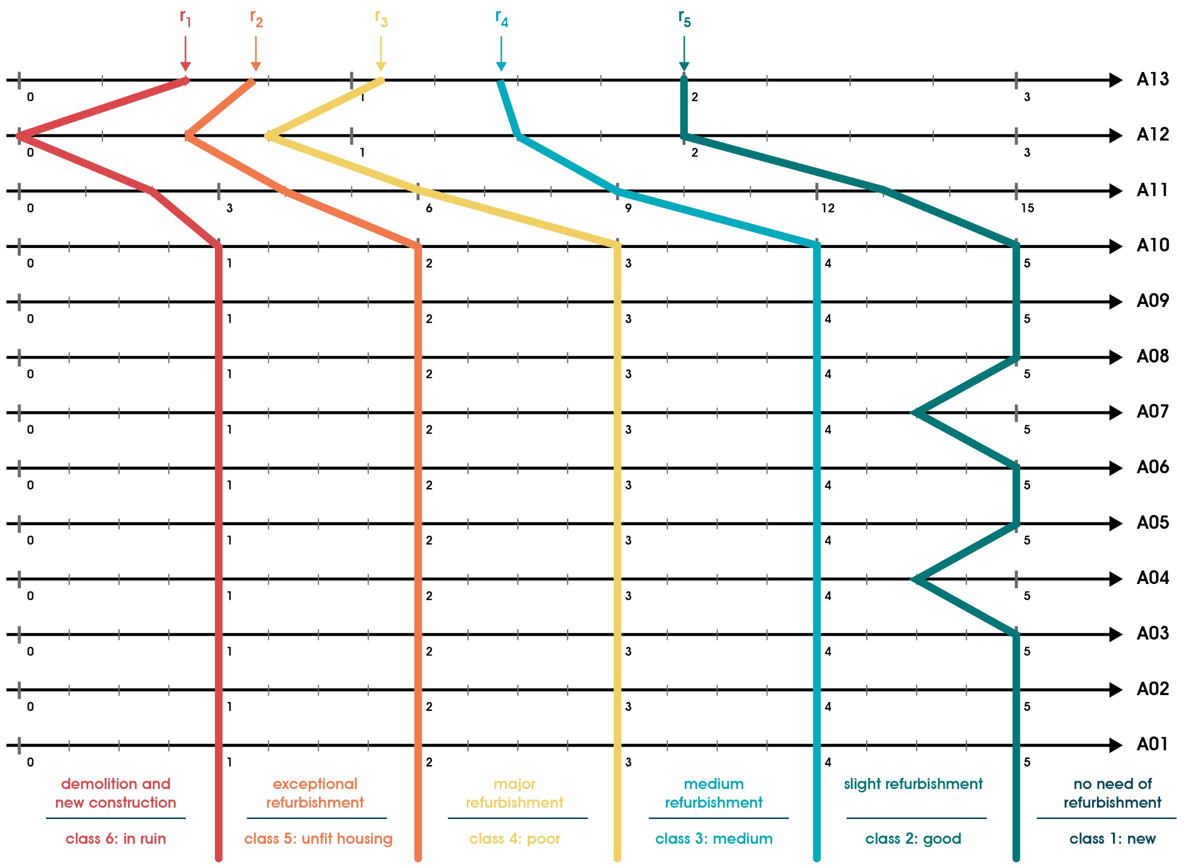

Figure 1. Reference profiles used for defining conservation status classes.

2.2. The decision support methods base

To operate the SDSS, the multi-attribute ELECTRE TRI method was implemented, due to its intrinsic non-compensatory nature, which incorporates in a natural way the imprecision and uncertainty inherent to Human decision processes. In the framework of ELECTRE TRI, after the definition of the technical parameters required by the methods, such as the weights or the thresholds of indifference, preference and veto, the SDSS classifies the selected alternatives according to the type of assignment, pessimistic or optimistic [9], depending the degree of exigency of the decision maker (DM).

The SDSS also allows the DM to perform a sensitivity analysis to identify the influence of variations of the threshold values in the outranking results. This possibility makes ELECTRE TRI method, in the operational framework of this SDSS, more adequate since in this manner the common attitude of DM, which is usually characterized by a gradual transition from the indifference to the preference state, can be better captured. Furthermore, the introduction of thresholds provides a technically sound way to deal with the uncertainties stemming from different sources (not just regarding preferences, but also lack of data precision).

Given all its characteristics, ELECTRE TRI is therefore a natural method for the study of building CS in urban regeneration projects, allowing to define (real or virtual) reference properties (according to current CS), and to group/classify the buildings into classes.

The SDSS incorporates a geographical information system (GIS), which enables the results to be visualized on maps, where the buildings under evaluation appear duly located, with colours that represent the respective classification. This feature is really useful for a municipal agency to generate a building CS map for planning and funding purposes, for instance for prioritizing intervention.

The methodology was tested with the case study of the Coimbra City historical centre, Portugal, where a large urban regeneration project, addressing about 750 buildings, is being undertaken. The GIS result is shown in the figure 2 below.

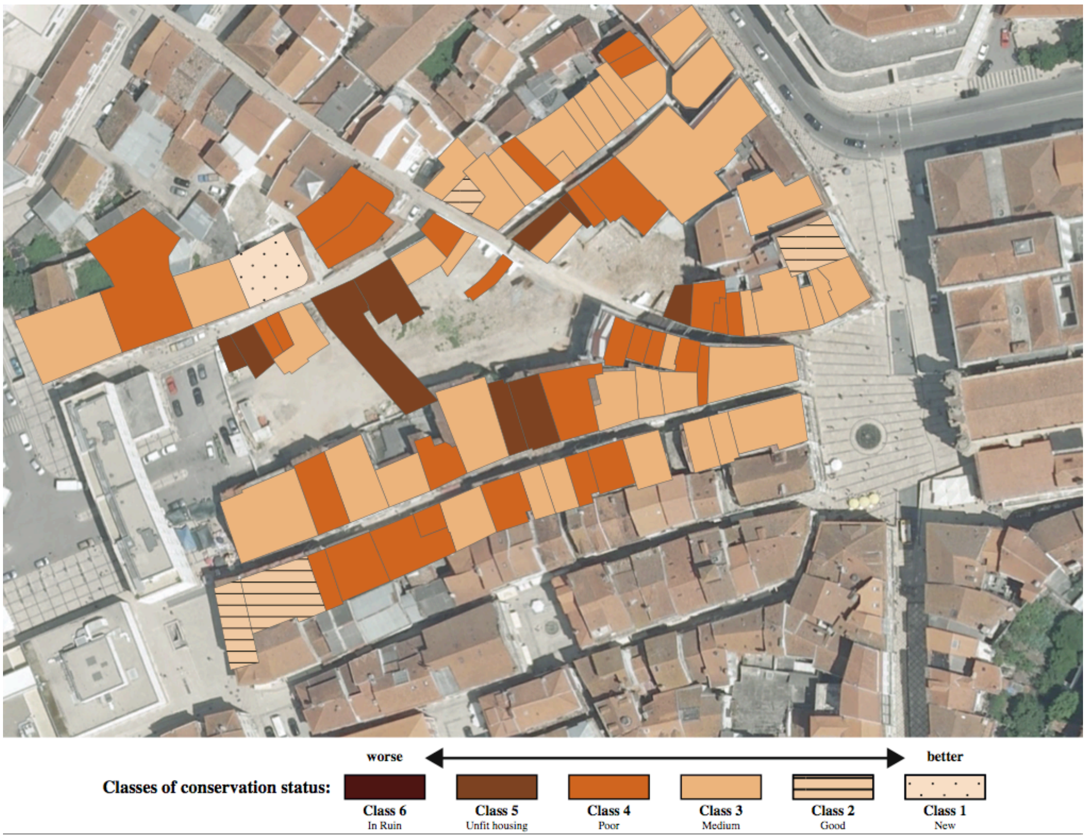

Figure 2. Case study GIS output.

3. CONCLUSIONS

The evaluation of buildings CS is a crucial step in the study of urban regeneration projects. This evaluation involves the analytical and systemic determination of all the factors influencing the CS of a building, supported in clear principles and using well-defined criteria. The SDSS presented in this paper, built on the ELECTRE TRI method, gives the DM a flexible, yet rigorous, analytic tool, based on formal multiple attribute methodologies. The results can then easily be displayed in GIS.

The system is flexible enough to be adapted to other applications: with different datasets, the system could be used to evaluate any building stock, and adapted for particular aspects, such as energy efficiency.

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REFERENCES

[1] Fujiwara A, Zhang J, Lee B and Da Cruz MRM (2005). Evaluating sustainability of urban development in developing countries incorporating dynamic cause–cause–effect relationships over time. Proceedings of the Eastern Asia Society for Transportation Studies 6: 4349–4364;

[2] United Nations (2010). World Urbanization Prospects – The 2009 Revision. United Nations Department of Economic and Social Affairs, Population Division, New York, NY, USA.

[3] Urge-Vorsatz D and Novikova A (2008). Potentials and costs of carbon dioxide mitigation in the world's buildings. Energy Policy 36(2): 642–661.

[4] D. Farr (2007). Sustainable Urbanism: Urban Design With Nature. Wiley, USA.

[5] Euroconstruct (2009). Proceedings of 68th Euroconstruct Conference, Zurich, Switzerland 2009 – Country Report. Euroconstruct, Zurich, Switzerland;

[6] Breda-Vázquez I (2009). Partnership diversity and governance culture: evidence from urban regeneration policies in Portugal. Urban Studies 46(10): 2213–2238;

[7] Kazmierczak AE, Curwell SR and Turner JC (2009). Regeneration of large urban areas: assessment methods. Proceedings of the Institution of Civil Engineers – Municipal Engineer 162 (2): 117–124;

[8] Laaribi A., 2000. S.I.G. et analyse multicritère, Hèrmes Science Publications, Paris, pp. 190;

[9] Yu W (1992). ELECTRE TRI: Aspects méthodologiques et manuel d'utilisation. Université Paris-Dauphine, Paris, France, Document du Lamsade 74.