The Architecture of a Decision Support Software System for Sustainable Projects Selection

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Abstract: *Considering the contemporary economic environment, integrating sustainability in project management doesn't rely only on carrying out socially responsible investments, but to the integration of principles specific to sustainable development thorough projects' life cycle, and especially in the decision making process carried out with the aim of selecting the optimal variant. In today's economy the decision for investment must be taken following given criteria that will reflect project's sustainability, and to have a portfolio of sustainable projects it is necessary to carry out a selection under uncertainty and multi-criteria conditions.Recognizing the importance for integrating sustainability during the evaluation process and for selecting the investment projects, and the rising interest for understanding and integrating this approach within organizations, highlights the utility of a software application based on which management could handle the decision making processes in the most efficient way.*

Keywords*: decision-making, informatics, investment, model, project, software, sustainability.*

1. Introduction

Investment projects represent a unique ensemble of objectives, activities and resources interrelated to achieve a predetermined goal. Project Management Institute suggests the following definition for project: "A temporary endeavor undertaken to create a unique product or service" (PMI, 2008).

Most companies use as reference for substantiating their investment decision to engage in a project, the value of the business. The classic indicators used to make such an assessment are: recovery period, economic performance, internal rate of return, net present value. But, classic appraisal methods have a great inconvenience, which lowers their contemporary use, when faced with development based on the sustainability of the world around us: they include exclusively monetary factors. The evolution of decision making systems indicates today relating, when analyzing an investment proposal to all categories of benefits, opportunities, costs and risks (Liang & Li, 2008) starting with the financial ones using additionally also aspects specific to environment protection or community development.

Investors are encouraged to choose to invest sustainably, in organizations that respect the principles for sustainable development or in project is this nature carried out in the current organization. In order to choose an organization, most often de decision is based on ratings given by specialized agencies. Rating agencies evaluate mainly the organizations to establish the involvement degree of the social responsible principles in their activities, with the purpose to making useful assessments for investors in substantiating their decision to choose a company where to invest. One of the oldest and well-known indices is FTSE (Makepeace, 2011).

Thus, in terms of a project, sustainability can be considered as a consequence of a sustainable general management, or, if we consider that the project is a distinct unity with its own purpose and objectives, carrying it out following the ESG principles imparts and favors the entire organization's sustainability (Silvius & Schipper, 2010; Silvius & van den Brink, 2011).

Kerry Griffiths (2011), senior at URS New Zeeland in the Corporate Social Responsibility and Sustainable Management Division, studies for over 10 years the integration of environmental and social elements into project management, considering delivering projects that will contribute also to sustainable development. The results highlight the necessity of the contemporary world to pay special attention to the two dimensions of sustainability by improving the air and water quality, preventing pollution, biodiversity protection, of habitats and species, but also considering the impact on the current and future community by efficient use of resources, waste management and preventing climate change effects. It is commonly assumed that the definitive sustainable management of projects must focus in including the practices specific to

sustainability for all the phases of a project and to enable measuring, evaluating and rewarding based on a multidimensional performance template of the project.

However, the most important phase, that requires a special involvement for implementing the sustainability principles, recognized by all the aforementioned authors, is initiating the project. Planning the core criteria in assessment, substantiation and decision making is crucial for the success of a sustainable project. During the implementation or execution stage, the focus moves towards integration of this principles in current activities and thus the main focus is on monitoring, measuring and reporting the method for attaining the objectives pre-established during the defining phase of the project.

Thus, the investment decision should be taken based on criteria that will reflect sustainability of the assessed project, and in order to have a portfolio of sustainable projects, a selection is mandatory, taking into account the conditions of uncertainty and multi-criteria.

2. Complex models for evaluation and selection of sustainable projects

History of the relevant published literature regarding the assessment and selection of investment projects provides numerous procedures and methods (Deng & Li, 2012; Kremmela et al., 2011; Sadjadi et al., 2012). Classical instruments focus mainly on assessing financial criteria. Others like Balanced Scorecard, applies multidimensional layouts to draw up the strategic map of the projects' financial effects (Ioppolo et al., 2012) considering aspects concerning financial performance, clients, internal processes or learning and development (Eilat et al., 2008). A third generation of methods includes those that quantify the environmental, social and economic effects on short and long term, including thus new criteria, sustainability (Khalili-Damghani & Sadi-Nezhad, 2013).

Jennifer Russell pointed out at the 2008 PMI Conference that sustainability is a too big problem to let someone else manages it. Experts from both academia and practitioners take interest in the interdisciplinary vision of project management and sustainable development. Although published studies over the last few years differ in terms of approach and depth, a comparative analysis of these can be the base for developing clear and unitary methodologies for implementing a sustainable and efficient project management.

Silvius (2012) identifies over 85 publications related to this topic. The nature of research is however mostly interpretative and aims at understanding the possibilities to adopt the principles of sustainability in projects (Barnard et al., 2011; Gareis et al., 2011; Maltzman & Shirley, 2010; Oehlmann, 2011). Only several papers include also a normative aspect, suggesting methods that describe the approaches needed to include sustainability into project management (Labuschagne & Brent, 2006; Silvius et al., 2012).

2.1. Labuschagne and Brent model

In some of the first studies conducted with this purpose, Carin Labuschagne and Alan Brent (2004, 2005 and 2006) at the University of Pretoria, outline two indicators for including the sustainable development principles into the life cycle of industrial projects. The Resources Impact Indicator (RII) and the Social Impact Indicator (SII) are computed based on a methodology of Life Cycle Impact Assessment, which quantifies de degree of falling within the limits enforced for a series of specific criteria, presented in table 1. The method for computing uses a simple weighted means, with equal weights for the criteria considered.

Table 1. Indicators for assessing the environmental and social impact on industrial projects

Dimension	Criteria	Sub-criteria
Resources Impact Indicator	Air	Regional pollution Global pollution
	Water	Consumption Pollution
	Earth	Use Pollution
	Natural resources	Mineral resources, energy
Social Impact Indicator	Internal human resources	Stability Labor conditions

	External population	Health and safety Professional development
		Human capital Productive capital Community capital
	Macroeconomic social performance	socio-economic performance socio-environmental performance
	stakeholders participation	Information Influence

Source: Brent (2004), Labuschagne et al. (2005)

The deployment into practice of the proposed methodology, for several projects and technologies from the manufacturing industry highlights the impossibility of quantifying at that time of proposed indicators, due to lack of information.

2.2. IPMA model

At the IPMA Expert Seminar "Survival and sustainability, challenges for projects" in 2010, the talks of the invited authors focused mainly on "translating" the sustainability principles into practical tools that can be applied to project management. The result is a notable one, materialized into a "Sustainability Checklist" for the projects and their managers. The dimensions and specific indicators are presented in table 2.

Table 2. The IPMA model for integrating sustainability into project management

Dimensions	Criteria
Economic	Financial return on investment Flexibility
Environmental friendly/Ecologic	Transport Energy Water Waste Resources
Social	Work environment Human rights Society Ethics

Source: Knoepfel, (2010)

2.3. Griffiths model

Infrastructure projects benefit, according to Griffiths (2011) from a special model, suggested by the New Zeeland strategy in transportations for substantiating sustainable investment decisions. The assessment is based on a scoring model with grades from 1 to 5 and different weights of the categories examined in determining the total score: 40% safety; 5% access and mobility; 40% environment; 5% community; 10% life cycle.

Table 3. Sustainable decision-making criteria in infrastructure projects

Principles	Criteria
Safety and security	Safety
Access and Mobility	Accessibility Public Transportation Walking and cycling
Environment	Terrain Landscape Fauna Cultural patrimony Water quality Air pollution Noise pollution
Community	Relations Positive/Negative Impact
Life cycle	Consumption of materials Maintenance

Source: Griffiths (2011)

2.4. ARUP model

Another model, more complex, that benefits from software support, is called SPeAR (Sustainable Project Appraisal Routine). It was developed in 2000 by Arup, a British engineering consultancy company, concerned with assessing projects; sustainability, based on indicators defined by the Sustainable Development Indicators from 'Quality of Life Counts', EU, UN and Global Reporting Initiative. The model is structured in four quadrants that capture sustainability aspects centered on elements like environmental protection, social equity, economic viability and efficient use of resources, and the assessments made in relation to these promote the sustainability of projects and decision making processes (ARUP, 2013). More recent version includes sustainability specific indicators like those established by the Organization for Cooperation and Economic Development, and assessment tools taken from the LEED, BREEAM and CEEQUAL methodologies.

Table 4. SPeAR model for sustainable project analysis

Quadrant	Criteria	Quadrant	Criteria
Environment protection	Transport Constructions Ecology Water Soil and land Air quality	Economic	Viability Competitiveness employment Benefits/Costs Transport
Social	Inclusion Wellbeing Access Form and space	Natural resources	Re-use Use of soil Energy Water Minerals

Source: ARUP (2013)

Derives from the published literature, but enable the inclusion of indicators that reflect the specificity of each project, to make a personalized assessment, in relation to rating scale of the best and worse practices. The inclusion of the specific indicators to each quadrant in the decision making process uses an aggregation method based on equal weight scoring. Drawing up the SPeAR diagram doesn't require quantifying the component elements, but their qualitative assessment.

2.5. BASF models

Eco-efficiency is a term that quantifies the impact over the environment in relation to economic efficiency of the assessed project and supports the decreasing the quantity of used resources in order to achieve the objectives. BASF, one of the world leaders of the chemical industry, uses the term eco-efficiency to define a two-dimensional project evaluation tool. The purpose of the Eco-Efficiency analysis is to compare similar products, processes or projects based on total cost and on the environmental impact throughout their entire life span (BASF, 2013). The environmental impact is determined by quantifying the following elements: raw material consumption, energy consumption, land use, emissions and waste, toxicity, risks. The economic and environmental data are represented in an x/y graphic, which highlights the comparative eco-efficiency of the assessed projects. The method, although it implies detailed analysis that can take up more time for implementation, provides results easy to interpret and use in substantiating the investment decision (Piepenbrink, 2006).

Although it exceeds the limit of the SPeAR model by using less subjective data, based on estimations and concrete measurements of the indicators values, it cannot be considered a complete tool because it does not include within the analysis social aspects.

Almost 10 years after the EE development, the same American company BASF proposes a new evaluation model of the projects' SocioEcoEfficiency. The aim of this model is to integrate into a single assessment tool the three sustainability dimensions: economy, environment, society, adding to the eco-efficiency indicators a series of social aspects. The social impact is quantified based on indicators specific to the five categories of stakeholders considered: employees, international community, future generations, consumers and local and national community. The results are presented in the form of a three-dimensional graphic SEECube, which highlights the projects compared considering points in space correlated with the impact on environment, cost and social estimated/measured influences.

Table 5. The BASF model for assessing projects' SocioEcoEfficiency

Dimensions	Specific indicators
Environment	Exploitation of land
	Energy consumption
	Raw materials consumption
	Emissions
	Toxicity
	Risk
Social	Labor conditions
	International communities
	Future generations
	Consumers
	Local and national community

Source: BASF (2013)

SPeAR, eco-efficiency analysis and SEE are assessment tools proposed by the ARUP and BASF and presented by McCullins.

2.6. Khalili-Damghani and Sadi-Nezhad model

One of the most complex and complete paper in the field, reference for establishing the ODInvest methodology, is the one published in 2013 by Khalili-Damghani and Sadi-Nezhad from the Islamic Azad University in Tehran. The methodology suggested by the two authors for the selection of sustainable projects starts from the definition of a template that includes the criteria presented in table 6. The relative importance of

criteria is determined based on programming software with fuzzy variables that quantifies the conflicting preferences of the different categories of decision makers. The assessment uses the fuzzy TOPSIS, to classify the analyzed projects. The multi-criteria and group decision methodology with fuzzy variables is also validated for the uncertain decision making processes, for a Iranian financial and credit institute. The computerized database used consists of Lingo, MS-Excel and Visual Basic.

Table 6. Criteria for assessing and selecting sustainable projects

Criteria	
Economic	Risk
Social	Strategic alliance
Environmental	Organizational training

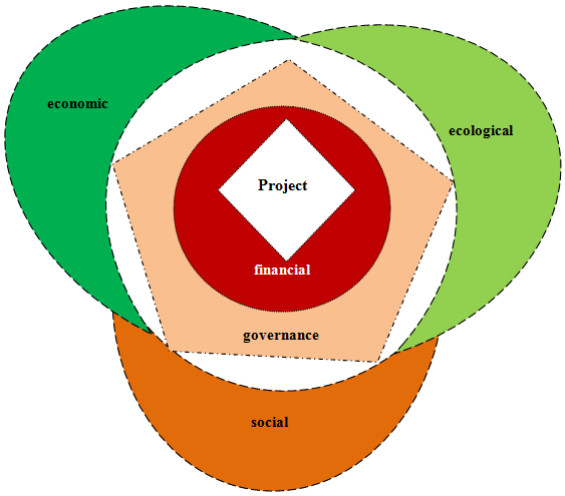
Source: Khalili-Damghani & Sadi-Nezhad (2013)

3. The proposed decision-making system

The investment decision is the decision-making group that requires managing a difficult and complex assessment. And if until now there has been a conflicting approach to substantiating the selection of investment projects based on economical-financial indicators, like the internal rate of return or the updated net income, under the current environmental conditions, there is a need to supplement the criteria, with the purpose to develop project characterized by cumulated performance of several decision making categories. With this purpose, many scholars present attempts to improve and adapt the assessment models, referring to tridimensional models such as: economic-social-environmental friendly (Khalili-Damghani & Sadi-Nezhad, 2013), triple P - people, planet, profit (Silvius et al., 2012), ESG – environmental, social, governance) (FTSE & EIRIS, 2011; PwC, 2012; SAM, 2012).

The detailed analysis of the proposals submitted by project management research and practice specialists resulted in a complex model, that takes into account the specific elements of the five dimensions: financial, economic, environmental friendly, social and governance (f2ESG). The five dimensions capture and classify all the support elements for an efficient investment decision in the sustainability context. The specifications and the characteristics of each one, the criteria, the indicators and corresponding relevance coefficients, as well as the calculation methodology are part of distinct papers.

Fig. 1. Dimensions of the sustainability of investment projects



Source: author

The complexity of an investment project is materialized in the multitude of decisional criteria used. Modeling the multi-criteria under sustainability involves numerous and diverse criteria. Therefore, they have been grouped according to their specificity into 5 dimensions/classes: financial, environmental, social and governance.

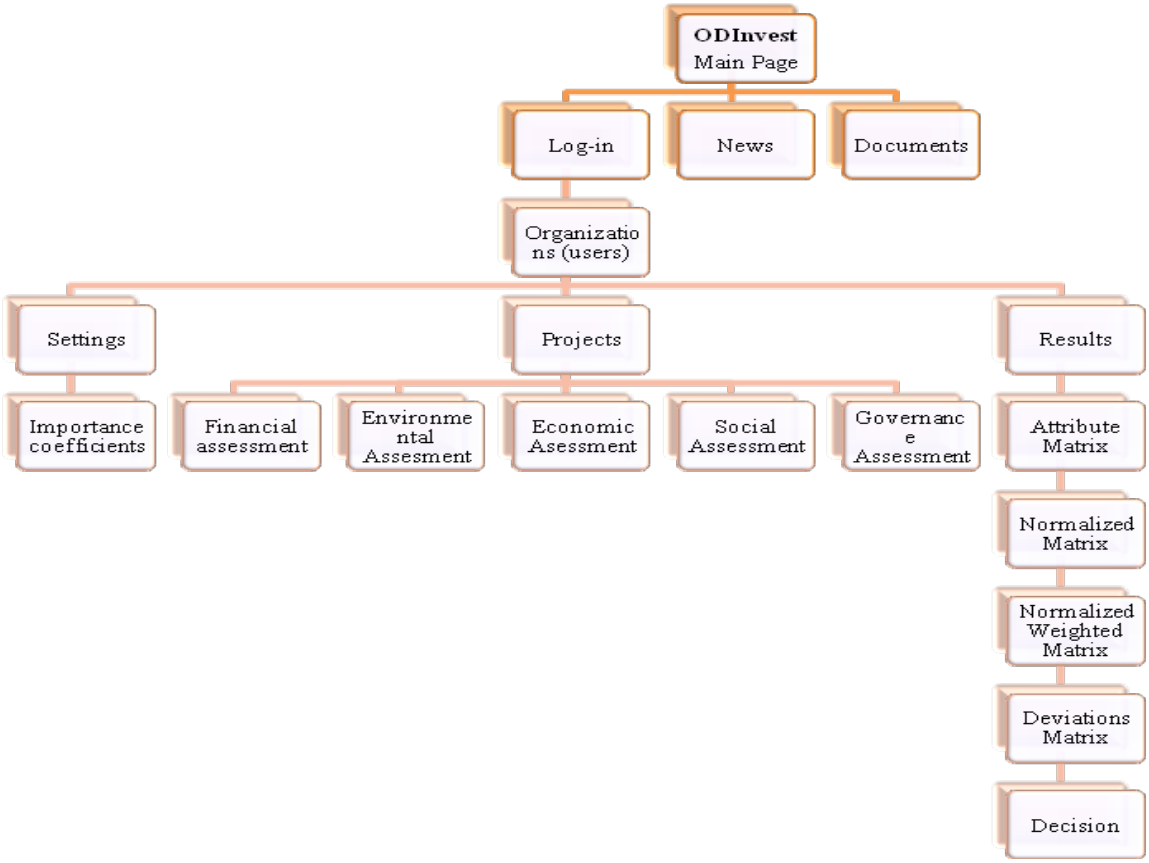
The classical financial dimension is the one underlying the model. Financial performance remains a class of particularly important indicators. Of major importance in terms of an outdated self-regeneration

capacity of ecosystems are the indicators that capture the environmental performance. The complexity and scale of environmental issues create a considerable pressure on organizations' entire activity, complying with the need to respect environmental principles. Economic dimension mainly consists of elements that need to be respected at the microeconomic level in order to achieve several objectives required by the European Union macroeconomic strategies. The social dimension has at the forefront the staff and everything representing wellbeing of the staff professionally and personally. Governance is the project' and entire business' method, aiming at enforcing ethical standard and holistic approach of the organization and of the investment projects in the portfolio.

To facilitate the methodology implementation within organizations, it has materialized in a computer-based support system of the sustainable investment decision (Decision Support System). Based on this software and its components, we can state that, by using it, even a management without comprehensive knowledge for modeling and assessing, confronted with the situation to select the investment optimum project or portfolio, can make a correct decision in relation to the type of organization, society and environment.

The architecture of the ODInvest is captured by the following chart:

Fig. 2. The structure of ODInvest



Source: author

This system accumulates the results of in-depth research in fields like project management, investment management and economic modeling, and present the hybrid model developed based on the interdependencies between elements specific to sustainability, investment projects, mathematical optimization and software development.

The approach suggested is based on a Fuzzy Multiple Criteria Group Decision Making with fuzzy variables. Thus, they are correlated methods that satisfy the necessity to include complexity and uncertainty in assessing and selecting the investment processes, with the aim to obtain a high level of performance, under the contemporary economic-social conditions. Specifically, it can be obtained based on the cumulated index, the indication regarding the optimum variant for an investment project development or classification of project from a portfolio.

4. Conclusions

The most important challenge of the contemporary business environment is integrating the sustainable development principles into business practice (Lacy et al., 2010). Its influences are also topical to projects. As core elements for an organization activity, the developed projects must adopt an integrative vision of the economic, social and environmental aspects (Keeys, 2012). Even if project management and sustainability are not "natural friends" (Eid, 2009) it is necessary to define such a holistic approach that will enable correlating the characteristics of the two concepts and overcoming the limits imposed by the existing differences between their specific working methods (listed in table 7).

Table 7. Elements to differentiate sustainable approach from the traditional approach of projects

Projects sustainable approach	Projects traditional approach
Consensus	Hierarchical decision making system
Uncertainty, environmental changes	Certainty
Systemic approach	Mathematical analysis
Ecology, social sciences	Engineering, technology
Managerial appreciation	Technical appreciation
Justification based on business benefits	Risk-based justification
Tridimensional performance assessment	VAN
Long term	Short term

Source: Garrett & Bradley (2006)

Research in the field focuses on implementing sustainability or of the elements specific to one of the dimensions, in different field of activity, such as industrial production (Labuschagne et al. 2005) or constructions (Edum-Fotoe & Price, 2008; Khalfan, 2006;), and within the project, throughout the life span (Labuschagne & Brent, 2004); or assessing the projects' contribution to the organization's sustainability (Presley et al., 2007). However, it is considered that special attention should be given to integrating the sustainability principles in defining, initiating the project (Keeys, 2012).

Therefore, the approach proposed in this paper is based on Fuzzy Multiple Criteria Group Decision Making. Thus, implementing the proposed model implies that each analyzed project should be assessed based on 20 criteria, specific to one of the five dimensions: financial, economic, ecologic/environmental social and governance. In order to determine the value of each criterion, characteristic indicators should be quantified (necessary input data are presented in the second part of this chapter). Criteria score are weighted with the corresponding importance. Establishing the importance coefficients is made using the fuzzy AHP method.

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