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A site planning approach for rural buildings into a landscape using a spatial multi-criteria decision analysis methodology

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ABSTRACT

Selection of rural buildings' site is a complex process to solve a discordant relation with other components of rural landscapes and needs many diverse criteria to deal with its situation. This paper presents a multi-criteria spatial decision analysis approach using geographic information system (GIS) technique for evaluating the suitability of rural buildings site selection with a case study in Hervás (northern Extremadura region), Spain. The aim of the methodology is to evaluate the suitability of the study region in order to optimally site a new single dispersed tourism-related commercial building with landscapes. The analytical hierarchy process (AHP) is used to generate the alternative decisions using the multi-criteria evaluation techniques standardised by fuzzy membership functions. The parameters are categorised into three criteria groups, namely physical, environmental and economic criteria and then the weights are verified by a group discussion with the experts for final weight consensus making them more objective. With the aid of the simple additive weighting (SAW) method, the calculation of final grading values in multiple criteria problem is evaluated for the study region. The resulting land suitability is reported on a grading scale of 0–10, which is, respectively, from least to most suitable areas. Combination of a spatial clustering process reveals the most suitable areas for rural buildings siting with their landscapes. The proposed methodology is intended to solve the rural building integration problem with its landscape and to facilitate the flexible methodology implementation from decision alternatives involved in the decision making process.

Introduction

The suitable siting planning of the numerous man-made elements is related with various interconnected factors which affect to the building itself and the relationship between the building and the current countryside environment and raises the questions of how negative impacts on these factors can be minimised (De Vriesa et al., 2012; Jeong et al., 2012; Tassinari and Torreggiani, 2006). The many man-made constructions' cluttering is being introduced in the rural area and its' recreational potential is growing and makes human movements to rural areas which is coinciding with the urban sprawl in the last 20th century (Dwyer and Childs, 2004; Van der Wulp, 2009). As a powerful tool, tourism also has long been identified for development, spurring economic growth, increasing foreign exchange, smallholder investment, and local employment (De Kadt, 1979). However, regional planning has not evolved to deal with this new rural area changes (Montero et al., 2005) but careful choosing locations of rural buildings which follows and meets certain criteria could mitigate the negative impacts on rural environments (Bell, 1995; García et al., 2006; Tandy, 1979).

The spatial modelling used by geographic information system (GIS) allows for analyzing large volumes of spatial data which give geographical expression to the economical, social, cultural ecological policies of societies (Böhme and Schön, 2006; Hermann and Osinski, 1999). GIS offers useful tools to study the location in depth when considering spatial planning limitations, opportunities, visual characteristics and the overall landscape scene (Domingo-Santos et al., 2011; Hernández et al., 2004; Tassinari and Torreggiani, 2006). From this modelling, decision-makers (or planners and local authorities) can find the current state of affairs and some idea of future conditions, ideally the possible consequences of the plans and policies they may have under consideration (Blaschke, 2006). The problems of spatial planning usually incorporate a large number of stakeholders (experts and non-experts) with different backgrounds, interests, authorities and interpretations of some of their issues (Fountas et al., 2006). A collaborative process is the right way to reconcile the individual approaches and to make

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decisions satisfying all or most participants (users: stakeholders and the public) (Jankowski et al., 1997).

Multi-criteria evaluation (MCE) is one particular type of spatial planning to help decision makers explore and solve multiple and complicating problems (Hwang and Yoon, 1981; Malczewski, 1999; Roy, 1996). This process forms three phases: first, identifying the problem; second, designing the alternative solutions to the problem; third, choosing the best alternative of the decision making process (Forman and Selly, 2001). Decision-making includes choosing from various criteria and alternatives. The criteria usually have different importance and the alternatives in turn differ on users' preference for them on each criterion. We need a way to measure to make such tradeoffs and choices. Measuring needs a good understanding of the measurement methods as well as the different scales of measurement (Saaty, 1996, 2005). The analytic hierarchy process (AHP) is a widely accepted decision-making method that is an effective approach to extract the relative importance weights of the criteria in a specified decision-making problem (Gemitzi et al., 2006; Saaty, 1996, 2005). One of the most crucial steps in any multiple criteria problem is the accurate estimation of the pertinent data. Although qualitative information about the criterion importance can be found, it is difficult to quantify it correctly (Faraji Sabokbar, 2005).

A close investigation of the current methods was carried out for determining the location of different types of rural buildings with a landscape. These studies often deal with minimisation of the overall environmental impact of these developments and mainly have essentially economic approaches, the analysis of criteria concerning the location strategy (Hsu and Tan, 1999; Inyang et al., 2003; Lahdelma et al., 2002). To the best of our knowledge, for the brevity's sake, few studies have been conducted on rural buildings' spatial clustering process that explicitly integrates multi-criteria decision analysis and GIS. In particular, this paper is the first of its kind in applying techniques of MCE combined with fuzzy standardisation and the simple additive weighting (SAW) for evaluating rural building siting into a landscape on the rural fringe of the northern Extremadura region, Hervás (Spain). By identifying local level criteria and indicators for spatial planning and evaluating alternative management schemes in a participatory decision environment, this study fills a crucial knowledge gap in design and planning processes and implementing sustainable rural development management in the Extremadura region. Also, this study is relevant to other rural areas with comparable socio-economic and environmental set-up.

The present paper describes a method for determining the site suitability of new single dispersed tourism-related commercial building based on the understanding the limitations of the existing regional planning in the northern Extremadura region, Hervás (Spain), using the AHP for MCE combined with fuzzy standardisation and the SAW (Eastman, 2003) in a GIS environment. The methodology presented herein evaluates the entire study area using a common grading scale, i.e. 0–10 byte grading value, where 0 values a site fully unsuitable for new rural building integration while 10 values a site optimum for its integration. Evaluation criteria are determined based on European planning policy (Council of the European Union, 2001) and regional planning law on Extremadura (LESOTEX, Law 15/2001 of land and landscape planning of Extremadura) and the relevant literature review which make the innovation of the evaluation criteria used and then we have a group discussion with a group of experts to validate the criteria's weights more objective although they were objectively based upon real data. Evaluation criteria identify a spatial data treatment with a grading system based on physical, environmental and economic aspects. In addition, the utilisation of sophisticated spatial statistics methods is an innovation in the rural building siting process, giving some efforts in the analysis of the results, showing the tools provided by GIS and spatial statistics are very important. Also, another goal of this research is to show this technique's flexibility as exploring different decision alternatives and patterns. The proposed approach is illustrated using a case study which is discussed and the methodology applied in this study in "Materials and methods" section. "Results" and "Conclusions" sections discuss the results and the conclusions from this approach.

Materials and methods

A sound rural building siting process into a landscape requires the considerations of extensive criteria and evaluation steps in order to identify the appropriate location or locations and to eliminate the overall negative impact and its subsequent effect on rural environment which affect to choose the criteria and in the weight attributed in the case study region. In the proposed study area, tourism-related jobs can be found in many different sectors, including food service, lodging, entertainment, retail sales, travel planning, and sectors providing transport services. In addition, local planning laws give building design guidelines directly and restrictions as well, regarding to maximum building area, maximum building height, and maximum number of floors. Based on this information, we define that the general characteristics of the building, a single dispersed tourism-related commercial building, have the construction size: 80% building to land ratio and 200% floor area ratio of 100 m^2 land (based on 10 m × 10 m grading cell) with minimum 3 m floor height as depicted in Fig. 1 (Hernández et al., 2007).

A substantial multi-disciplinary evaluation process with multiple set of criteria is applied through the use of the spatial analysis tools provided by GIS with MCE enhanced fuzzy factor

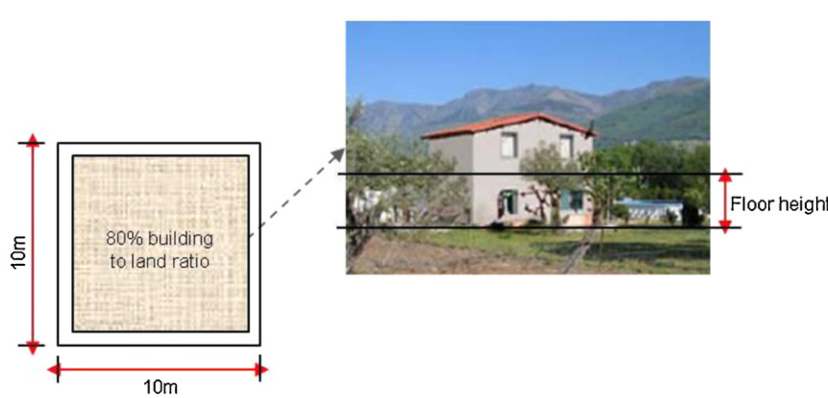

Fig. 1. An example of a single dispersed tourism-related commercial building based on the proposed construction size.