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# Method for estimating the social sustainability of infrastructure projects

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ABSTRACT

Nowadays, sustainability assessments tend to focus on the biophysical and economic considerations of the built environment. Social facets are generally underestimated when investment in infrastructure projects is appraised. This paper proposes a method to estimate the contribution of infrastructure projects to social sustainability. This method takes into account the interactions of an infrastructure with its environment in terms of the potential for short and long-term social improvement. The method is structured in five stages: (1) social improvement criteria and goals to be taken into account are identified and weighed; (2) an exploratory study is conducted to determine transfer functions; (3) each criterion is homogenized through value functions; (4) the short and long-term social improvement indices are established; and finally, (5) social improvement indices are contrasted to identify the socially selected alternatives and to assign an order of priority. The method was implemented in six alternatives for road infrastructure improvement. The results of the analysis show that the method can distinguish the contribution to social sustainability of different infrastructure projects and location contexts, according to early benefits and potential long-term equitable improvement. This method can be applied prior to the implementation of a project and can complement environmental and economic sustainability assessments.

## 1. Introduction

The sustainable contribution of an infrastructure has to be measured within its own context. Social facets are more influenced by context than environmental or economic ones. These social facets have to be considered in the short and long term and must be properly defined for each project investment (Valdés-Vásquez and Klotz, 2013).

Infrastructure projects promote economic well-being, complement many social interventions and facilitate participation in sociopolitical processes (Asomani-Boateng et al., 2015). An infrastructure by itself, however, may have a reduced impact on society (Gannon and Liu, 1997; Van de Walle, 2009). The assessment of the social impact that an infrastructure has on a region has been under-researched to date. Since the mid-20th century, monetization-based methods have been widely used to evaluate infrastructure projects (Mostafa and El-Gohary, 2014). Nevertheless, some authors have introduced environmental aspects into this evaluation (Torres-Machí et al., 2014; Torres-Machi et al., 2015; Yepes et al., 2015a), with sustainability reaching beyond the analysis of monetary efficiency (Colantonio, 2011). Mostafa and El-Gohary (2014) emphasize the limitations of these methods compared to equitable distribution and the assessment of non-economic aspects; they also add the assumption that investment is inadequate if the benefits do not exceed the costs.

In the last decade, methods have been proposed to assess the sustainability of infrastructure projects, aiming to make sustainable development measurable. In Spain, the "Integrated Value Model for Sustainability Assessment" (MIVES in Spanish) can consider the social facet, even though it has been extensively used for the assessment of environmental and economic criteria (De la Cruz et al., 2015). The social facet can be assessed with a value function proportional to the average satisfaction of the experts. There is no evidence of a simultaneous treatment of different contexts considering the social facet. Nor is there a clear approach that maximizes the improvement of social need in the context of an infrastructure project.

The "Sustainability Appraisal in Infrastructure Projects" (SUSAIP) has been applied in the Chinese construction industry for bridges and viaducts (Ugwu et al., 2006a, 2006b). This method assesses different types of designs considering their geographic context. Thirty percent of its indicators consider the social facet. However, the method assumes the same conditions for different contexts. Furthermore, there is only one decision-maker in the method.

The "Technical Sustainability Index" (TSI) has been applied in Canada for electrification infrastructures (Dasgupta and Tam, 2005). This method takes into consideration a set of indicators applied to

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different stages of the assessment. Within the environmental indicators, the method deals with human indicators such as health, wealth and politics. Socially, the method is focused on long-term efficiency in a single context; short-term impact is not considered.

## 2. Point of departure

Colantonio (2011) establishes social sustainability as a condition and a process that improves a community's quality of life. Asomani-Boateng et al. (2015) identify states of social development according to the extent of improvement after an intervention. Other authors associate social sustainability with the adequate distribution of well-being in the present and future (Valdés-Vásquez and Klotz, 2013; Mostafa and El-Gohary, 2014). Indeed, the social impact of infrastructure depends on its life cycle (design, construction, operation and disposal) (Sierra et al., 2016). Based on these assumptions, this study allows for the current (short-term) and future (long-term) states with respect to an infrastructure project.

In the short term, Valdés-Vásquez and Klotz (2013) consider that the context of the place, the user and the commitment and identification of the key stakeholders are aspects to take into account in the design and planning of an infrastructure project; in addition, a large part of the social impact depends on the pre-existing conditions or immediately added interventions (Van de Walle, 2009). Short-term social improvement does not necessarily imply adequate distribution of the social benefits; in fact, in some cases it harms sectors in social need (Foth et al., 2013). Therefore, distribution mechanisms that include the most vulnerable population must be ensured (Mostafa and El-Gohary, 2014) so those abilities are developed in conditions of social need. This is a process with long-term results.

An infrastructure project contributes to sustainability in the short and long term, which can be measured using social improvement criteria and goals, respectively. The criteria are requirements to an intervention that must be fulfilled to obtain a sustainability standard (Pavlovskaia, 2013). Most of the social criteria cited from the 1990s have been addressed by Labuschagne et al. (2005). On the other hand, the social improvement goals for a zone are more appropriate for a long-term approach. Specifically, the orientation of a social improvement goal is related to types of social indicators (Fulford et al., 2015); a social indicator is a measurement to monitor society's progress in terms of improvements in well-being over time, or the change in society with respect to evolving development goals (Noll, 2013).

Therefore, according to what was set out in the previous points, the knowledge gap in the social sustainability assessment of infrastructure presents two aspects: (1) the social contribution in terms of how infrastructure interacts with its context (Gannon and Liu, 1997; Van de Walle, 2009; Asomani-Boateng et al., 2015), and (2) the potential benefit distribution effects on a long-term basis balanced with its short-term contribution (Colantonio, 2011; Foth et al., 2013; Sierra et al., 2016). These ideas are the point of departure for this study.

## 3. Objectives of the research

This article proposes a general method to assess the contribution of infrastructure projects to social sustainability in different geographic contexts simultaneously. This purpose is achieved with three specific goals that determine: (A) the estimation of social improvement produced by the infrastructure project in the short term; (B) the estimation of social improvement produced by the infrastructure project in the long term (or social development); and (C), the joint assessment of social improvement produced by the infrastructure project in the short and long term, prioritizing the different alternatives.

In order to accomplish these goals, this article is structured as follows: The first section contains the proposed method, based on multicriterion and multi-objective techniques, the Delphi method and systems theory. Next, the proposal is applied to a specific case so the reader can appreciate its practical implementation. Then the results are discussed. Finally, the contributions, recommendations, limitations and future lines of research are presented.

## 4. Proposed method

In order to fulfill the goals of this research, a general method is presented to evaluate an infrastructure's contribution to social sustainability. Its use supports the decision-making process in the early formulation phases of the project. This method is structured in three groups of processes, according to the three aforementioned specific goals. For each group of processes, the outcome is: (A) an index of short-term social improvement (STSI); (B) an index of long-term social improvement (LTSI); and (C) the multi-objective prioritization of different alternatives of an infrastructure investment. STSI identifies an infrastructure's contribution in interaction with the present context. In this study, the short term considers the social effects of infrastructure planning, design and construction for approximately three years from the start of the operation. On the other hand, in the long term, the distribution impact of the benefit considers the zones in social need. The long term considers the social effects on the type of tenure and preservation of the infrastructure. Once the social improvement for the different alternatives has been identified, this can then be prioritized according to their contribution to social sustainability.

Fig. 1 illustrates the processes that intervene in the assessment method. In accordance with the previously established objectives, the processes labeled “A” intervene in social improvement in the short term. Comparably, the processes labeled “B” determine social improvement in the long term. Finally, processes “C” determine the prioritized solution of socially sustainable infrastructure projects and their stability. The dotted line shows the flow of information as well as the scoring steps of criteria and social goals. In the following sub-sections, each of the processes that compose the proposed method is explained according to the layout shown on the left side of Fig. 1.

### 4.1. Selection and weighting of social criteria and goals (A0, A1, B0, B1)

The specific criteria and goals of social improvement are selected from a pre-established set of criteria (Labuschagne et al., 2005) and national goals (UN, 2015). The pre-selection takes into account: (1) the general interests for social improvement in the short and long term, and (2) incidence of characteristics of the type of public infrastructure being studied. Experts are needed to disclose their conformity or nonconformity with every aspect of the sample of criteria and goals, and may consider others to be relevant.

At least eight experts are required to obtain a consensus applying the Delphi method (Hallowell and Gambatese, 2010), a qualitative structured communication technique developed as an interactive systematic method of prediction based on a panel of experts (Cortés et al., 2012; Alshubbak et al., 2015). Generally, the expert's profile must fulfill a minimum of four requirements from a list of 10 proposed by Hallowell and Gambatese (2010) in order to guarantee the rigor of the method. These include university degree, membership in professional associations, minimum of professional experience, authorship of papers or book chapters, and so on. In particular, for the short term, experience in public infrastructure projects as well as specific knowledge of the region under study are desirable. Conversely, for the long term, institutional representation and sociohistorical knowledge of the context can be required. Additionally, an interdisciplinary expert panel configuration is also necessary (Munda, 2006) as a panel of experts should represent the interests of the stakeholders involved in the region.

Later, the experts are asked to provide a solution to the following question:

A.1. Based on the greater contribution to short-term (or long-term) social improvement, compare the degree of importance between the