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Sustainability assessment of alternative end-uses for disused areas based on multi-criteria decision-making method

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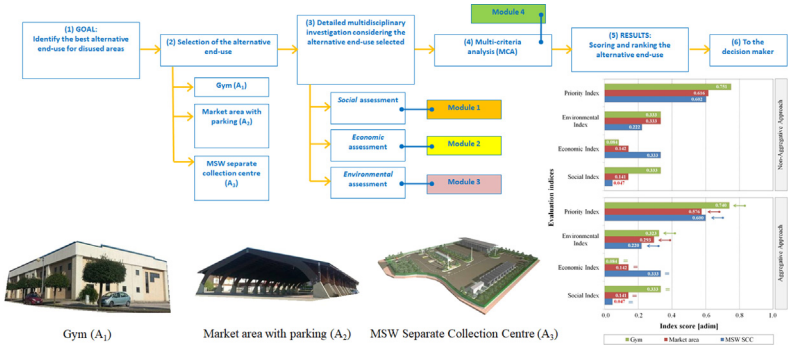
HIGHLIGHTS

- The study defines and applies a multi-disciplinary and multi-criteria approach to sustainability.
- It evaluates alternative end-uses for disused areas considering the three pillars of sustainability.
- The sociological module was useful to select the most socially sound alternative.
- The economic evaluation was conducted defining the bill of quantities.
- The environmental evaluation was performed applying the Delphi method.

GRAPHICAL ABSTRACT



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ABSTRACT

The main aim of this study was to define and apply a multidisciplinary and multi-criteria approach to sustainability in evaluating alternative end-uses for disused areas. Taking into account the three pillars of sustainability (social, economic and environmental dimension) as well as the need for stakeholders to have new practical instruments, the innovative approach consists of four modules stated (i) sociological, (ii) economic, (iii) environmental and (iv) multi-criteria assessment. By means of a case study on a small Municipality in Southern Italy, three end-uses alternatives, representing three essential services for citizens, were selected: Municipal gym; Market area; Municipal Solid Waste (MSW) separate collection centre. The sociological module was useful to select the most socially sound alternative by means of a consultative referendum, simulated with the use of a structured questionnaire administered to a sample of the population. The economic evaluation was conducted defining the bill of quantities with regarding to six main items (soil handling, landfill disposal tax, public services, structure and services, completion work, equipment and furnishings). The environmental evaluation was performed applying the Delphi method with local technicians who were involved in a qualitative-quantitative evaluation of the three alternatives with regarding to eight possible environmental impacts (landscape impact, soil handling, odour, traffic, noise, atmospheric pollution, wastewater, waste). Finally, the Simple Additive Weighting was used as multi-criteria technique to define alternatives priorities. The obtained results showed how the multi-criteria analysis is a useful decision support tool able to identify transparently and efficiently the most sustainable solutions to a complex social problem.

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1. Introduction

Urban regeneration may be understood as a policy for sustainable development of cities. Recovering disused areas and returning new environmental, economic and social quality in poor neighbourhoods responds perfectly to the concept of sustainable cities, limiting urban sprawl and reducing environmental impacts (Musco, 2016).

An important issue for urban regeneration is the construction of appropriate inclusive decision-making processes as well as decision support tools. For this, the participation of citizens is certainly an important element, which allows identifying, supporting, developing and supporting sustainability policies as well as being a tool to reach shared solutions (de Magalhães, 2015; Alexandrescu et al., 2016).

One of the most common problems in urban regeneration is the selection of the best alternative end-use for disused or reclaimed areas (Laprise et al., 2015). In general, the choice is made with a technocratic top-down approach based on a one-dimensional methodology. Moreover, public opinion of the citizens is generally not considered.

To date, there are numerous studies concerning the assessment of sustainability, understood as an assessment based on the three pillars of sustainable development: social, economy and environment (van Timmeren et al., 2012; Braulio-Gonzalo et al., 2015; Chen et al., 2016; Grafakos et al., 2016; An et al., 2017a; Schuetze et al., 2017). However, practical studies that address the issue of the selection of the best end-use alternative are limited and poorly detailed.

With the intent to fill this gap, the main aim of this work was to develop and apply a multidisciplinary and multi-criteria approach to sustainability in evaluating alternative end-uses for disused areas.

To the best of our knowledge, there are not studies of this type in the literature.

The complexity of the issues required multidisciplinary expertise. In such situations, the multi-criteria analysis is the most efficient methodological approach able to achieve the ultimate objective (goal) taking into accounts the various aspects that compose the problem.

A brief state-of-the-art on the use of multi-criteria decision analysis (MCDA) in complex issues is herein reported.

2. Background information on the use of MCDA

Environmental decisions are often complex and draw upon multidisciplinary knowledge bases, which incorporate natural, physical social sciences, politics, and ethics. MCDA provides a systematic methodology to combine these inputs with cost/benefit information and stakeholder views to rank project alternatives.

MCDA is used to discover and quantify decision-maker and stakeholder considerations about various (mostly) non-monetary factors in order to compare alternative courses of action. MCDA supports decision making in the choice between several options or cases based on evaluations involving several different criteria (Godskesen et al., 2018). Numerous approaches fall under the umbrella of MCDA, each involving different protocols for eliciting inputs, structures to represent them, algorithms to combine them, and processes to interpret and use formal results in actual advising or decision-making contexts.

MCDA techniques have been applied for the resolution of many complex environmental problems such as the remediation of contaminated sites (Alvarez-Guerra et al., 2009; Rosén et al., 2015; An et al., 2017a), the siting of MSW management and treatment facilities (De Feo and De Gisi, 2010a, 2014), the assessment of impacts induced on the total environment by municipal wastewater treatment plants (De Gisi et al., 2014a,b; De Gisi et al., 2015; Sabia et al., 2016), the selection of suitable processes for wastewater treatment (De Feo et al., 2013a; Castillo et al., 2016), the equalization of the workload of personnel when operating wastewater treatment plants (De Feo et al., 2013b), the selection of suitable sludge treatment technologies (An et al., 2017b) as well as industrial wastewater treatment technologies (Castillo et al., 2017).

In some of these studies, the researchers have explicitly taken into account the opinions of local community groups and other stakeholders through focus groups, surveys, and other techniques and formally integrated these opinions into the decision process (De Feo and De Gisi, 2010a). Many papers concluded that the application of MCDA methods provides a significant improvement in the decision process and public acceptance of the suggested remedial or abatement policy.

Herva and Roca (2013) highlighted how the main areas of application of MCDA in the environmental field are industry-related applications, energy decision-making, waste management and treatment, wastewater treatment. The main advantages of using MCDA are (i) the possibility of structuring the complex problem to be solved in a hierarchy of different levels constituting the goal, criteria, sub-criteria and alternatives; (ii) the ability to handle a large number of criteria; and (iii) the use of a single comparable index that can simplify the analysis and extraction of conclusions. Conversely, (i) the imprecision of data, (ii) the choice of weights and (iii) the aggregation system are among the main weaknesses.

Finally, in terms of operational tools, many affordable approaches such as the AHP (Analytic Hierarchy Process, Saaty, 2001, 2005), PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation, Ali Nikouei et al., 2017), ELECTRE (ELimination and Choice Expressing Reality, Govindan and Jepsen, 2016) and TOPSIS (Technique for Order Preference by Similarity, Shanian and Savadogo, 2006) are commonly used.

3. Methodology

3.1. Background information for the case study developed

Santa Lucia di Serino is a little village in the Province of Avellino, in the Campania region of Southern Italy. It has a population of 1402 inhabitants (680 male, 722 female), with a surface of 3.87 km^2 and a corresponding population density of 362.3 inhabitant/km^2. The average age is 43.7 years with 20% of over-65 and 13.1% of under-15.

The disused area under study was originally a clay soccer field that was transformed in a MSW storage site in 2007, after one of the numerous periods of waste management emergency occurred in the Campania region in the last two decades. The study area, located immediately upstream of the town and served by a municipal road, is a wide esplanade of 5000 m^2, bounded upstream and downstream by artificial terraces.

At the time of the performed research, in the municipality of Santa Lucia di Serino there were not public sports facilities such as gyms, swimming pools, athletic fields, etc. Even in terms of commercial activities, they are all of little dimensions and a great market area is still missing.

MSW was collected by means of a separate kerbside collection system. It was separated into the following components: putrescibles for composting (twice a week); paper and cardboard (once a week), glass (twice a month), aluminium and other metals together with plastic for recycling (twice a week); non-recycling residues for RDF production (twice a week). A separate collection centre (SCC), namely a centralised collection site where the citizens can deliver the recyclable fractions of MSW, was missing. Usually, SCC is a fenced and manned area, equipped to weigh and collect mainly recyclables.

In terms of MSW per capita production and percentage of source separation, in the period 2010–2015, the municipality of Santa Lucia di Serino averaged around 312 kg_{MSW}/capita/year and 67.5%, respectively, while, in the same period, Italy average around 505 kg_{MSW}/-capita/year and 41.3% (Ispra, 2016).

As shown in Fig. 1, three were the alternative end-uses for the disused area under investigation taken into consideration: (a) a gym (alternative A_1); (b) a market area with parking (alternative A_2); (c) a municipal solid waste separate collection centre (MSWSCC) (alternative A_3). The three alternatives are among the essential services offered to the population.