Sustainability in project management: Investigating the significance of sustainability indicators for the construction industry

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Sustainability in project management: Investigating the significance of sustainability indicators for the construction industry

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Declaration

I Marios Stanitsas, declare that this Doctoral Dissertation has been completed by me and does not include previously submitted information for any other qualification without acknowledgment. Concerning academic integrity and ethics, I declare that this Thesis is the outcome of my efforts and all substantial third-party contributions to notable works, including collaboratively produced publications.

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Abstract

Sustainability constantly gains importance over the last few decades. Concerns about sustainability implementation into societies have steadily grown. The focus seems to be on long-term issues concerning environmental, social, and economic implications. As sustainability challenges can no longer be overlooked, there is compliance with the need to modernize the sustainability tools used by promoting new methods of sustainable development knowledge. The discipline of project management is also integrating sustainability issues into its approaches. Developing a new sustainable-oriented way of thinking into project management practices to favor society becomes necessary. This Thesis explores the indicators that affect the integration of sustainability into project management practices of construction projects. Though many indicators that contribute to the implementation of sustainable construction projects have been identified in the literature, project managers face several issues in their proper use due to the lack of a comprehensive classification. This Thesis combines the views of all construction project stakeholders and delivers the most contributing sustainable project management indicators that lead to sustainable construction projects.

This research aim will be achieved by addressing the following research objectives:

1. Explore state of the art for sustainability in project management by identifying sustainability indicators into project management for the construction industry.
2. Explore and rank the relative importance of the retrieved sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders.
3. Identify the underlying factors that give rise to the set of sustainability indicators used to implement sustainable construction projects and eventually the production of sustainable built assets and propose a conceptual model of sustainability indicators based on underlying factors.
4. Propose a Multi-Criteria Decision Analysis-based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable project management-related indicators.

The research strategy follows a mixed-methods approach. Initially, a Systematic Literature Review (SLR) to explore the literature (identify the indicators as distinguished in previous studies from the construction projects standpoint in general) is followed. Semi-structured interviews have been conducted to seek expert opinions on the validation of each indicator for sustainable PM practices for construction projects identified in the literature review. As a next step, the research design involves a questionnaire survey to investigate stakeholders' perceptions of the construction sector regarding the usage of the identified sustainable project management indicators when seeking sustainability attributes in their projects. The data gathered has been analyzed through the relative importance index (RII) approach. The results of the same questionnaire survey were used as input for the employment of the statistical method of exploratory factor analysis (EFA), out of which five distinct dimensions (factors) of stakeholders' attitudes were revealed. As a last step in the methodological design, a Multi-Criteria Decision Analysis-based method (MCDA), namely the PROMETHEE method, was proposed to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of the already retrieved sustainable project management indicators. The case study that was conducted in a market-leading design, engineering, and project management consultancy organization was based on the MCDA method, in which the 82 indicators used in the proposed model (all related to critical aspects of organizations) measured how the departments' staff utilize sustainable project management processes in their construction projects By utilizing the proposed approach to compare internal organizational

structures, insights into the sustainability integration level within different business units are revealed, to allow organizations to make decisions toward sustainable practices.

Findings of the Thesis include the retrieved eighty-two (82) sustainability indicators related to project management practices in construction projects and their categorization according to the triple-bottom-line (TBL) scenario of sustainability (economic, environmental and social/management), as these were finalized by semi-structured interviews with construction experts and via previous literature analysis. Through the RII, environmental indicators were identified as the most important for practitioners seeking sustainable construction achievements. The findings derived through the EFA merged the initial set of the 82 indicators into five factors, indicating that the sustainability indicators are based on five underlying factors, namely (1) sustainable competitiveness; (2) stakeholder engagement; (3) sustainable economic growth; (4) social sustainability; and (5) resource conservation and environmental policy. on

As a theoretical contribution to knowledge, this study enhances the body of knowledge by revealing the usefulness of sustainable PM indicators, which are used to enable sustainable construction projects. Additionally, it examines the stakeholders' beliefs and attitudes who adopt sustainability approaches in the construction sector. In practice, the findings offer the possibility for practitioners to choose the right mix of indicators, depending on the sustainability focus they want to provide in their projects, and adopt strategies that enhance the delivery of sustainable construction projects.

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List of Abbreviations

TBL	Triple-Bottom Line
PM	Project Management
SD	Sustainable Development
CSF	Critical Success Factor
SLR	Systematic Literature Review
WoS	Web of Science
ECO	Economic
ENV	Environmental
SOC	Social
RII	Relative Importance Index
EFA	Exploratory Factor Analysis
KMO	Kaiser–Meyer–Olkin
MCDA	Multi-Criteria Decision Analysis
IT	Information Technology
BIM	Building Information Model

List of publications related to this Thesis

1. **Journal Articles:**
    - Stanitsas, M., Kirytopoulos, K. and Vareilles, E. (2019), “Facilitating sustainability transition through serious games: a systematic literature review”, Journal of Cleaner Production, Vol. 208, pp. 924-936. https://doi.org/10.1016/j.jclepro.2018.10.157
    - Stanitsas, M., Kirytopoulos, K. and Leopoulos, V. (2021), “Integrating sustainability indicators into project management: the case of construction industry”, Journal of Cleaner Production, Vol. 279, Article no. 123774. https://doi.org/10.1016/j.jclepro.2020.123774
    - Stanitsas, M. and Kirytopoulos, K. (2021), “Investigating the significance of sustainability indicators for promoting sustainable construction project management”, International Journal of Construction Management, Vol. ahead-of-print, No. ahead-of-print, pp. 1-26, doi: 10.1080/15623599.2021.1887718.
    - Stanitsas, M. and Kirytopoulos, K. (2021), “Underlying factors for successful project management to construct sustainable built assets”, Built Environment Project and Asset Management, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/BEPAM-10-2020-0166
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2. **Conference Papers:**
    - Stanitsas, M., Vareilles, É., Kirytopoulos, K. & Aldanondo, M., 2018. Sustainable development in serious games: rethinking game-based learning strategies for master's degree engineers. Toulouse, MOSIM'18-12ème Conférence internationale de Modélisation, Optimisation et SIMulation.

1. Introduction

1.1 Research background

An indication of modern societies is the rapid change they experience. Significant social changes affect or characterize every aspect of society; changes that shape all of society's principal sectors (economics, politics, education, family, religion, etc.). In summary, they affect our lifestyle and cause more and more confusion in people's daily lives. (Van Opstal and Hugé, 2013). Scientific techniques are called to intervene in order to provide viable solutions to perpetual sustainability concepts. Target scenarios should include environmental issues such as climate change, social issues such as poverty and welfare, and economic aspects such as viable investment.

Terminology/definitions in the field of sustainability have showcased a wide variety. However, it is mainly perceived that all definitions should include environmental, human-centered, and economic attributes. As Dick et al. (2018) and Ramcilovic-Suominen and Pülzl (2018) indicated in their work, sustainability may be defined as the interaction of people with the environment and, more broadly, with other humans in order to attain environmental, social, and economic benefits. The Sustainable Development Goals (SDG) established by the United Nations (UN) supplement this ideology. The report is split into 17 categories according to the major challenges that humanity faces nowadays (United Nations, 2015), the basis of which are the vital human needs of energy, water, and food. These goals are set to be accomplished by 2030. Such is the length of this report that societies in developing countries will have to fulfill the needs of an additional 70 million people each year over the next 20 years (Wood et al., 2018). According to Bieber et al. (2018), the solution towards achieving these goals can be obtained with the use of urban settlements that will be used as providers of controlled energy (carbon emissions) and water usage.

Concerns about sustainability implementation into societies have steadily grown during the last thirty years. The focus seems to be on long-term issues concerning environmental, social, and economic implications. After all these years of sustainable development (SD) discussions, reports, and symbolic actions, the ecological earth status, the social equity, and the economic sustainability are still in a "bad" state, mainly due to slow societal implementation, lack of political will and ineffective educational methods (awareness) (Van Opstal and Hugé, 2013). In agreeing with this approach, any society wanting to turn the tables towards sustainability should be concerned with economic performance, as is usually the case, and its social and environmental efficiency. Such concern comes as a reason that the extreme complexity of SD as a concept makes it incomprehensible for the majority of modern inhabitants (Hák et al., 2018). The fact that the basic economic model has become the primary pursuit for modern societies, which theoretically leads to prosperity, is also a reason (Kakoty, 2018).

Understanding the term sustainability and the whole concept around it comes with obstacles. Despite its immense popularity (Dagiliūtė et al., 2018, Jaca et al., 2018, Thürer et al., 2018, Saunila et al., 2018, Beumer et al., 2018), sustainability has no fixed meaning. It is defined either as the conservation and protection of natural ecosystems or as an amelioration of living standards under the scope of economic analysts (Cairns and Martinet, 2014). The Brundtland Report, issued by the World Commission on Environment and Development, is widely acknowledged by the scientific world (Renoldner, 2013, Schubert and Láng, 2005, Vasconcellos Oliveira, 2018). According to this report: "*Sustainable development is a development that meets the needs of the present without jeopardizing the ability of future generations to meet their own needs*" (WCED, 1987). The abovementioned content involves the highly integrative and global assessment of complex schemes. The concept of sustainability is intrinsically ambiguous due to the variety of parallel definitions regarding the term itself (Annan-Diab and Molinari, 2017). The difficulty of defying the crux of the term sustainability lies in the fact that a large number of scientific fields refer to the same approach with varying interpretations (Bolis et al., 2014). The interactive relationship between people (society) and the natural ecosystem (environment) defines the profound meaning of sustainability. Its value was recognized with the formation of the United Nations Decade for Education for Sustainable Development (ESD) (2005-2014). According to UNESCO, the lead department for the decade, educational methods for SD are "*processes of learning how to make decisions that consider the long-term future of the economy, ecology and equity of all communities*" (UNESCO, 2005). UNESCO's proposal is the perfect chance to jump into the significant and radical changes necessary for the world's higher education institutions (HEIs) to obtain an educational philosophy that contributes to a better and self-sustainable world (Fumiyo, 2007). Theorists and modern philosophers have concluded that the protection of the natural environment is a way for humans to self-protect their kind. Nevertheless, sustainability that includes the human development approach and the significance of human capital without making that perspective supplant to the environmental and economic dimension is set to fail (Anand and Sen, 2000). Three dimensions interact with each other subject to the definition of sustainable development (SD), namely, the economic, social and environmental, also known as the Triple Bottom Line (TBL) scenario (Major et al., 2017).

The economic dimension has to do with maximizing profits, reducing costs, and increasing revenue. These are some of the most well-known business techniques (de Lange, 2017). The most important achievement of a society is to achieve wealth for the shareholders. According to the analysis that Silvius (2017b) did in integrating sustainability in the project management (PM) context, the economic dimension is of great importance among the TBL as it preserves the shareholders' capital. Profits are reinvesting in the community (organization) itself to guarantee that it reaches economic prosperity. The project's crucial elements are analyzed in terms of various economic factors that are featured inside the TBL of sustainability. Financial worth, economic benefits, and wealth generation may be translated differently to stakeholders. Each part seems to appear dissimilar in the project and during the product's life cycle, thus challenging the requirements of the project's objectives (Kivilä et al., 2017).

The social dimension invokes the societies in which communities coexist. Organizations and other micro-scale communities interact to form a more significant social set. Inhabitants and other hypo-societies that coexist in one or more environments are the ones who produce the results in this dimension. The social system itself should reward them. The results of the societal work rely on how communities support the organizations. Utilizing communities and inhabitants for societal prosperity without manipulation is the balance adopted by the notion of the social dimension. As Dempsey et al. (2012) proposed, organizations need to "protect" the individual communities in which they operate. They have to develop a new sustainable oriented way of thinking into their project management procedures so that society accepts their practices (Silvius, 2017b). Anything that negatively affects the community in which the organization is active may create dilemmas and affect its prestige. Organizations that take into consideration the social dimension often perform socially responsible leadership, which improves the quality of life of the communities. Social sustainability is about analyzing and regulating positive and negative impacts on people (Sierra et al., 2018a).

The environmental dimension deals with the natural ecosystem people live in (Ludwig, 1993). The literature indicates that the earth's ecosystems have been negatively impacted by various activities of humans (Sha et al., 2017). Natural environments introduce the primary source of resources, and thus their survival is of a vital meaning to make sure that natural processes will continue. Sustainability is utterly linked to environmental protection and humanity's incapability to reserve natural wealth (Ferguson, 2016). Natural resources are the main reason that societies and organizations are functioning correctly. As these resources are reduced, societal schemes have difficulty continuing their activities and thus their survival. Environmental non-sustainability has a dramatic effect on people's lives and negatively affects the other two dimensions. Social unhappiness and costs rise as supplies become rarer to obtain (Nawaz and Koç, 2018).

Sustainable development is a vast field that needs to attend innovative approaches, products, and services (Kantola et al., 2017). Existing interrelationships between economy, environment, and society need to consider three pillars of sustainability simultaneously, both conceptually and quantitatively (Mihelcic et al., 2003). During the last decades, the primary purpose of projects has become the assessment of the three dimensions of sustainability at the same time. In compliance with modern, continually developing societies, the way through SD comes with complexity, and no single innovation will be sufficient to achieve the necessary transitions to equitable, sustainable, livable post-fossil carbon societies. Societies require a wide diversity of innovations to make real progress. Therefore, multi-disciplinary thinking, cooperation, research, and practice are needed. It is crucial to escape the conservative way of thinking in order to create sustainable and equitable solutions (Kantola et al., 2017).

SD has been proposed as one of the bottom-line literacies with which a contemporary society should be adorned. Education is the key to providing such literacy (Ann and Lenore, 2005). The problem, however, is that while pedagogy for sustainability continues to be touted as “the way of saving the earth,” an also great query emerges on what kinds of relative SD educational methods are required in addressing some of the challenges of our time. In the absence of such crucial investigation, higher institutes are based on assumptions, predictions, and aspirations rather than critically audited schemes (Manteaw, 2012). Multiple definitions concerning the term sustainability and SD make it impossible to defend one “leading policy” of educating and acknowledging the antecedences at a comprehensive level (Cicmil et al., 2017). Equally importantly, eagerness to pursue the “leading policy” to encourage educational methods that create a complete understanding of the term and create an acceptable area of knowledge, amid the diversification, needs to be enabled in joint innovations of acceptable ways, where consensus, equality, interdependency, safety, connectivity, and diligence are clear taken as analytical criteria(Gladwin et al., 1995). The above arguments form a forceful notice for instructors and universities about what the view of responsible educational methods for SD should entail. As Nikodemus et al. (2011) suggested and later explained by Mollie (2015) and Painter-Morland et al. (2016), practical methods instead of just theoretical background are necessary if we are to practice SD responsibly and in a way that matters for disparate groups of educational stakeholders influenced by it. According to Godemann et al. (2014), in their analysis of Sharing Information on Project (SIP) reports, most institutions are addressing the Principle of Responsible Management Education (PRME) through teaching rather than through institutional activity.

Implementing the TBL scenario aspects has become increasingly complex for organizations seeking to integrate innovative, up-to-date solutions (Pope et al., 2004). Countless studies cover project management and sustainability, but the intersection of these two disciplines is still refined, with only a few studies focusing on both topics (Aarseth et al., 2017, Silvius, 2017a, Carvalho and Rabechini, 2017). According to (Gimenez et al., 2012), sustainability combines social, environmental, and economic responsibility in order to make better use of current assets and provide a quality lifestyle for future generations. The development of this study was prompted by the need for studies on the interrelated themes of sustainability and project management and the growing importance of both topics in today's business context. It intends to contribute to a better understanding of the concept of sustainability in project management. The main contribution of this research is to address sustainability in the context of project management and define important elements from the stakeholders’ perspective.

Increasing adoption and awareness regarding the inclusion of sustainability in various domains heightens the necessity to discover and implement effective methods of achieving this objective (Jayanti and Rajeev Gowda, 2014). In addition, sustainability appears to be at odds with typical project management, in which practically all variables are overlaid on the economic success of the venture (Keeys and Huemann, 2017). Sustainability and project management have steadily grown concerns on various aspects that researchers have shown attention to. To better accumulate these aspects, researchers have shown devotion to matters like the definition of sustainability in all projects, the management of sustainable projects, and how a project manager includes sustainability when setting up and managing his projects.

The fact that our attention goes towards sustainable construction projects derives from the high social impact that these new technologies deliver. Although the majority of indicators can be considered for all construction projects that seek sustainability attributes, the social aspect that these factors deliver needs to be familiarized in favor of sustainable projects. The first challenge in creating societal acceptance for sustainable construction projects is thus to find a location for a project that can exploit potential benefits offered by the project. Such projects can be an important source of income and employment for the rural decline. Still, they can also compete with other sectors such as tourism, food, and other agricultural or timber industries. From this perspective, engaging stakeholders and clarifying expectations when starting a new project is a way to connect the project to its context. Defining and listening to expectations in the early stages of a project can help adjust the project to context and better communicate the benefits and risks of the project to the project manager (Raven et al., 2009, van der Horst, 2007, Sauter and Watson, 2007, Wüstenhagen et al., 2007).

However, the holistic approach and classification of indicators contributing to the sustainable management of construction projects under the TBL scenario, remains a gap between literature and practice (Bon-Gang, 2018, Fernández-Sánchez and Rodríguez-López, 2010). To address such a gap in the body of knowledge, this research approaches sustainability in the PM context and reveals related indicators as effective tools for construction projects.

1.2 Research problem

Integration of sustainability into project management practices has remained an overlooked area. In particular, a review of the literature reveals a noticeable absence of studies on identifying indicators of sustainable delivery of construction projects (Dobrovolskienė and Tamošiūnienė, 2016b, Martens and Carvalho, 2017, Martens and Carvalho, 2016, Kiani Mavi and Standing, 2018, Banihashemi et al., 2017, Ahadzie et al., 2008, Ihuah et al., 2014). As Brones et al. (2014) indicate in their research, there is a gap between sustainable strategy and project management that, if filled, could enhance the effectiveness of the project in the development process. To address such a gap in the body of knowledge, the indicators that are affecting the integration of sustainability into practices of project management in construction projects need to be well-defined. The study encapsulates these identified indicators into an integrated model that contributes towards the sustainable management of the project, leading to sustainable results.

Indicators play an important role in enabling and facilitating the process of integrating sustainability into project management practices (Chang et al., 2016, Martens and Carvalho, 2017, Zhang et al., 2014). In essence, understanding sustainability-related indicators is a prerequisite for integrating sustainability into project management practices for construction projects. (Pade et al., 2008).

The need for research on the overlapping topics of sustainability and project management, and the growing importance of both topics in the current business context, has led to the development of this study, which contributes to a better understanding of the sustainability topic of project management. Accordingly, this study fulfills this gap by identifying sustainability indicators in a project management context and understanding the importance based on stakeholders' lens. The results show that companies are concerned about the sustainability of project management. However, there is a gap between perceived importance and practical use.

As shown in Figure 1-1.2, there is a relation between the topics of sustainable development and project management in this research. The focused ground is the study area where sustainable development and project management intersect. Sustainability and construction projects are considered a noteworthy context since it is demonstrable that considering sustainable development in project management helps create sustainable project results.

The complications and opportunities of sustainable development in project management have yet to be thoroughly investigated. This study attempts to take the first step in this approach by establishing a pattern for linking sustainable development ideas to project management.

Figure 1-1.2: Research area

1.3 Research aim and objectives

This research aims to contribute towards the holistic view of sustainability in project management, especially for construction projects, by delivering the principal sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders.

This research aim will be achieved by addressing the following research objectives:

1. Explore state of the art for sustainability in project management by identifying sustainability indicators into project management for the construction industry.
2. Explore and rank the relative importance of the retrieved sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders.
3. Identify the underlying factors that give rise to the set of sustainability indicators used to implement sustainable construction projects and eventually the production of sustainable built assets and propose a conceptual model of sustainability indicators based on underlying factors.
4. Propose a Multi-Criteria Decision Analysis-based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable project management-related indicators.

Thus, this research extends the body of knowledge in two distinct areas, firstly towards sustainable project management indicators and their contribution towards delivering sustainable construction projects and secondly towards the stakeholders' perspectives within the discipline that enhances the understanding of how practitioners consider sustainability in their work, by studying the consideration of sustainability indicators in the project decision-making processes. Furthermore, this research provides valuable insight into critical aspects of sustainability in the project management context and an understanding of its importance from the stakeholders' perspective.

1.4 Structure of the Thesis

Chapter 1 comprises the introduction of the Thesis, which entails the background to both the research aim and objectives. The research problem is further described as the need to understand the sustainable project management practices that give rise to the set of sustainability indicators used to provide sustainable construction projects.

The introduction is followed by Chapter 2, which provides a review of the literature relevant to the research. This review discusses the sustainable PM framework, along with the correlation between sustainability and PM in construction projects. Indicators for sustainable PM of construction projects are also introduced in this section. The purpose of this Chapter is twofold, firstly, to provide an overview of the literature (identify the indicators as distinguished in previous studies from the construction projects standpoint in general) and secondary to conduct a series of semi-structured interviews to validate the results. Semi-structured interviews have been undertaken to seek expert opinions on the validation of each indicator for sustainable PM practices for construction projects identified so far.

The methodological framework is explained in Chapter 3. This chapter includes a concise introduction of the overall research philosophy that leads to the methodological approach. It is followed by the philosophy and approach to research, the methodological choice, the research techniques, the research design, the conducted data analysis, and the validity and reliability of the study.

Chapter 4 presents the research analysis and findings, where the indicators contributing to the sustainable PM for construction projects and the perceived stakeholder views of these indicators are reported, contributing to construction projects. Qualitative information obtained from a questionnaire survey helped understand the stakeholders' beliefs and attitudes when seeking sustainability attributes in the construction sector. Furthermore, the findings indicate that the sustainability indicators are based on five underlying factors, namely (1) sustainable competitiveness; (2) stakeholder engagement; (3) sustainable economic growth; (4) social sustainability; and (5) resource conservation and environmental policy. Finally, a MCDA method was used to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable PM-related indicators.

Chapter 5 discusses the research findings and conducts a comparison with state-of-the-art sustainable project management practices. This research opens the discussion towards a set of sustainability indicators that lead to sustainable construction projects via examining the stakeholders' beliefs and attitudes who adopt sustainability approaches in the construction sector. Additionally, it provides help to organizations that target their efforts in certain aspects (enhancing sustainable outcomes).

Finally, Chapter 6 concludes this Thesis, providing a summary of the research findings, the thesis's contribution to knowledge, research limitations, and recommendations for further research.

2. Literature review

2.1 Introduction: The concept of sustainable construction project management– Sustainability indicators

Several worldwide events emphasize in the context of sustainable development norms and ideals. The United Nations Conference on Environment and Development, for example, took place at the well-known Rio 92, in Brazil in 1992 (which resulted in the creation of a letter with 27 principles that could offer help and actions for partners and countries); the formulation and signing of the Kyoto Protocol in 1997; the Rio +10 conference in Rio de Janeiro again; and the Bellagio Principles, among other events. According to Gimenez et al. (2012), by assessing the effect of organizational operations, the TBL concept encapsulates the core of sustainability. In this light, sustainability is more than a management tool for businesses. Furthermore, if organizations are to thrive in the long run, they must contribute to the sustainable management of TBL factors that include natural resources, as well as the overall well-being of society and the economy (Sharma, 2018, Allouhi et al., 2015, Gimenez et al., 2012, Wu et al., 2018a).

Sustainability is a collaborative process that creates and advances the vision of a community that wisely respects and uses natural resources while striving to enable current generations to achieve high levels of economic stability, democracy, and public participation; to manage communities while preserving the integrity of ecosystems and life. (Gladwin et al., 1995). With regard to project activities, sustainability issues are acute, especially with complex projects involving many resources and disrupting the daily life of the surrounding communities. A significant number of companies are adopting sustainable project management practices and investing resources and effort into their implementation. (Berssaneti and Carvalho, 2015, Kudratova et al., 2018, Amini and Bienstock, 2014, Boons and Lüdeke-Freund, 2013). There are a plethora of guidelines in the project management context; for example, the Guide of the Project Management Body of Knowledge (PMBOK) given by the Project Management Institute (ten areas of knowledge are described) (Project Management, 2013); the International Project Management Association (IPMA), the Australian Institute of Project Management (AIPM) and the Projects in Controlled Environments (PRINCE2); however they do not pay specific attention to the topic of sustainability. To handle sustainability challenges in project management, it is necessary to have a thorough grasp of the numerous components involved in a project and the inner relationships. (Sánchez, 2015, Brones et al., 2014, Carvalho and Rabechini, 2017, Egilmez et al., 2013, Labuschagne and Brent, 2005).

There are pieces of literature that investigate the links between project management and sustainability. The majority of studies concentrate on defining a process or a long-term project management approach. (Kivilä et al., 2017, Gilbert Silvius et al., 2017, Martens and Carvalho, 2017, Kudratova et al., 2018, Ali et al., 2016, Hwang et al., 2017). Silvius and Schipper (2014a) created a methodology for exploring the connection between sustainability and project management. The developed model incorporates concepts of sustainable development (holistic approach, long-term orientation, vast geographical and institutional scale, risk and uncertainty reduction, values, ethical concerns, and participation) as well as project management initiatives (e.g., project objectives, scope, schedule, resources, organization, context and project management design). As a consequence, new research goals and directions in sustainable project management were recognized. The focus is on sustainably managing projects. A model/tool that guides researchers and practitioners towards the competencies that the combination of sustainability and project management could provide developed to integrate sustainability into project management by Silvius and Schipper (2015). The model assesses the level (i.e., resources, business process, business model, and product and services delivered by the project) on which different aspects of sustainability are considered in the project. Labuschagne and Brent (2005) propose a comprehensive sustainability assessment framework for evaluating projects at an early stage of their life cycle in terms of their impact on the sustainability of future assets and products provided. The framework

presents high-level criteria and possible metrics to consider. Labuschagne and Brent (2008) conclude that the three most important lifecycle stages whose impacts should be assessed are the asset's construction phase, the operational phase whereby all product life cycle impacts are also grouped, and the asset dismantling phase. As a result, they analyze these processes to check the suggested indicators' appropriateness and completeness. The challenge of picking the optimum portfolio in relation to the organizational strategy that incorporates long-term goals was addressed by Vandaele and Decouttere (2013). The authors create a methodology to assist in the management of strategic research and development portfolios. They suggest using two case studies to employ development expenses, investment costs, and technical risks as inputs for the proposed model and performance metrics such as market size, competition, sales potential, profitability, or technical likelihood of success as outcomes.
Banihashemi et al. (2017) examine the critical success factors (CSFs) that influence the incorporation of sustainability into construction project management methods in developing nations. CSFs were discovered by a comprehensive analysis of the literature, using innovation diffusion theory as a theoretical starting point. By conducting semi-structured interviews, the CSFs were modified for the context of developing nations and presented as a conceptual model. A survey was used to validate the model, which used partial least squares structural equation modeling (PLS-SEM) as the analytical approach. Nevertheless, this study does not address how to carry on the research when there are sustainability concerns, such as how to incorporate environmental or social effect data into project evaluation.
This research defines the incorporation of sustainability into project management processes. Further, it refers to the comprehensive assimilation and harmonization of social, economic, and environmental principles (TBL) into effective project delivery systems. Indicators related to sustainability improvement in construction project implementation and project management practices were identified through a comprehensive literature review. This resulted in a list of relevant indicators. The indicators identified cover a wide range of sustainability-related areas in the construction and project management activities.

2.2 Integrating sustainability indicators into project management: The case of construction industry

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2.2.1 Abstract

Sustainability concepts showcase significant value in construction projects. The discipline of project management is also integrating sustainability issues into its approaches. Under this notion, this study explores the integration of sustainability indicators into project management practices of construction projects. Current literature discloses many indicators/key factors as contributing towards the sustainability success of construction projects. However, the lack of an all-encompassing categorization creates difficulties in directing project managers towards their proper utilization. This paper aims to contribute towards the holistic view of sustainability in project management, especially for construction projects. A systematic literature review was conducted towards the understanding of the key topics and the findings were validated through semi-structured interviews. Eighty-two (82) sustainability indicators related to project management practices in construction projects were finally identified. Their categorization into economic, environmental and social/management sustainability indicators was completed through semi-structured interviews with construction experts and via previous literature analysis. The economic related indicators finalized in 27; 18 for the environmental dimension and 37 indicators were included in the social/management dimension. This study contributes to research on sustainable project management for construction projects in two main ways: (1) it provides a holistic view of sustainable project management indicators, covering the full spectrum of the triple constraint (TBL); (2) it offers the possibility for practitioners to choose the right mix of indicators, depending on the sustainability focus they want to provide in their projects.

2.2.2 Keywords

Sustainability; Indicators; Project management; Triple-bottom line; Construction

2.2.3 Introduction

Sustainability, sustainable development (SD) and project management (PM) have always been major topics of discussion amongst scholars. The World Commission on Environment and Development, also known as the Brundtland Report, shaped in 1987 a definition for sustainable development that has been widely accepted by the scientific community (Renoldner, 2013, Schubert and Láng, 2005, Vasconcellos Oliveira, 2018, Martens and Carvalho, 2017). According to this report "*Sustainable development is a development that meets the needs of the present without jeopardizing the ability of future generations to meet their own needs*" (WCED, 1987). Sustainability from a TBL perspective was a concept conceived in 1994 by John Elkington so that the sustainability movement could, more explicitly, incorporate the social dimension (Elkington, 2004). The whole concept is based on the three pillars of sustainability which interact in a constant flow of movement due to social, political, economic, and environmental constraints, and its effects occur at the interface of the pillars (Elkington, 2012).

While some studies in the field present skepticism over the TBL concept (Norman and Macdonald, 2004, Milne and Gray, 2013); Silvius and Schipper (2014c) indicate in their research (systematic literature review), that 86% of the publications address sustainability in terms of the TBL. A more acceptable concept of sustainability is the one based on the integration of economic, environmental, and social dimensions (TBL), and it has nowadays become widely known (Elkington, 1998, Labuschagne and Brent, 2005, Carvalho and Rabechini, 2017, Gimenez et al., 2012, Banihashemi et al., 2017, Martens and Carvalho, 2017, Silvius et al., 2017). According to Savitz (2014), "*the TBL concept captures the essence of sustainability*". On the same line of thought, Othman (2013), describes five major groups that influence the sustainable delivery of projects in developing countries, namely technical, human development, managerial, political and TBL attributes.

In this study, the authors follow an approach that considers the sustainability in the TBL perspective. Integration of sustainability into project management practices is also defined in line with the sustainability TBL concept, also followed by Silvius (2017a) and Banihashemi et al. (2017).

Many studies showcase the necessity for PM to evolve towards the sustainable "path", especially in the construction sector (Saad et al., 2019). Silvius et al. (2017) based on Labuschagne and Brent (2005) and Silvius and Schipper (2014c) initial approach of sustainable PM, describe the broader social framework and argue that this is the starting point of the recognition of this societal context considering sustainability in PM. Silvius (2017a) argues that traditional PM practices do not successfully address the basic principles of sustainability as described in the TBL scenario. Furthermore, Shen et al. (2010) describe the reasons why sustainability should be in the PM plan: "*With reference to construction business, sustainability is about achieving a win–win outcome for contributing to the improved environment and the advanced society, and at the same time for gaining competitive advantages and economic benefits for construction companies.*"

Having reviewed the relevant definitions, four characteristics occur as the main aspirations for sustainable PM. These are (1) Sustainable PM should reflect all of the TBL perspectives, and not just the economical profitability (holistic TBL approach); (2) sustainable PM should consider the entire life cycle of the project, and the project's outcomes (long term assessment); (3) sustainable PM should involve stakeholders' analysis that leads to a "managing for stakeholders" tactic (stakeholders' involvement); and (4) sustainable PM should contribute to the sustainability of the organization and society (ethics). Henceforth, through the literature search, for the purpose of this study the authors conclude to a refined definition of sustainable PM by following the four abovementioned aspirations: Sustainable PM is the management of all the phases of a project through planning, monitoring and controlling during the entire life-cycle of the project's processes and deliverables, in order to fully comply with the stakeholders' demands, opting for transparency and ethics for the organization and society and assuring that economic, social and environmental dimensions are taken into consideration.

In order to address issues related to sustainability in construction projects, understanding of the relevant indicators is required (Pade et al., 2008, UNCSD, 2001, Ugwu and Haupt, 2007). According to Reid and Rout (2020), the term "indicator" does not refer to a singularly defined and highly precise concept". Moldan and Dahl (2007), in line with Gallopín and Assessment (1996), argue that not all set of indicators are equally accurate and quantifiable. There are obscurities and inconsistencies in the definition of indicators in literature. Jollands (2006) indicates in his research that "an indicator is, fundamentally, a sign; a sign, which requires interpretation". Following Reid and Rout (2020) original idea, and the fact that the word "indicator" (despite often connected with quantitative measures) derives from the Latin term "indicare" which means "to point out" or "one who points out", this study takes a broader view of the term indicator and aims to provide insights into sustainability indicators for project management of construction projects.

However, a holistic approach and taxonomy of the indicators that contribute towards sustainable PM in construction projects according to the TBL scenario, remains as a gap in the literature and in practice (Bon-Gang, 2018, Fernández-Sánchez and Rodríguez-López, 2010). To address such a gap in the body of knowledge, this research (1) approaches sustainability in PM context and reveals related indicators as effective tools for construction projects; (2) provides initial insights into sustainable PM practices that can assist project managers by focusing their attention on indicators that improve the sustainability of the project; and (3) presents a structured literature on sustainability and PM. This study makes use of the existing literature data from carefully chosen related areas and uses it to create a relevant theoretical framework.

Construction projects use specific indicators that guide project success (Sibiya et al., 2015, Chan, 2004). To identify these indicators a thorough literature review was conducted, and the authors gathered all those indicators relevant to the construction industry. The analyzed indicators provide a generic framework criterion for sustainable construction project performance. It is possible that some of these indicators conform with the likes of other projects as well, but this is beyond the scope of this paper; further research can thus shed light towards this direction.

The rest of the paper is structured as follows. This introduction is followed by Section 2 that discusses the sustainable PM framework, along with the correlation between sustainability and PM in construction projects. Indicators for sustainable PM of construction projects are also introduced in this section. The research method is explained in Section 3. The results are presented in Section 4, where the authors report the indicators that contribute towards sustainable PM for construction projects and cluster these factors into categories according to the TBL scenario. Finally, the conclusion is drawn in Section 5.

2.2.4 Sustainable project management in construction projects – Sustainability indicators

Recent studies have highlighted the importance of civil construction materials in attaining sustainable projects (de Azevedo et al., 2020, Carvalho et al., 2014). The need for SD in constructions occurs through the shortage of natural resources, leading the construction sector into new perceptions and technical "green" solutions (Azevedo et al., 2019). While sustainable materials seem to dig into modern practices, sustainable PM ideas have gained momentum too.

The vast majority of today's organizations are adopting PM techniques, investing resources and efforts in the integration of PM issues into their construction projects (Carvalho et al., 2008, Linnenluecke and Griffiths, 2010). On top of the iron triangle, objectives of scope, time, and cost, organizations are progressively dealing with added value and benefits that stem from new construction projects (Silvius and Schipper, 2014a). Benefits, value, and value creation indicate diverse options to the stakeholders and might change during the different stages of the project's life cycle. Thus, identifying the project goals can be very stimulating (Keeys and Huemann, 2017, GRI, 2015). There are more than a few reference guides in the PM field. Two of the most well-known guides are the *Project*

Management Body of Knowledge (PMBOK® Guide) (Project Management, 2013), and the *Projects In Controlled Environments (PRINCE2)* adopted by the UK government (Murray et al., 2009); structured into categorized areas of knowledge. Yet, they seem not to pay special attention and in-depth analysis to sustainability attributes. Nevertheless, the presence of sustainability in PM events and conferences is intense (Silvius, 2017a). According to Martens and Carvalho (2017), who conducted a systematic search to identify some of the biggest events, sustainability and SD concerns were noticeable. This finding indicates that the concept of sustainability, “seeks” its way through the PM context.

As the PM field matures, the definition of what “project success” means, is changing (Belout and Gauvreau, 2004). Traditional PM principles are expanding into delivering the project’s objectives while preserving lifecycle focus (Carboni et al., 2018, Fiksel, 1999). PM must make greater efforts to address sustainability issues (TBL) into each project and assure a sustainable way of life for future generations. To achieve this, PM must change into a wider and well-rounded view of the project’s impact and value (Kolltveit et al., 2007, Robèrt et al., 2002). Through synthesis of the literature related to sustainable PM practices, Figure 1 provides an overview of how the top eight core PM values can be enhanced to accommodate sustainability under the TBL consideration. The selection of the eight core PM values occurred by the authors after reviewing the analysis of three fundamental studies on PM (Kouzes, 2017, Bennis and Goldsmith, 1997, PMI, 2014). Taking into consideration the concluded PM values, and the need that literature presents for sustainable evolvement, the authors show the “path” towards sustainability integration into these practices.

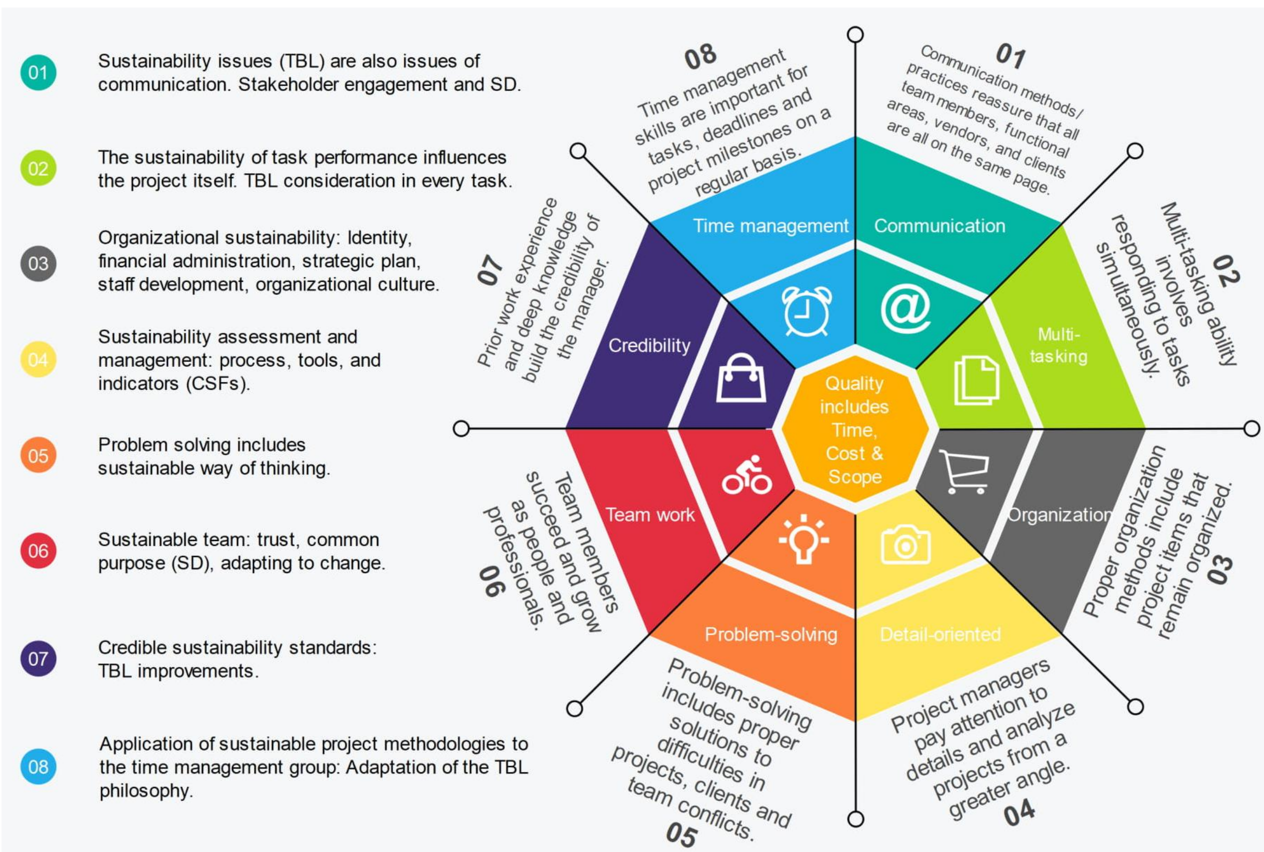

Figure 1: Embedding sustainability in project management

There is a growing interest in studies on the congregating themes of sustainability and PM (Sroufe, 2017, Sneddon et al., 2006). The fact that SD principles have been previously integrated into various sectors, as a repercussion of the Brundtland Commission Report, which established a definition about sustainability amongst scholars, drove the development of this study. While many scholars have deepened into the indicators/key factors of sustainable PM, only a very small number of studies emphasize thoroughly the context for construction projects (Maqbool, 2018). In line with this development, this study looks upon project managers who target SD (TBL) by focusing much more attention on specific indicators rather than paying equal attention to all of them. The beneficiaries of the findings will be all those project managers who are interested in implementing sustainability construction patterns through the use of specific indicators. This study enables them to familiarize themselves with and then select the set of indicators that best serves their needs. The purpose of this research is to provide a holistic view of sustainable PM indicators, covering the full spectrum of the TBL. The focus is in identifying the indicators on sustainable PM that affect the processes of construction projects. However, by considering and implementing sustainable PM indicators during the processes, the project deliverable (product) is also affected by sustainable PM (process) (Kivilä et al., 2017, Aarseth et al., 2017).

To ensure project management's efficiency towards global upcoming sustainability-related complications, sustainability and PM need to be combined (Marcelino-Sádaba et al., 2015). Bhakar et al. (2018) emphasize the importance of including sustainability-related key factors into PM's basic principles of planning, monitoring, evaluation, and decision making to augment the overall quality of construction projects. Al-Saleh and Taleb (2010), Baumgartner and Ebner (2010) and later Ahmed (2010) contend that sustainability in PM can be effective through various practices: committing sustainable purchases, changing the value management development of projects, using "practical" barriers (ex. time limitations and behavioral issues), carrying out risk management analysis, and integrating sustainability within value management practices of projects.

Hence, the prospect for integration of sustainability issues in PM and the understanding of both topics as presented in this section, validate the importance of combining the theme of sustainability with traditional PM. It also highlights the importance of identifying indicators that can be used in PM and thus bringing forward additional value in the applied context. To further understand and evaluate this statement, it is of vital need to examine the level of involvement of the roles given to stakeholders in a sustainable construction project. Figure 2 shows the project governance roles that occur when the personnel that works on a project is after the four characteristics that occurred from previous literature and already described in the introduction section: (1) holistic TBL approach, (2) long term assessment, (3) stakeholders' involvement, and (4) ethics. Goedknegt (2012) identified six key project governance roles, that are used in Figure 2. Brauer (2013) indicates the high importance of values and ethics when in seek of sustainability because he strongly believes that this should be the starting point of a project. Figure 2 is not offered as a result of a systematic empirical analysis, but rather as a suggested model as perceived by the authors after their interaction with the literature sources. The success of a project in relation to sustainability is dependent on the priorities that the project participants (project governance roles) set. These priorities embrace the four prementioned characteristics for sustainable PM. By reaching the "goal" of these characteristics, the project attains a sustainable profile.

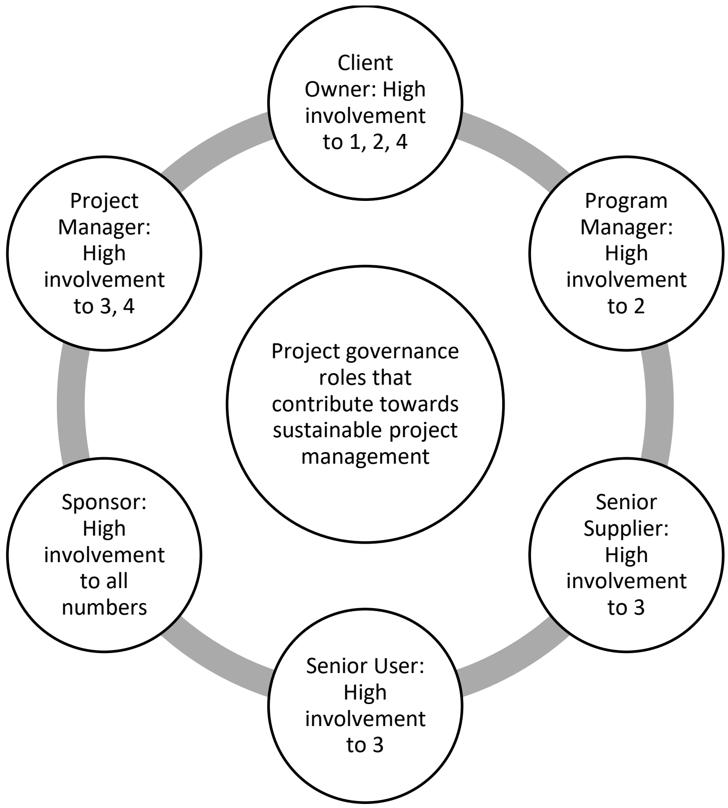

Figure 2: Project governance roles that contribute towards sustainable PM - level of involvement. (1) Holistic TBL approach, (2) long term assessment, (3) stakeholders' involvement, (4) ethics.

This literature review search of previous empirical studies on indicators/key factors of sustainability, PM and construction area, guides this study towards the selection and the categorization of sustainable PM indicators for construction projects. Indicators/key factors have previously been mentioned as important key features that lead projects to sustainability success (Ahadzie et al., 2008, Gan et al., 2017). Maghsoodi and Khalilzadeh (2018) in alliance with Iram et al. (2017) initial analysis, have identified fifteen critical success factors (CSFs) that can lead to sustainable project success. Amid these CSFs, project scope identification and skilled PM team were the most fitting CSFs for leading to project success (Development, 1995). Zhao and Chen (2018) concluded in identifying the CSFs that affect the renewable energy sources' electricity production in China. The results showcase the creation of clusters concerning the project's management parameters. Xu et al. (2011), based in Chen and Chen (2007) and Chan et al. (2004a), have established twenty one indicators under six clusters, of energy performance constraints for sustainable buildings in China.

Thus, literature search reveals various classifications around indicators/key factors that concern construction projects. Nonetheless, a holistic approach and taxonomy of the indicators that contribute towards sustainable PM in construction projects against the TBL scenario has not yet been proposed and remains as a gap in the literature. Although the taxonomy of indicators against the TBL scenario within PM has been attempted (Martens and Carvalho, 2017, ICHEME, 2002), there are not so many studies to ensure saturation of information. Following this impression, this research suggests that the sustainability side of construction projects can be significantly improved when looking at specific, categorized indicators (TBL scenario).

2.2.5 Research method

To meet the aim of the paper and identify the indicators of sustainability in PM context that affect construction projects, the research strategy follows a mixed methods approach. Initially, the researchers conduct a Systematic Literature Review (SLR) to explore the literature (identify the indicators as distinguished in previous studies from the construction projects standpoint in general) and then a series of semi-structured interviews to validate the results. Semi-structured interviews have been conducted to seek expert opinions on the validation of each indicator for sustainable PM practices for construction projects identified so far. After analyzing the results, the designation/description of the indicators was revised accordingly by the authors.

Data collection via systematic literature review

The SLR method is considered amongst scholars as a particularly useful technique that draws vital conclusions, identifies patterns and gaps based on the published literature (Sengers et al., 2019). In this paper, it helped to identify the links between PM, sustainability and sustainability indicators in construction PM. The initial stage of the SLR includes a systematic search for articles through the online databases of Scopus, Science Direct, Web of science (WoS), Google Scholar, and Springer Link. The abovementioned databases are considered by scholars to include the vast majority of scientific documents. The original sample analyzed was composed of 4.227 documents. After the exclusion of duplicate papers (same paper retrieved from different databases), 1.237 documents were obtained (journal and conference papers). These were reduced to 613 after consideration of titles and to 338 after consideration of abstracts. Finally, a further reduction to 133 was reached based on the full-text reading. Thus, 133 articles were reviewed in their full length.

Due to the fact the scientific area analyzed is under development (PM, sustainability, indicators, SD, construction projects), the reduction from the initial number of identified documents is satisfactory. Documents with sustainability focus were more than 50% of the total sample. The development of the theme of sustainability in PM started relatively recently in 2003. In addition, indicators in sustainable PM concepts that concern construction projects have recently been used in a small number of documents. These results show that the field of sustainability in PM and more specifically the use of indicators in construction projects that help the process is still in the exploratory stage (Maqbool and Sudong, 2018, Kiani Mavi and Standing, 2018). The literature was traced, filtered, and evaluated, in Stanitsas et al. (2019) who followed Thürer et al. (2018) and Tiwari and Gupta (2015) initial research. The process that was followed is depicted in Figure 3. Figure 3 outlines the research design followed sequentially for tracing (documentation), filtering, and evaluating the documents.

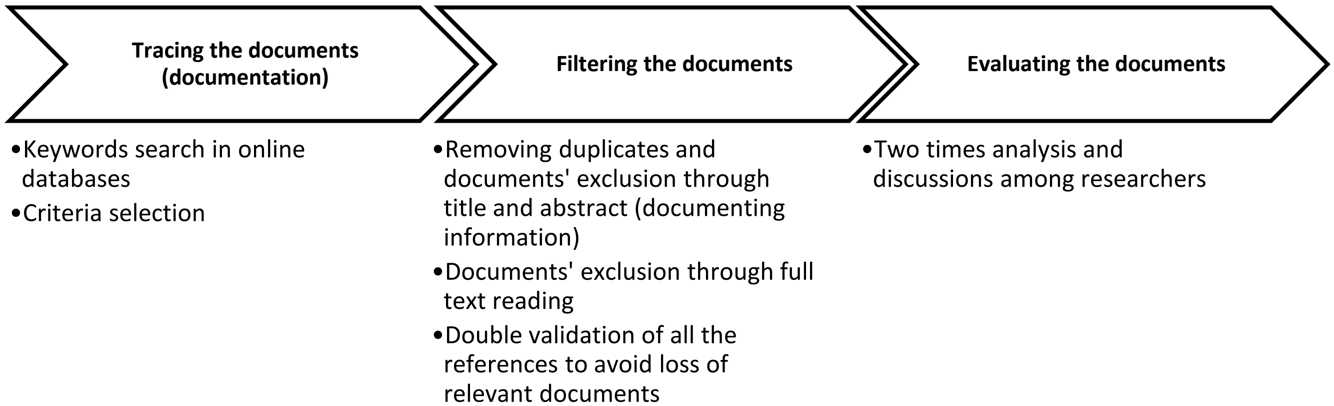

Figure 3: Research method (SLR) presented in steps.

Tracing the documents (documentation) was used as guidance to retrieve indicators in sustainable PM. This step was conducted through a review of conference papers, journal articles, book chapters, and reports from international organizations.

The research subject is the indicators in sustainable PM and their use in construction projects. Therefore, keywords of wide scientific fields were used, so that the authors could reassure that most of the relevant documents were included in the study. The use of the keywords Indicators, Key factors CSFs, Sustainability, PM and Construction was vital as the research subject has immediate and closest relation to these scientific themes. The notion of "Sustainability" cannot be evaluated without the TBL scenario, so the use of this keyword was inevitable too. The sustainability concept is rooted in the TBL concept (Purvis et al., 2019). Connecting the two concepts with an "AND" reassures the authors that both concepts have been taken into consideration in the papers included in the systematic literature review process. The main focus of this paper is on the sustainability indicators that contribute towards the TBL scenario for construction projects and thus, these concepts constitute indivisible in this research. As the term "project success" has been directly linked with the attainment of the sustainability objective (Carvalho and Rabechini, 2017, Iram et al., 2017), the authors decided to include this keyword in the Boolean expression as well. The main search keywords occurred through pilot searches to test and tune the search string (Calderón and Ruiz, 2015). The final search strings consisted of the following Boolean expression:

> ((Indicators OR Key Factors OR Critical Success Factors) AND (Sustainability AND Project Management AND Construction AND Project success AND Triple bottom line)).

These keywords were used in the most general search tabs of all databases (e.g. Scopus: "All fields"). Nevertheless, the Google Scholar database produced a very large amount of results (41.900 results) by using the abovementioned expression, which is normal due to the "nature" of the database. Thus, the authors decided to analyze the first 1.000 results, as the most relative to the search keywords (Google follows this search pattern). Through these keywords the initial selection of documents took place. The authors used MS Excel™ to save the information collected about the searches. It should be noted that the final results are not at all indicative of completeness of the databases as it was the keyword string that dictated the outcomes. Also, the fact that an article does not come up on a specific database, does not mean that it does not exist in it but again it is the search string that affects the result. However, among the different strings explored, this one was selected as it gave the most complete result, in terms of the number of relevant articles.

The second stage of the SLR included the filtering of the documents. The final number of documents through this stage finalized in 332. Double validation of all the references was made in order to avoid possible document loss (Stanitsas et al., 2019). This resulted in 6 additional documents that were added to the total documentation sample and settled the 338 documents. The final sample (journal and conference papers) was 133 documents (excluding duplicates) from which 32 were reviews on indicators/key factors of sustainability, 101 referred to PM and the rest to construction projects. Figure 4 depicts the filtering process and the relevant sources. It provides an overview of the progression of documents retrieved in scientific databases**.** Science Direct and Google Scholar were the databases with the most primary documents of this systematic literature review.

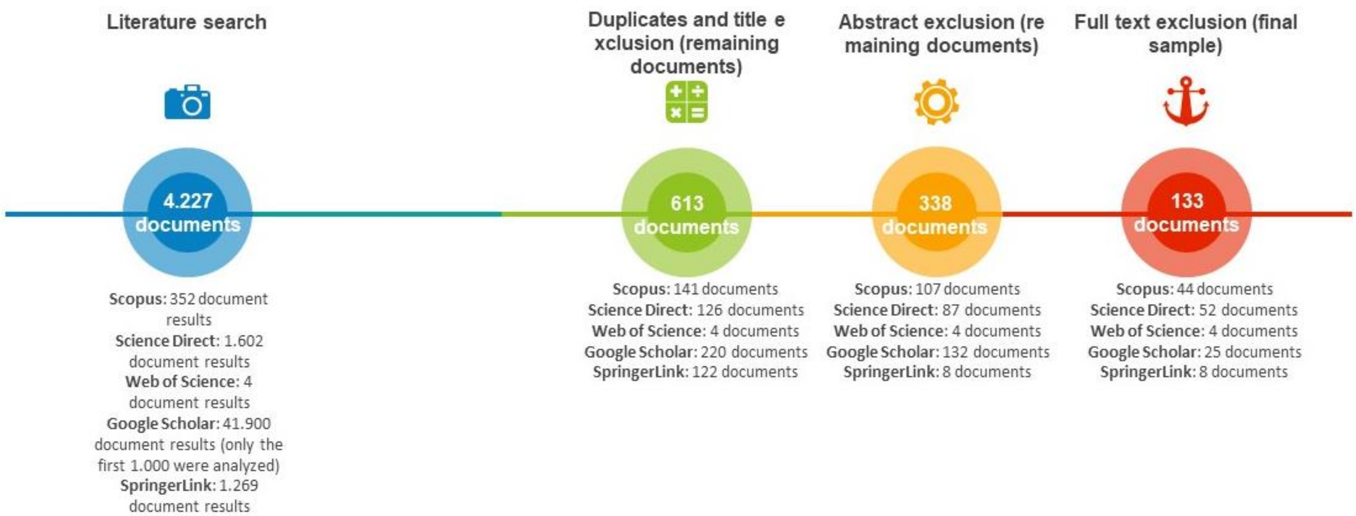

Figure 4: Filtering of documents and sources.

The final phase of the systematic literature review is extracting the useful information from each of the 133 final documents. Objectivity was achieved through a two-time analysis and discussions among researchers for alleviating any potential biases (Thürer et al., 2018).

The difficulty of assessing the final selection of documents lies in determining which indicators from literature are appropriate for sustainable PM practices in construction projects. To describe the systematic approach for selecting the indicators, the authors have identified four basic activities based on Caralli et al. (2004) initial analysis that comprises the following steps: 1.) Scope definition, 2.) Data collection (SLR), 3.) Indicators extraction, 4.) Indicators breakdown. Each of these activities are provided in Figure 5.

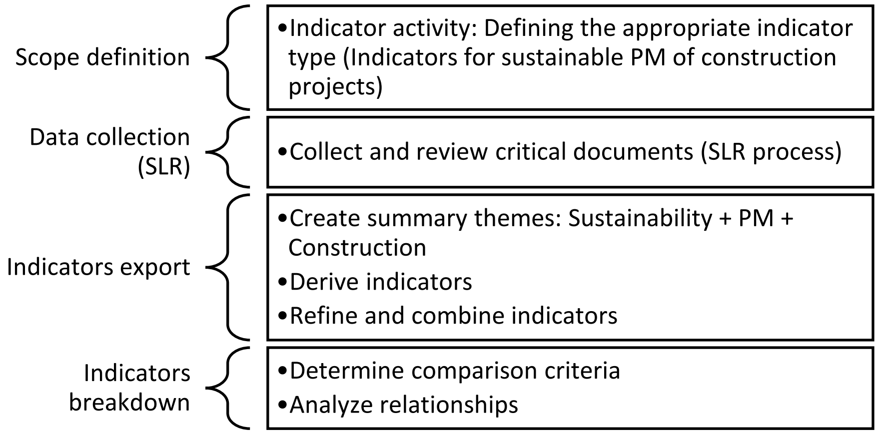

Figure 5: Systematic approach for selecting the indicators. Adapted from Caralli et al. (2004).

The integration of sustainability in PM context, especially in construction projects involves various perceptions of numerous features from different disciplines (Mazzetto, 2017). The vital stage of the progressive filtering lies in the perception of how concepts are presented in the literature and what is their use in the sustainable PM context.

Validation of results via interviews

To validate the applicability of the indicators for sustainable PM in construction projects, as they were identified from the SLR, semi-structured interviews were conducted. The interview scheduling plan was inspired by Öberg et al. (2018) and Tura et al. (2019). The main purpose for the interviews was to investigate if construction experts validate the outcomes of the literature review regarding the indicators relevant to sustainable PM in construction.

Interviews are meant to investigate people's views in greater depth, collect thoughts, and attain a systematic conclusion around various scientific topics (Goodell et al., 2016). Interviews, as a validation method, were chosen to gather project managers' views, and validate the results of the SLR process on the sustainable PM indicators. All the interviews were semi-structured and focused on obtaining viewpoints on the value of the extracted indicators. The interview process covered the customization/merging of the preliminary list of identified indicators (97 in total). Interviewees were provided with the initial list of indicators and were asked to express their views about each of the items. They were also free to proceed to detailed modifications, including add, delete or combine. This process resulted in modifying the initial indicators to the ones (82) in Tables 2,3 and 4. The interviewees expressed similar opinions in evaluating the initial list. Any inconsistencies in the evaluation process were handled by the authors in the sense of majority's opinion. Changes occurred in both the title and the explanatory text of the indicators. In order to analyze a wide-ranging multiplicity of ideas and views, the authors chose to interview persons from public authorities (government, regional/local authority), private infrastructure companies and public/private universities (Guest et al., 2006). Particularly, the first participant is employed in the educational sector (university); participants 2,3,4, and 5 are employed in private infrastructure companies; and finally, the last participant comes from the public authorities' sector. All the interviewees had previous construction management experience and were aware of the sustainability practices that their organizations implement. Following Faulkner (2017) research that briefly provides a definition for data saturation ("*it refers to the point in the research process when no new information is discovered in data analysis, and this redundancy signals to researchers that data collection may cease. Saturation means that a researcher can be reasonably assured that further data collection would yield similar results and serve to confirm emerging themes and conclusions*."); the authors concluded that the information retrieved from the 6 respondents attended this goal. The industry / academia / public mix was not regarded of particular importance, especially because the beliefs were similar. However, this might be indeed a limitation of the study that needs to be further investigated. An overview of the participants' profile is presented in Table 1. In total, 5 persons were located in Greece and 1 in United Kingdom. The interviews lasted between 49 and 120 minutes. The interviews were conducted as semi-structured interviews with the help of an information sheet that included all the initially identified indicators. Interviews were held via in person meetings from November 2018 to January 2019. The interviewees' personal opinions were asked for, considering their previous construction management experience. They expressed their point of view and gave emphasis on answering the questions that derived during the interviews. All the interviews focused on the value of sustainable PM and the validation of the initially identified indicators for construction projects. However, there were some significant differences between the participants' opinion on the importance of the indicators. The first participant (educational sector) documented the social related indicators as the most contributing towards the sustainability goal. On the other hand, participants 2,3,4,5 (private infrastructure companies) seemed to care more for the economic related indicators. Finally, the last participant (public authorities) presented emphasis on the environmental and social indicators.

Table 1: Participants' profile

Participant	Industry	Business titles	Length (min)
1	Infrastructure and heavy construction	Construction Manager/Researcher	83
2	Energy construction/Renewables and Green buildings	Chief Operational Officer (COO)/Chief Construction Officer (CCO)	90
3	Architectural industry	Design Architect/Sustainable Design Specialist	54
4	Construction/Power Grids	Project Manager	120
5	Renewables	Engineering Project Manager	49
6	Design and Construction	Environmental Engineer	69
Total		6 persons	465

2.2.6 Results and discussion

Indicators/key factors have been extracted from previous studies that refer to various construction projects. The prerequisite is to work towards sustainable PM in construction projects. Based on this line of reasoning, indicators related with enhancing sustainability and PM practices in various construction projects were identified through a SLR. These indicators were purposively put at high-level to cover the whole spectrum of the relevant field. Generally, there can be many different measurable indicators that could be used to measure the high-level indicators provided in this study. Such measurable indicators may be affected by culture and region and might not be universally accepted. The purpose of this paper is not to go down to the level of such measurable indicators but to synthesize the relevant literature and come up with the high-level indicators (not always and necessary measurable at this level) that will help project managers to understand the areas that they should consider in order to successfully implement sustainable project management. The result was a large record of 446 indicators/key factors extracted from previous studies. The 446 identified indicators/key factors enclosed multiple scientific areas linked to sustainability, PM and construction projects. To evaluate these indicators/key factors, a review as suggested by Banihashemi et al. (2017) was conducted. This process has been named by the authors as "*applicability of literature*". It involves evaluating the outcome as it derived from analyzing older documents and using only the parts related to the aim of the research (Levy, 2006). Thus, the initial record was significantly reduced in 127 indicators, in view of the four literature observations for sustainable PM, as they previously described (holistic TBL approach, long term assessment, stakeholders' involvement, and ethics). The selected 127 indicators were then confirmed as contributing for sustainable PM practices through interviews. The interviewees, based on their previous construction management experience and awareness of sustainability practices, concluded in reducing the final list into 82 indicators. This reduction occurred through the merging of two or more indicators with similar content. These indicators were then categorized according to the TBL philosophy to better reflect their usage when in use by project managers in construction projects, and shown in Tables 2, 3 and 4. The categorization into economic, environmental and social/management sustainability indicators was made with the help of the interviews and after reviewing their way of usage in previous literature (Ahmadabadi and Heravi, 2018, Joung et al., 2013). The interviews also revealed the next immediate relation of some indicators with a second or a third TBL aspect (column 4). Column 3 reveals the main TBL relation of each indicator, as the basic criterion for the initial categorization. The classic TBL scenario includes social, economic, and environmental attributes. Nevertheless, the literature has revealed the direct relationship of the social part with numerous managerial issues (Eizenberg and Jabareen, 2017, Roca-Puig, 2019). Thus, this study uses this feature of sustainability under the scope of social/management side of TBL, instead of just social. It is to be noted that the order in which the indicators appear is not indicative of their importance.

Table 2: Pool of sustainable PM indicators for construction projects of economic sustainability, extracted from previous studies

Economic (ECO) sustainability indicators				
Indicator	Description	Main TBL relation	Next immediate TBL relation	Indicative References
ECO1: Financial/Economic performance	Objective measure that concerns the return on investments, the creditworthiness, the viability, and the cash flow of a project.	ECO	-	(Azapagic, 2004, Martens and Carvalho, 2017)
ECO2: Economic and Political stability	Economic growth and political stability are interconnected. An unstable political environment impacts investment and increases the risk.	ECO	SOC	(Gudienė, 2013, Liu et al., 2016)
ECO3: Stakeholder involvement/ participation	Satisfying stakeholders' needs and interests by their involvement in the design of the project and in the project itself, leads in delivering successful projects.	ECO	SOC	(Buson, 2009, Martens and Carvalho, 2017)
ECO4: Innovation management/new product development	It refers to product, process, and organizational innovation. Innovation management practices come through research and development, productivity, and flexibility.	ECO	SOC	(Martens and Carvalho, 2017, Liu et al., 2016)
ECO5: Target marketing and benefits	Proper target market shapes the desired services and products for the project's outputs.	ECO	-	(Berssaneti and Carvalho, 2015, Lam et al., 2017)
ECO6: Effective Project Control	Effective Project Control concerns the data gathering for effective time management, risk management, cost management, value management, document control, supplier performance and reporting.	ECO	-	(Belout and Gauvreau, 2004, Lee et al., 2018)
ECO7: Best practice strategy	Strategy in which the organization who realizes the project monitors and benchmarks the best practices and integrate them into its processes.	ECO	-	(Mulder and Brent, 2006, Veleva and Ellenbecker, 2001)
ECO8: Efficient allocation of resources	It refers to the distribution of inputs such that the resources will be efficiently utilized.	ECO	-	(Ihuah et al., 2014, Songer and Molenaar, 1997a)
ECO9: Customer-relationship management/ Access to a range of customers	It concerns the managerial process of an organization's interaction with current and potential customers.	ECO	SOC	(Labuschagne et al., 2005, Veleva and Ellenbecker, 2001)
ECO10: Scope control through managing changes	Scope control safeguards that corrective actions are efficiently applied to prevent negative impacts.	ECO	-	(Chan et al., 2004b, Tabish and Jha, 2011)

ECO11: Business ethics	It examines moral/ethical problems that may result from trading, affiliation with competition, and governmental obligations.	ECO	SOC	(Martens and Carvalho, 2017, Brauer, 2013)
ECO12: Facility management technologies/ general improvements	It refers to general constructions, building maintenance and renovation, green buildings and services that come with the new improvements.	ECO	-	(Xing et al., 2009, Martens and Carvalho, 2017)
ECO13: Cost management plan	It concerns the process of planning and controlling the cost associated with the resources of a project and the other costs.	ECO	-	(Pulaski and Horman, 2005, Martens and Carvalho, 2017)
ECO14: Resource planning	It involves the human resources, potential machinery, building materials, etc.	ECO	ENV, SOC	(Duy Nguyen et al., 2004, Tabish and Jha, 2011)
ECO15: Supply chain collaboration	Collaboration practices and criteria to select order-winners, leading to improved business outcomes.	ECO	SOC	(Sáez-Martínez et al., 2016, Banchuen et al., 2017)
ECO16: Effective strategic planning	It concerns organizational management activity. Such planning is used to reinforce procedures and to set priorities.	ECO	SOC, ENV	(Duy Nguyen et al., 2004, Domingues et al., 2017)
ECO17: Organizational culture	It concerns the collective values, beliefs and principles of organizational members. It directs people on how to behave in organizations.	ECO	SOC	(Mulder and Brent, 2006, Martens and Carvalho, 2017)
ECO18: Project outputs emphasis	Financial measurements, tracking processes and status reports, planning and management of the project focusing on the project outputs.	ECO	SOC	(Maqbool and Sudong, 2018, Xu et al., 2011)
ECO19: Developing efficient "iron triangle" parameters by the Project Management Team (PMT)	Project management plan – Scope, time and cost aspects of a project.	ECO	SOC, ENV	(Ihuah et al., 2014, Rand, 1993)
ECO20: Ability to pay and affordability	It refers to the capacity to pay for building, operating and maintaining the project.	ECO	-	(Devece et al., 2016, Laasch, 2018)
ECO21: Environmental/economics accounting	Integration of economic and environmental data to reach project success.	ECO	ENV	(Pissourios, 2013, Martens and Carvalho, 2017)
ECO22: Developing an efficient risk management plan by the PMT	It is all about the variables that can affect the project's progress and outcome, both internally and externally, taking into consideration uncertainty.	ECO	-	(Songer and Molenaar, 1997a, Ihuah et al., 2014)
ECO23: Implementing an effective change management strategy	The process that can help facilitate change and make the transition easier for the project.	ECO	SOC, ENV	(Fortune and White, 2006, Toor and Ogunlana, 2008)
ECO24: Efficient data processing for decision-making practices.	Data processing helps managers to solve problems by examining alternative choices and help the decision making.	ECO	SOC	(Banihashemi et al., 2017, Toor and Ogunlana, 2008)
ECO25: Bureaucratic streamlining	Less bureaucracy for projects improves the effectiveness of the project processes.	ECO	SOC	(Ahmadabadi and Heravi, 2018, Wilkerson et al., 2018)
ECO26: Internationalization	It refers to the process of increasing involvement of the organization in international markets.	ECO	-	(Martens and Carvalho, 2017, Ukaga, 2014)
ECO27: Targeted incentives	It refers to the total cash or other incentives that can offered as a bonus. A stakeholder can have a personalized target incentive.	ECO	-	(Lam et al., 2017, AlSanad, 2015)

Table 3: Pool of sustainable PM indicators for construction projects of environmental sustainability, extracted from previous studies

Environmental (ENV) sustainability indicators				
Indicator	Description	Main TBL relation	Next immediate TBL relation	Indicative References
ENV1: Energy efficiency	It refers to efficient production, use, distribution, and transmission of energy to provide products and services.	ENV	ECO, SOC	(Nord and Sjøthun, 2014, Baatz et al., 2018)
ENV2: Available - fitting renewable energy resources/fossil fuels	It refers to the environmentally friendly selection of the primary energy sources that contributes towards the effective operation of the project.	ENV	ECO	(Martens and Carvalho, 2017, Verdolini et al., 2018)
ENV3: Eco-efficiency	It refers to "green" business orientation, regarding services and products, construction materials, environmental footprint, and energy consumption in built.	ENV	ECO, SOC	(Wang et al., 2015, Gavrilidis et al., 2019, Martens and Carvalho, 2017)
ENV4: Consistent and predictable load	Uninterrupted energy supply.	ENV	-	(Chan et al., 2004b, Ali et al., 2008)
ENV5: Sustainable use of natural resources	It refers to minimizing resource usage, primary material input and output, waste recovery and disposal operations.	ENV	ECO	(Fellows and Liu, 2008, Spangenberg, 1998)
ENV6: Up to date environmental construction technologies and methods	It refers to resource-efficient and environmentally responsible processes in order to ensure lifetime sustainability of the project.	ENV	ECO, SOC	(Toor and Ogunlana, 2008, Banihashemi et al., 2017)
ENV7: Environmental responsibility/justice	It refers to the developing equity between members of different generations, and to the cooperation for the improvement of environmental quality.	ENV	SOC	(Jeurissen, 2000, Martens and Carvalho, 2017)
ENV8: Construction water quality impact	It refers to water quality during the construction phase and after the completion of the project, reduction of liquid waste, risks on water pollution.	ENV	SOC	(Liu et al., 2013, Pulaski and Horman, 2005)
ENV9: Environmental impact assessment project report	The process of evaluating the likely environmental impacts of a project.	ENV	SOC	(Chang et al., 2018, Židonienė and Kruopienė, 2015)
ENV10: Environmental management systems/policy implications	It refers to all environmental obligations, environmental adaptation and infractions for evolving, implementing and preserving the strategy for environmental protection.	ENV	-	(Martens and Carvalho, 2017, Gotschol et al., 2014)
ENV11: Identify and address choke points	Choke points include mainly social and psychological barriers that prevent development towards an environmental objective.	ENV	SOC	(Devece et al., 2016, Potts et al., 2015)
ENV12: Climate change adaptation/disaster risk management	It refers to the development, field testing and promotion of a "*climate-smart approach to disaster risk management*" (Mitchell, 2010).	ENV	ECO, SOC	(Pilli-Sihvola et al., 2018, Spangenberg, 1998)
ENV13: Appropriate and flexible environmental design details and specifications	It refers to the process of addressing surrounding environmental parameters in projects.	ENV	ECO	(Tabish and Jha, 2011, Yong and Mustaffa, 2013)
ENV14: Project biodiversity	It refers to the protection of all environmental ecosystems.	ENV	-	(Fellows and Liu, 2008, Fernández-Sánchez and Rodríguez-López, 2010)
ENV15: Environmental education and training	Skills like critical thinking, problem-solving, and effective decision-making, are cultivated through education and training, in order for individuals to	ENV	SOC	(de Sousa Jabbour et al., 2018, Martens and Carvalho, 2017)

	expand their viewpoint around environmental issues.			
ENV16: Sustainable project delivery through project stakeholder management	It refers to sustainable development principles through stakeholder management.	ENV	SOC	(Li et al., 2011, Huemann and Eskerod, 2013)
ENV17: Considering the life cycle of products and services to reduce environmental impacts	It includes lifecycle analysis, product disassembly analysis, post-sale tracking, and reverse logistics.	ENV	ECO	(Buson, 2009, Sarkis et al., 2012)
ENV18: Environmental management plan for impacts by the PMT	Effective environmental management and monitoring ensures the environmental objectives of the project.	ENV	SOC	(Ahadzie et al., 2008, Banihashemi et al., 2017)

Table 4: Pool of sustainable PM indicators for construction projects of social/management sustainability, extracted from previous studies

Social/Management (SOC) sustainability indicators				
Indicator	Description	Main TBL relation	Next immediate TBL relation	Indicative References
SOC1: Social responsibility	It refers to competition and pricing policies, compliance with anti-corruption practices and contribution to social campaigns.	SOC	-	(Xing et al., 2009, Ukaga, 2014)
SOC2: Social action funding/Concepts of social justice	It refers to the importance of funding a social act which takes into account the actions and reactions of individuals/communities. It also includes charities, constitutional social activities, and social influence.	SOC	ECO	(Fernández-Sánchez and Rodríguez-López, 2010, Martens and Carvalho, 2017)
SOC3: Corporate sustainability and organizational culture	Integration of corporate practices under an organizational prism about the natural and the social environment. That includes all the values and ways of interaction that contribute towards the TBL scenario and SD.	SOC	ECO, ENV	(Liu et al., 2016, Baumgartner and Ebner, 2010)
SOC4: Labor practices	It includes issues around employment (general conditions, health, safety), training and education, employee relations, openings (career opportunities, salary issues, etc.). Includes acquirement, development and management of the project team.	SOC	-	(Ali et al., 2008, Martens and Carvalho, 2017)
SOC5: Needs assessment of society/people	The social apprehension of needs for desired living conditions.	SOC	-	(Banihashemi et al., 2017, Liu et al., 2016)
SOC6: Sustainable employment	It concerns the empowering of young people with better job opportunities, the creation of green jobs and the conditions needed to create them.	SOC	ECO	(Knockaert and Maillefert, 2004, Cappuyns, 2016)
SOC7: Community relationships and involvement	It includes the development of engagement plans, and communities' potentials and desires. Focus on strategic investments shaped by the community, and the development relationships with community leaders are two possible practices of this kind.	SOC	ECO	(Labuschagne and Brent, 2005, Martens and Carvalho, 2017)
SOC8: Human rights	Includes freedom of association, connection with trade unions, and social management.	SOC	-	(Martens and Carvalho, 2017, Belout and Gauvreau, 2004)
SOC9: Employee commitment/commitment in the workplace	It refers to the team-building experience of employees, regarding the connection with their organization and their workplace.	SOC	-	(Chan et al., 2004a, de Sousa Jabbour et al., 2018)

SOC10: Public acceptance towards the project	It refers to the social willingness of embracing the project's outputs.	SOC	-	(Liu et al., 2018, Sütterlin and Siegrist, 2017)
SOC11: Stakeholder engagement/management	Stakeholder engagement refers to the interaction with the project stakeholders to the overall benefit of the project, while stakeholder management is "*the systematic identification, planning and implementation of actions designed to engage with stakeholders*"(Management, 2012).	SOC	-	(Martens and Carvalho, 2017, Huemann and Eskerod, 2013)
SOC12: Project independence of political factors	The development of a project according to the society's interests and not according to political interests.	SOC	-	(Soltani, 2018, Gan et al., 2017)
SOC13: Social impact reports	It refers to reports presenting society's viewpoints on projects (statistics and analysis).	SOC	-	(Martens and Carvalho, 2017, Schönborn et al., 2019)
SOC14: Transparent and competitive procurement processes	It refers to the transparency of the processes and policies when there is direct engagement with the suppliers, without discrimination and by safeguarding all confidential information.	SOC	-	(Ahadzie et al., 2008, Yong and Mustaffa, 2013)
SOC15: Absence of bureaucracy from the workplace	Faster procedures for delivering the project's outputs to the society.	SOC	-	(Duy Nguyen et al., 2004, Ukaga, 2014)
SOC16: Contractor - supplier relationship	It refers to the selection, evaluation, partnership and development of long-lasting and stable collaboration. Supply chain improvements derive through such relationships.	SOC	ECO	(Martens and Carvalho, 2017, Li et al., 2011)
SOC17: Commitment to the stakeholders 'needs	It refers to the respect of the stakeholders' needs that should be followed according to the project scope. It also includes the necessity of clearly defined goals.	SOC	-	(Ahadzie et al., 2008, Chan et al., 2004b)
SOC18: Well-defined project scope and project limitations	It includes the creation of precise project goals, through the implementation of a PM plan.	SOC	ECO, ENV	(Songer and Molenaar, 1997a, Tabish and Jha, 2011)
SOC19: Holistic view of benefits	It refers to the way of providing optimal command (project management) and visibility, allowing organizations to more easily execute a benefits strategy.	SOC	ECO, ENV	(Wilkerson et al., 2018, Kivilä et al., 2017)
SOC20: Product - service systems	Business model which targets in fulfilling the stakeholders' demands through a joined mix of products and services so that the interest of the providers continuously seek TBL solutions.	SOC	ECO, ENV	(Martens and Carvalho, 2017, Veleva and Ellenbecker, 2001)
SOC21: Emphasis on high quality workmanship	It refers to the human attribute relating to knowledge and skills for performing a task.	SOC	ECO	(Toor and Ogunlana, 2008, Yong and Mustaffa, 2013)
SOC22: Encourage competition	Encouraging positive competition among the PMT, marks increased productivity resulting from cooperative teamwork and mutual efforts.	SOC	ECO	(van Horen et al., 2018, Lam et al., 2017)
SOC23: Implementing a quality management system	It includes implementation of an effective quality control and quality assurance system.	SOC	-	(Ahadzie et al., 2008, Yong and Mustaffa, 2013)
SOC24: First mover advantage	A marketing strategy that follows the philosophy that the initial significant occupant of a market sector harnesses a competitive advantage.	SOC	ECO	(Lieberman and Montgomery, 1988, Gomez et al., 2016)
SOC25: Culture of accountability	It refers to the sense of ownership for processes, project results and risks by the employees within their roles and responsibilities for the organization.	SOC	-	(Toor and Ogunlana, 2008, Iacono, 2013)

SOC26: Comprehensive contract documentation	This documentation includes contract arrangements, work declaration contracts, possible special conditions, bill of quantities, drawings, construction schedule, and common types of insurance. Stakeholders should be able to comprehend the main terms of the contract.	SOC	-	(Du Plessis, 2007, Saqib et al., 2008)
SOC27: Diversification	It refers to strategy that follows the saying of "*don't put all your eggs in one basket*." It is the process of managing the project in a way that reduces the exposure to a specific asset or risk.	SOC	-	(McDowell, 2018, van Horen et al., 2018)
SOC28: Competitive tendering/comprehensive pre-tender investigation on project	It refers to various processes that can be used effectively to achieve value for money practices in project procurement.	SOC	ECO	(Chan et al., 2004b, Yong and Mustaffa, 2013)
SOC29: Adaptability in project environment	Employees are required to adapt to new environments, technologies, expectations and conditions.	SOC	-	(Banihashemi et al., 2017, Tabish and Jha, 2011)
SOC30: Intangible asset management	Intangible assets include exclusive rights, patents, trademarks, trade names, etc.	SOC	-	(Martens and Carvalho, 2017, Berssaneti and Carvalho, 2015)
SOC31: Multidisciplinary /competent PMT	It refers to the importance of multidisciplinary experience of PMT contributing to the PM success.	SOC	-	(Ihuah et al., 2014, Sáez-Martínez et al., 2016)
SOC32: The role of trust within the PMT	It refers to the importance of trust amongst the PMT for enhancing project performance.	SOC	-	(Du Plessis, 2007, Zhang et al., 2013b)
SOC33: Following project management phases/processes	It refers to all the basic PM processes (ex. defining scope, planning, project closure).	SOC	-	(Fortune and White, 2006, Toor and Ogunlana, 2008)
SOC34: Project manager's leadership style	Leadership styles can be creating vision techniques, coaching/unlocking potential and commanding/giving direction. It is influenced by the project manager's experience and competence.	SOC	-	(Saqib et al., 2008, Turner, 2005)
SOC35: Employing of operational decision-making techniques by the PMT	It refers to the utilization of structured data and procedures at all levels by the PMT for decision making.	SOC	-	(Fortune and White, 2006, Gudienė, 2013)
SOC36: Project monitoring and evaluation by the PMT, through previous experiences in projects (access to relevant experience)	*"A project monitoring and evaluation system is designed to mitigate poor project performance, demonstrate accountability and promote organizational learning for the benefit of future projects" (Crawford and Bryce, 2003).*	SOC	-	(Callistus and Clinton, 2016, Callistus and Clinton, 2018)
SOC37: Managing knowledge and awareness to promote sustainable project delivery (PMT)	The PMT is focusing on the project processes though the gain of knowledge from all project phases; enables learning, awareness and ensures to integrate finalized projects' lessons learned into new projects.	SOC	ECO, ENV	(Ihuah et al., 2014, AlSanad, 2015)

Analyzing the abovementioned tables, the economic side of sustainability includes technical factors, engineering measures and viability factors. A construction project can be said to be economically viable when its multi-factor productivity has risen in a particular period (Ehui and Spencer, 1993). The environmental attribute introduces quality factors as parameters related to the damage in the quality of elemental environmental services and the deterioration of the ecosystem's value (Ferrarini et al., 2001). Environmental management factors is a PM practice through which an organization manages the impacts of its project activities on the environment, providing a structured approach for sustainable planning (Gotschol et al., 2014). The social/management aspect includes communication and team factors that describe how to advantageously connect with the stakeholders and the local society about the construction project. Communicating and teaming around the sustainability project's success, distinguishes the project and shapes the stakeholders' approval (Schönborn et al., 2019).

These indicators include extents on values of PM, user participation, team members, organization, availability of technical resources, external environment, accurate project task, development aims, natural resources, and managerial support (White and Fortune, 2002, Saqib et al., 2008).

Sustainable construction projects are meant to provide services to local societies that positively impact all TBL attributes of sustainability (Ali et al., 2008). Before even the first phase of construction of a project, studies need to be undertaken in order to reveal the sustainability potential of the final outcome (Ding, 2008).
The results of the research identify the highest number in social/management indicators in construction projects (total number of 37 factors). The social acceptance of construction projects has been negatively impacted by factors like high cost, planning problems and lack of information on new technologies. Thus, it is exactly this unusual aspect of such type of projects that demand the social acceptance in order for local societies to favor construction (Zhang et al., 2013a). The practical implication of the study is that sustainable project managers who participate in construction projects, gain an in depth understanding of possible indicators that could lead to sustainability success. Moreover, the indicators categorization under the TBL scenario of sustainability and their detailed investigation offers project managers and scholars with a basis for further analysis and research into indicators for construction projects. The results of the research can aid project managers, scheme new sustainable strategies in order to attain sustainability success in the project, especially in ground-breaking projects, taking into consideration the indicators identified. In an applied real-life scenario, the results of the research provide strategies for policy makers and companies' executives.

The economic, environmental, and social/management aspects of construction projects can be understood in a better way when the TBL scenario is present. A set of indicators is important for the integration of sustainability into project management practices that can lead to sustainable project success (Presley et al., 2007). Following this idea, this research suggests that by following the identified indicators within the proposed taxonomy, project managers may significantly enhance and expand their original practices and improve chances of sustainability success.

2.2.7 Conclusion

This paper aims to contribute towards the holistic view of sustainability for PM in construction projects. The objectives of the research involve (1) exploring the concept of sustainability in PM of construction projects; (2) identifying the sustainability indicators for construction projects in relevant literature; (3) categorizing the indicators identified according to the triple-bottom line scenario of sustainability (hence the economic, environmental and social dimension).

Several indicators have been identified via a systematic literature review and validated with semi-structured interviews of construction management experts. The indicators concerning the economic dimension finalized in 27; 18 for the environmental dimension and 37 indicators in the social/management dimension. The interviews also revealed the immediate relation of some indicators with a second or a third TBL aspect (Tables 2, 3, 4).

The literature review also revealed the need for more empirical studies on the promising theme of sustainable PM indicators in construction projects, as no widely accepted strategy of reaching sustainability in construction projects has been discussed. Thus, one possible direction for further research could be the creation of additional studies on how to recover and reveal indicators that actually contribute towards this track. Furthermore, researchers could proceed into mapping all the possible control mechanisms for sustainable PM across dissimilar types of construction projects, explore the problems that might occur during the phases of the project, and focus on the TBL scenario of sustainability to relate the results. Indicators can perform the main role towards this route. The examination of other aspects of sustainable PM via the utilization of indicators, such as stakeholder characteristics and lifecycle management, could also be studied further. Concerning the generalizability of the research findings of this study; interview data derived from two countries (Greece and UK) in construction projects framework, which may be considered as a limitation of this study. All the interviews were semi-structured and focused on the theme of sustainable PM in construction projects, based on the interviewees' previous construction management experience, their current and previous working organizations implement. Further research can be applied to other countries in order to identify varieties amongst different manufacturing features.

There is an urgent need to define a commonly accepted process for identifying and selecting the most suitable set of indicators for sustainable PM practices in construction projects. Sustainable PM methods are suggested by researchers as a way for achieving the "sustainability goal" in construction projects. This study presents a total amount of 82 indicators. The purpose of such research is to: (1) provide a holistic view of sustainable PM indicators, covering the full spectrum of the triple constraint (TBL) and (2) to offer the possibility for practitioners to choose the right mix of indicators, depending on the sustainability focus they want to provide in their projects (e.g. TBL balanced / economically focused / environmentally focused / socially focused).

2.3 Summary

This chapter has provided a literature review of the research topics related to this research, namely sustainability, project management, indicators, and construction projects. Overall, through the systematic literature review analysis, it can be conceptualized that the integration of sustainability indicators into project management practices can guide practitioners seeking sustainability attributes in their projects. Based on the underlying themes from several studies, it is perceived or implied that sustainable PM indicators can be the start for delivering a more sustainable society. The review of various studies related to sustainability revealed different controversial definitions that can impact the way stakeholders perceive the whole concept.

The review of the literature revealed the knowledge gap in the context of sustainable PM indicators for construction projects. According to the TBL scenario, a holistic approach and taxonomy of the indicators contributing to sustainable PM in construction projects remains a gap in the literature and practice. The SLR method that was conducted is considered amongst scholars as a particularly useful technique that draws vital conclusions, identifies patterns and gaps based on the published literature. To address such a gap in the body of knowledge, this chapter (1) approached sustainability in PM context and revealed related indicators as effective tools for construction projects; (2) provided initial insights into sustainable PM practices that can assist project managers by focusing their attention on indicators that improve the sustainability of the project; and (3) presented a structured literature on sustainability and PM.

This chapter makes use of the existing literature data from carefully chosen related areas and uses it to create a relevant context that identifies the indicators as distinguished in previous studies from the construction projects' standpoint in general.

3. Research Design

3.1 Introduction

This chapter presents the methodology and the research design followed by this thesis. The research methodology underpins the philosophy and approach to research, the purpose, the data collection and analysis, the validity and reliability of the retrieved data, and the ethical considerations. It is divided into seven subchapters that include the pre-mentioned considerations followed by a Chapter summary.

The purpose of this Chapter is to provide an overview of the research approach, which entails all methodological steps followed, the research design, and provide insights into how these research methods align with the underlying research aim and objectives.

3.2 Philosophy and approach to research

According to Bajpai (2011), the philosophy and approach to research deals with the sources analyzed, nature, and knowledge development. This research identifies, amongst others, the human parameter as an indication for providing results. However, when it comes to understanding and interpreting social worlds and contexts, factors like uncertainty, chance events, and random errors exist (Saunders et al., 2019). Saunders et al. (2019) indicate in their study that the "*principal to the interpretivist philosophy is that the researcher has to enter the social world of the research subjects and understand their world from their point of view*." Sustainable PM issues can be considered as paradigms for management and business research to generate fresh insights into real-life problems. The philosophical approach of the interpretive paradigm reflects this concern.

Another philosophical approach analyzed in the same study is Posivitism. Positivism is the term used to describe an approach to the study of society that relies specifically on scientific evidence, such as statistics. Thus, it can be concluded that the philosophical approach of this research lies between the Positivist and the Interpretivist approach and is reflective of the mixed research methods used as these were previously described in the introduction section.

Inductive reasoning is also part of the philosophical approach of this research. Moving from specific observations to broader generalizations and theories is the characteristic path of this research. Induction in this research emphasizes in gaining an understanding of sustainability in project management, especially for construction projects, by delivering the principal sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders. Furthermore, it targets the collection of qualitative data, and it develops a more flexible structure to permit changes of research emphasis.

3.3 Purpose of research

The purpose of the research reflects the way in which the researcher provides answers to the predefined research aim and objectives (Saunders et al., 2019). The present thesis follows the exploratory direction in a way to seek new insights into the vast field of sustainable PM. According to Dudovskiy (2016) and Saunders et al. (2019), exploratory research is linked to the research methods of literature review and interviewing experts in the analyzed subject; research techniques existent in this study. The research is exploratory in nature, in the sense that it investigates the integration of sustainability indicators in PM practices to deliver sustainable construction projects; the findings remain to be tested in practice so as to offer the possibility for practitioners to choose the right mix of indicators, depending on the sustainability focus they want to provide in their projects, and adopt strategies that enhance the delivery of sustainable construction projects. The applicability of these indicators in the construction industry is of further research (draw concrete conclusions in practice); thus, the exploratory concept is more suitable.

The present research has been conducted in several phases, with each phase deliberately chosen to use a different methodological choice. The research flowchart that includes all the phases and approaches is revealed in Figure 2-3.1. The flowchart shows the exploratory nature of the study.

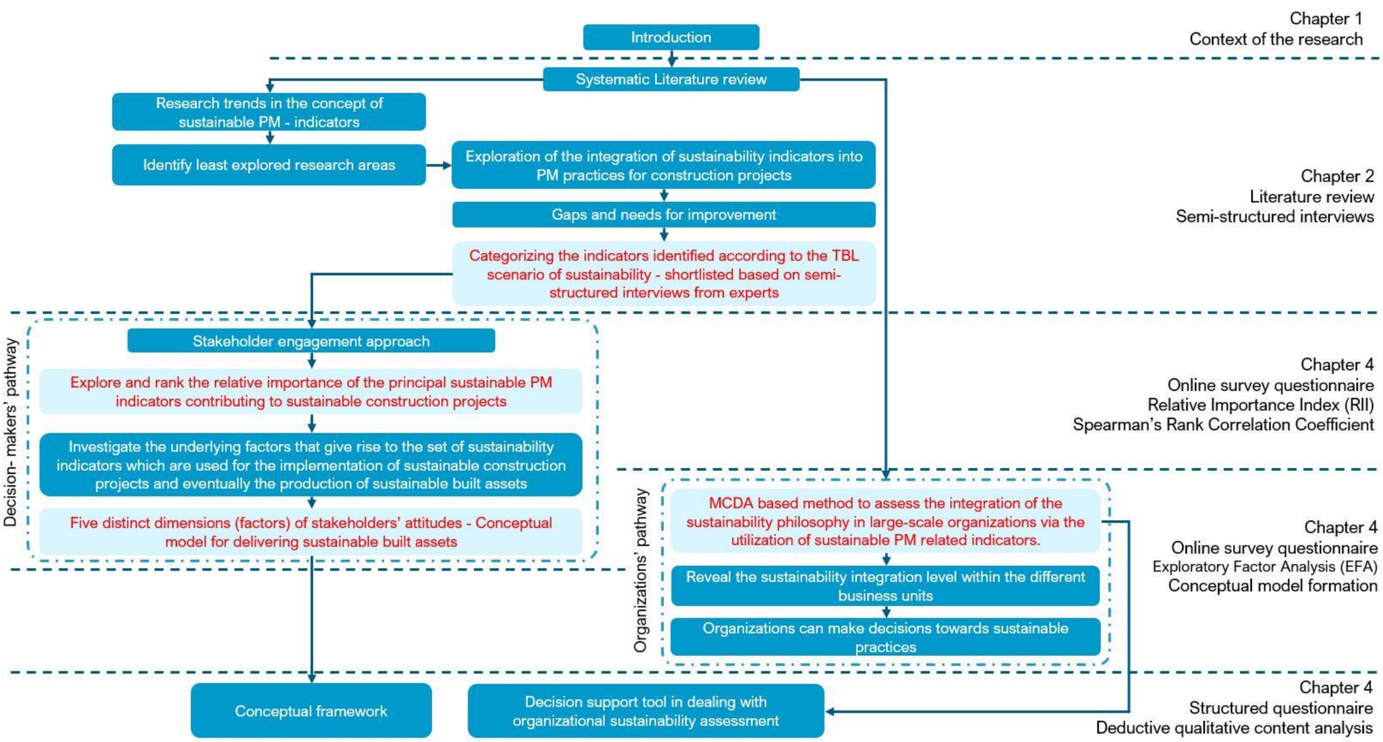

Figure 2-3.1: *Research design*

This study seeks to reveal insights into the use of sustainable PM indicators for delivering sustainable construction projects. The exploratory research analysis is an attempt to set the basis for future studies and to determine observations that could reveal new concepts on the promising theme of sustainable PM. Furthermore, it discloses a unique angle of the analyzed theme that derives through innovative ways of perceiving sustainable PM practices, either from a theoretical perspective or by implementing the proposed initiatives.

3.4 Methodological choice and Research design

To meet the aim of the study and to contribute to a holistic view of project management, particularly towards the sustainability of construction projects, the research strategy follows a mixed-method approach. A systematic literature review (SLR) was initially carried out to examine the literature (definition of indicators highlighted in previous studies in terms of general construction projects). Semi-structured interviews were conducted to obtain expert opinions on the validation of each indicator of sustainable project management practices for construction projects. After analyzing the results, an online questionnaire survey was distributed to investigate the stakeholders' beliefs, as these were recognized via a literature review search around the importance of the predefined indicators. This methodological technique proved quite useful, especially for gathering data from a large sample on a global scale, as was the intention in this research. The collected data was furtherly analyzed to measure the significance of the final indicators. The relative importance index (RII) formula was used for this purpose. As a next step, the statistical method of exploratory factor analysis (EFA) was employed. Five distinct dimensions (factors) of stakeholders' attitudes were revealed. Finally, a case study was conducted in a market-leading design, engineering, and project management consultancy organization to reveal the sustainability integration level within different business units in order to allow organizations to make decisions toward sustainable practices. A Multi-Criteria Decision Analysis-based (MCDA) method is proposed to assess the integration of the sustainability philosophy via the utilization of the sustainable project management-related indicators. Evaluating organizational sustainability can help organizations target their efforts in certain areas (enhancing sustainable outcomes). Figure 3.1 reveals the research design of the thesis.

The use of sustainable PM indicators is not a widely experienced practice within the context of construction projects. In order to attain sustainability in projects, identifying indicators is particularly valuable as it brings structural clarity and enables proper management (Banihashemi et al., 2017). In view of an extensive literature search that backed similar claims and by following the aim of this study, the methodological choice was planned as the theoretical point of departure and the basis for development. The research strategy follows a mixed-methods approach, meaning the combination and collection of both qualitative and quantitative data, integrating the two forms of information for the purposes of this research (Berta et al., 2016). As it will be presented in the analysis and findings Section, the specific approach proved quite useful for addressing the research problem/gap and defining the objectives that needed to be reached by a qualitative investigation that is followed by a mixed-method analysis.

By adopting the mixed-methods approach, minimization, and reduction of the over-dependence on statistical data to explain the integration of sustainable indicators in PM practices to deliver sustainable construction projects was achieved. According to, Opoku and Ahmed (2013), "*using mixed methods research provides strengths that offset the weaknesses of both quantitative and qualitative research. It also provides more comprehensive evidence for studying a research problem than either using quantitative or qualitative research alone*". This thesis considers the integration of various methods to reach the aim of the study, starting from the early stages of the design process to the definition of the objectives.

Initially, a systematic literature review (SLR) was conducted, exploring the literature by identifying a set of indicators distinguished from previous studies from the construction projects' standpoint. According to Stanitsas et al. (2019), "*the SLR method is considered particularly useful when publishing the crucial conclusions of a large and complex body of research literature*." Aarseth et al. (2017) indicate that SLR is a method that is widely used by researchers who wish to generate robust results in their literature analysis. In this research, to reach the aim, an identification of the links between PM, sustainability, and sustainability indicators in construction projects was planned. The SLR method was the means to this path. It is considered a particularly useful technique that draws vital conclusions and identifies patterns and gaps based on the published literature (Sengers et al., 2019).

Thus, the aim of the SLR within the research includes:

1. Contribution towards the holistic view of sustainability for PM in construction projects by exploring all the concept angles.
2. Identification of the sustainability indicators for construction projects in the relevant literature.
3. Categorization of the identified indicators according to the triple-bottom-line scenario of sustainability (hence the economic, environmental, and social dimension).

As a next step in the study's methodological approach, a series of semi-structured interviews to validate the extracted results of the SLR were conducted. To finalize the set of the sustainable PM indicators as these were revealed through the SLR, expert opinions on the validation of each indicator for sustainable PM practices for construction projects were a valuable input. After analyzing the results, the designation/description of the indicators was revised accordingly. This method permits in-depth discussions and analysis with the interviewees to ensure that valuable outcomes are revealed (Athapaththu Kushani and Karunasena, 2018). Based on the aim of the study, this methodological approach proved beneficial for this research.

Building upon the previous research methods, the next step of the research includes an online questionnaire survey to investigate the stakeholders' beliefs (the stakeholder categories that get involved in sustainable construction projects were recognized in the literature review section) around the importance of the predefined indicators. The specific research method serves the purpose of gathering data from a large sample on a global scale, whereas it presents practicality and relative simplicity, as all the returned answers can be easily analyzed. Furthermore, it supports reduced bias that may be introduced by the researcher's verbal and visual clues (Jarkas and Younes, 2012, Gunduz, 2016). The results of this questionnaire were analyzed using statistical analysis. The first step of this analysis was to measure the significance of the final indicators. The relative importance index (RII) formula was used for this purpose. *RII is a non-parametric technique commonly operated by construction and sustainability management scientists* (Waris et al., 2014). This technique is quite useful when there are data involving ordinal measurement of attitudes (stakeholders' views, expressed via structured questionnaire responses) (Waris et al., 2014, Kometa et al., 1994). The second step of the analysis continued by employing the statistical method of exploratory factor analysis (EFA), which revealed five distinct dimensions (factors) of stakeholders' attitudes. The EFA was followed as a way to reveal the fundamental concepts of a large set of variables so as to understand the factor structure of the data. The application of EFA for sustainability indicators seems promising since most of the variables involved are not quantifiable.

Following the previously described statistical analysis, a conceptual model of factors, indicators, and the selection process for delivering sustainable built assets was designed. The purpose of the conceptual model was to aid practitioners in understanding the core concepts (described here as factors) that give rise to the indicators and the selection process that needs to take place to facilitate sustainable construction management.

Finally, an MCDA-based method, namely PROMETHEE, was used to assess the integration of the sustainability philosophy in a large-scale organization via the utilization of the predefined sustainable PM-related indicators. The alternatives (departments of the organization) were ranked with respect to the TBL philosophy. The PROMETHEE method is an effective, straightforward, and simple tool for conducting an unbiased evaluation of the organization's departments that have focused their efforts on a specific set of indicators through a high level of transparency in decision-making processes related to the integration of sustainable PM indicators in a way that will allow organizations to make decisions toward sustainable practices.

To better understand the contribution of the methodological choice to the aim of the research, the methods are mapped to objectives within the following Table:

Table 3.4. 1: Mapping of research methods to research objectives

	Research objective	**Method**
1	Explore state of the art for sustainability in project management by identifying sustainability indicators into project management for the construction industry.	• Systematic Literature Review (SLR) • Semi-structured interviews with experts
2	Explore and rank the relative importance of the principal sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders.	• Questionnaire survey to investigate the stakeholders' beliefs around the importance of the predefined indicators (*Descriptive Statistics - Relative Importance Index (RII)*)
3	Identify the underlying factors that give rise to the set of sustainability indicators used to implement sustainable construction projects and eventually the production of sustainable built assets and propose a conceptual model of sustainability indicators based on five underlying factors.	• Questionnaire survey (*Exploratory Factor Analysis (EFA)*)
4	Propose a Multi-Criteria Decision Analysis-based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable project management-related indicators. By utilizing the proposed approach to compare internal organizational structures, insights into the sustainability integration level within different business units are revealed to allow organizations to make decisions toward sustainable practices.	• Multi-Criteria Decision Analysis (MCDA) method (*PROMETHEE*)

3.5 Data analysis

The data retrieved during this research were carefully analyzed to draw vital conclusions. A process for analyzing the content from the interviews, the results of the questionnaire surveys, and perceptions as these were revealed from the systematic literature review, was followed.

The conducted SLR that revealed the final set of indicators has used data obtained from journal articles, books, conference papers, and the final validation of field experts (interviews). The SLR proved quite useful in identifying the links between PM and sustainability indicators for construction projects. The whole process included a systematic search for relative articles through online academic databases. The final retrieved set of indicators was then validated as contributing to the purposes of this research through interviews. The indicators were then categorized according to the TBL philosophy (economic, environmental, and social/management sustainability indicators) to reflect their usage better when in use by practitioners. The categorization was achieved with the help of the interviews and after reviewing their way of usage in previous literature.

The extracted data of the perceived stakeholder views of the final set of sustainable PM indicators, contributing to construction projects that derived through an online questionnaire survey, aided in understanding the stakeholders' beliefs and attitudes when in seek of sustainability attributes in the construction sector. Qualitative and quantitative data from the findings were used as input for the employment of the RII analysis. The derived rankings were used to cross-compare the relative importance of the indicators as perceived by the questionnaire survey respondents.

The results of the online questionnaire survey that was administered to a sample of experts (stakeholders) were used as input for the statistical method of exploratory factor analysis (EFA), through which five distinct dimensions (factors) of stakeholders' attitudes were revealed. The Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) and Bartlett's sphericity test were the two statistical tests conducted in this research. Furthermore, the application of EFA for the indicators was quite fitting since some of the variables involved were not quantifiable.

The PROMETHEE method (MCDA) adequately handled qualitative and missing values data from a newly structured questionnaire distributed to experts of a large-scale organization to reveal the use of the predefined sustainable indicators in its internal policies. By using the Visual PROMETHEE software, the alternatives (departments of the organization) were ranked with respect to the TBL criteria. The primary input data for the analysis were the weights of the criteria which have been extracted by the RII analysis and the results of the questionnaire survey.

Descriptive and inferential analyses were conducted concerning the semi-structured interviews and the questionnaires data. Descriptive Analysis was followed to describe and summarize data inputs in a constructive way to attain the aim of the research. According to Anåker et al. (2021), descriptive analysis is considered a vital step for statistical data analysis. Inferential analysis was used to estimate the participants' characteristics (parameters) for establishing association and influence patterns and differences between stakeholders' categories. Kuhar (2010) indicates in his research that it is possible to develop oversimplification on a large sample population through the investigation of the collected samples. A similar approach to what was followed throughout the semi-structured interviews and the questionnaires data was carried out for the finalization and classification of the final indicators according to the TBL scenario during the SLR.

3.6 Validity and reliability of data

Field (2009a) argues that validity can be described as the extent to which a test measures what it is intended to measure. Wiese et al. (2015a) quote that qualitative research is connected to content validity in a way to express the capability of the researchers concerning the measurement items.

The content validity in this research is thoroughly described through the questionnaire survey that consists of the identified indicators. The methodology used to extract the variables had content validity. Questionnaires can be considered as an advanced statistical technique for analyzing data. They disclose validity, reliability, and statistical significance (Fox et al., 2000). Through the EFA (one of the methodological choices of this research), the efficiency of the measurements, the percentage of variance explained, the reliability value (Cronbach's alpha), and the KMO test for all the analyzed factors revealed a total validity and reliability of data.

According to Sondhi (2011), single observation and subjectivity in a research context are a risk to preserve the validity and reliability of the data analyzed. The motive for using a questionnaire in addition to interviews in this study was its ability to reach a large target group in a practical and efficient way, and it's a relatively high validity of result due to its vast geographical coverage (Opoku and Ahmed, 2013). To address reliability concerns to the most possible extent, this study involved an internal audit of the retrieved data by engaging with other researchers and confirmation of the posed questions among previous literature. Construct, internal and external validity have been considered to the most possible extent. Internal validity threats were minimized in terms of reducing logical errors and participant bias in the research by the openness of the semi-structured interviews, conducting pilot-testing of the questions amongst researchers before discussions with the participants, and cross-verification and clarification of questions before the interviewees respond. According to Saunders et al. (2019), "*pilot testing of semi-structured questions in a study helps in refining the questions and enhancing the quality of semi-structured interviews*." Construct validity was ensured by the accuracy in the methodology used in terms of previous literature analysis (SLR). External validity was performed in two phases. The first phase included the retrieved data (data collection). The second phase included the reveal of the research outcomes. Overall, this research used a number of techniques (Table 3.6. 1) so as to secure the validity and reliability of the data.

Table 3.6. 1: Quality assurance methods used. Adapted from Trochim (1985)

Tests	Techniques used for this research
Construct validity	The analyzed theme's perceptions derived through the conducted SLR were used to build observational constructs. Identified evidence from previous literature was used to enhance the validity of constructs.
Internal validity	A mixed-method approach, including quantitative and qualitative characteristics, was used to test and explore the research objectives.
External validity	Previously conducted case studies were used as reference point validation to help establish the generalizability of the findings.
Reliability	The case study protocol was followed for qualitative data collection. The conducted methodological path included questionnaires distributed to field experts and MCDA to rank the case alternatives. Thus, the data collection and analysis procedures were repeatable.

3.7 Ethical considerations

Ethical considerations in research are a set of principles that guide the researcher towards creating the appropriate research design. Researchers must always comply with specific regulations involving critical ethical considerations when collecting data, especially when involving humans. Hoping to achieve an understanding of real-life phenomena, behaviors, and other patterns of interest, researchers must always protect the rights of the research participants and enhance research validity and integrity (Polonsky, 2019).

According to Bryman (2007), the following ten points represent the most important principles related to ethical considerations in research:

1. "*Research participants should not be subjected to harm in any ways whatsoever.*
2. *Respect for the dignity of research participants should be prioritized.*
3. *Full consent should be obtained from the participants prior to the study.*
4. *The protection of the privacy of research participants must be ensured.*
5. *Adequate level of confidentiality of the research data should be ensured.*
6. *Anonymity of individuals and organizations participating in the research must be ensured.*
7. *Any deception or exaggeration about the aims and objectives of the research must be avoided.*
8. *Affiliations in any form, sources of funding, as well as any possible conflicts of interests must be declared.*
9. *Any type of communication in relation to the research should be done with honesty and transparency.*
10. *Any type of misleading information, as well as representation of primary data findings in a biased way, must be avoided*".

Shamoo (2015) highlight the importance of research ethics in 5 key points:

1. "*They promote the aims of the research, such as expanding knowledge.*
2. *They support the values required for collaborative work, such as mutual respect and fairness. This is essential because scientific research depends on collaboration between researchers and groups.*
3. *They mean that researchers can be held accountable for their actions. Many researchers are supported by public money, and regulations on conflicts of interest, misconduct, and research involving humans or animals are necessary to ensure that money is spent appropriately.*
4. *They ensure that the public can trust research. For people to support and fund research, they must be confident in it.*
5. *They support important social and moral values, such as the principle of doing no harm to others*".

According to DePoy (2016), ethical considerations in research and the construction of protection strategies require careful planning and execution by the researchers. On the contrary, "*un-ethical or inappropriate research harms not only study participants but also the target population, society, and the overall research enterprise*."

Any personal information provided in this research remained confidential. As far as possible, researchers secured the research data that were safely stored electronically. The results of this research were published in the form of written scripts, which were included in the researcher's Ph.D. Thesis and Research Papers, Journal Articles, and they were of a general nature without mentioning the participants' personal details. This study was carried out in accordance with the ethical norms for human interviews established by the academic staff of the National Technical University of Athens (non-funded research activities). Before conducting interviews with the organization's members, the case-study organization was thoroughly briefed on the ethical processes.

This research included participation by field experts (questionnaires and interviews); thus, it was the researcher's responsibility to ensure that all participants consented to the use of their information within this research. The data extracted have been provided to the research participants who wished to receive a summary report on the results.

3.8 Summary

The research methodology followed, and the rationale for selecting each method was described in this chapter. The sequential mixed methods design was followed in view of the targeted research aim and objectives. The exact design included a SLR to explore and identify the sustainable PM indicators as distinguished in previous studies from the construction projects standpoint in general, which were further validated by semi-structured interviews with field experts. Subsequently, a questionnaire survey was designed to address the objective of investigating the perception of stakeholders from the construction sector regarding the usage of sustainable project management indicators when seeking sustainability attributes in their projects. The data collected were analyzed to measure the significance of the final set of indicators. The relative RII formula was used for this purpose.

Furthermore, all the information extracted from the questionnaire survey was used to conduct the statistical method of Factor Analysis (FA). In this research analysis, the principal component analysis was chosen as a useful technique for analyzing the large dataset by increasing the interpretability while minimizing information loss. The EFA sought to research the fundamental mechanisms that give birth to a collection of sustainability indicators utilized in implementing sustainable construction projects and, ultimately, the production of sustainable built assets. Finally, the methodology part was concluded with the presentation of a Multi-Criteria Decision Analysis based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of the sustainable project management-related indicators. By utilizing the proposed approach, which was based on questionnaire inputs from key managers of the analyzed organization, to compare internal organizational structures, the sustainability integration level within the different business units was revealed.

4. Analysis and Findings

4.1 Investigating the significance of sustainability indicators for promoting sustainable construction project management

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4.1.1 Abstract

Sustainable project management practices constantly gain importance over the last years. Relevant indicators constitute a means of leading modern projects to sustainability. Hence, it is necessary to identify a set of sustainability indicators that affect the construction process. The aim of this research is to explore and rank the relative importance of the principal sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders. To achieve this aim, this study followed a research design including a questionnaire survey to investigate the perception of stakeholders from the construction sector regarding the usage of sustainable project management indicators when in seek of sustainability attributes in their projects. The structured questionnaire survey included 82 identified indicators, which were shortlisted based on relevant previous literature research and the input of semi-structured interviews from experts and professionals. The data gathered has been analysed through the relative importance index approach which has been widely used for similar purposes in the literature. Employing the relative importance index approach, environmental indicators were identified as the most important. The findings are helpful for practitioners that seek achievements in the sustainability construction sector by focusing, acting upon, and controlling the most important indicators.

4.1.2 Keywords

Sustainability; Indicators; Project management; RII; Construction

4.1.3 Introduction

During the last decades, the construction sector has been strongly criticized of poor sustainability performance (Švajlenka and Kozlovská, 2020). This offers the construction industry a unique opportunity to contribute in improving global sustainability initiatives (Lee et al., 2019). Literature reveals various approaches that tend to contribute towards this direction (Caiado et al., 2017, Švajlenka and Kozlovská, 2020, Stanitsas et al., 2019). According to Martens and Carvalho (2017), new tools that will create sustainable constructions need to be developed.

Several studies have connected project management (PM) principles with sustainability attributes via the use of critical success factors (CSFs) and indicators in projects (Banihashemi et al., 2017, Keeble et al., 2003). However, the concept of attaining sustainability in construction is still ambiguous, mainly due to dissimilarities in outlooks of the sustainability concept amid stakeholders of a project. Hence, there is a need to develop a strategy that will affect the sustainability performance of projects considering the perception of success by project stakeholders. The authors of this study suggest the use of relevant indicators to attain this path.

While the ambiguity and polysemy of the concept of sustainability in construction is an issue often faced by researchers (Pesqueux, 2009, Salas-Zapata and Ortiz-Muñoz, 2019); the fundamental concept that is generally most considered in academia, includes the responsibility of the construction industry in incorporating all three dimensions of sustainability (economy, environment, society). Nonetheless, literature reveals several definitions to describe this concept. These definitions are based in directly related concepts such as; "green infrastructure" (Seiwert and Rößler, 2020); "high performance buildings" (Majumdar, 2020) and "sustainable building design"' (Asman et al., 2019). According to (Mellado and Lou, 2020), it can be postulated that, integrating sustainability issues promote performance improvements in the construction industry. This describes, in its broadest sense, that such an approach makes it plausible to apply sustainability concepts to construction projects that seek triple-bottom line (TBL) improvements. The whole TBL concept is based on the three pillars of sustainability; namely economy, environment and society, which constantly interact. Hence, the sustainable construction concept can be described as the application of sustainability principles (no matter the TBL dimension they derive from) within the construction industry (Spence and Mulligan, 1995).

The sustainable construction momentum has directly laid its impacts on many organizations that wish to include TBL policies into their business plans (Rodriguez et al., 2020, Bossink, 2020). The aim of sustainable development (SD) is to improve the way the construction industry is developed by promoting environmental protection, economic growth, and social advancements (Sev, 2009). As a result, the identification, and the evaluation of sustainability indicators from the stakeholders' perspective can be used to mitigate their impacts and initiate performance improvements (Kiani Mavi and Standing, 2018, Banks et al., 2011).

The introduction of sustainability in construction projects is a fact. Numerous policies, restrictions and regulations around the world define the need to apply sustainability concepts to societies at a strategic level (Fernández-Sánchez and Rodríguez-López, 2010). As referred to Agenda 21 (Bredillet et al., 2013, U.N., 1992), one of the most popular guidelines on sustainability issues, "*there is a need to construct an indicator set that allows sustainable targets to be met in urban development, as well as to control and monitor the progress of these indicators over time*". Thus, the need for exploring sustainable PM indicators for construction projects is of vital meaning. This need motivates the research within this paper that focuses on the indicators that drive sustainable construction projects at the project management stage.

The aim of this research is to explore and rank the relative importance of the principle sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders.

Indicators from past research were gathered and allocated under the main three TBL dimensions, namely, economic, environmental, and social. A questionnaire survey including these listed indicators was prepared and distributed to various experts in the sustainability/construction/PM fields to be ranked. These indicators were used to gather perceptions of seven main stakeholder categories. These categories are (1) Clients, (2) Users; (3) Manufacturers; (4) Contractors; (5) Designers/Consultants; (6) Authorities/Government; (7) Research academics. The impact of each category on each indicator was quantified with the help of RII. This prioritization can lead to more effective sustainable construction PM practices when applying these indicators.

The results of this research can be beneficial to construction stakeholders and future researchers in understanding the use of sustainable PM indicators to attain sustainable construction projects. Even though, such an analysis presents difficulty in affirming unanimously, as to its application or interest; it can constitute a useful guide for practitioners who wish to focus their sustainable PM efforts on specific indicators and to furtherly proceed to contributing implementations, attaining sustainability in their projects. Under this philosophy, they will heighten sustainable PM effectiveness and the sustainability realization of construction projects. The fact that this research showcases views of international experts; the findings contribute towards the establishment of a widely accepted set of sustainable PM indicators for construction projects.

4.1.4 Literature review

The introduction of sustainability in construction projects comes with the need to develop sustainable societies (Du Plessis, 2007). “The concept of “sustainable construction” was first mentioned in academia at the First International Conference on Sustainable Construction in Tampa, Florida, US in 1994” (Kibert, 1994, Yu et al., 2018b). It was the beginning of a new era for the construction sector. Various studies started implementing sustainability into their viewpoint when referring to construction projects. Hill and Bowen (1997), put forward the case of a conceptual framework that leads to sustainability in construction under the concept of four pillars (TBL and technical perspectives). Shen et al. (2011a), developed a set of indicators to assess the sustainability of construction projects. They categorized the indicators found according to the TBL scenario. Banihashemi et al. (2017) conclude that sustainable PM practices into the construction phases of a project can be done via the utilization of CSFs. Internationally recognized assessment systems for buildings are also showing the way towards sustainability (e.g., BREEAM, LEED, DGNB) (Mohamed, 2019). Sustainable construction may progressively become a “trend”; yet it constitutes a novel field that calls for additional research (Goel et al., 2019b).

Focus on sustainability issues in construction, needs to be developed even further (Dobrovolskienė and Tamošiūnienė, 2016a). Goel et al. (2019c), highlight the past and current situation of the construction industry and argue for the adoption of a sustainable project portfolio management. Szekely and Knirsch (2005), share the idea of integrating sustainability into construction through sustainability indices and performance indicators that measure sustainability performance and conclude that this is where researchers should turn their view on. Yu et al. (2018b), emphasize the importance of developing an appropriate sustainability evaluation system for construction projects. By reviewing previous literature, they conclude in 4 key points that will constitute such a plan possible; (1) a comprehensive approach of sustainability, including product organization, key stakeholders, and economic concerns; (2) a small number of indicators for practical and cost-effective implementation; (3) a lifecycle concern; and (4) project focus. Modern literature seems to turn its attention towards indicators for sustainable construction practices (Wirahadikusumah and Ario, 2015).

Many studies propose the use of factors/indicators for assessing the sustainable index, under the TBL context, for relating the sustainability performance of construction projects (Kiani Mavi and Standing, 2018, Martens and Carvalho, 2017). Though the use of sustainable PM factors/indicators, the researchers examine the sustainable development benefits associated with all parts of a construction project to improve its sustainability.

In order to attain sustainability in construction, it is very important to select the proper set of indicators. "*These indicators should include the main building impacts and assess the particular aspects of the socioeconomic context*" (Vilnītis et al., 2019). Accordingly, it is important for projects to achieve a balance amongst the three dimensions (Guangdong et al., 2018). This is further supported by Zhong and Wu (2015), who highlight the need to balance these dimensions under the indicators "umbrella" in successfully achieving sustainability in projects.

The need for the definition of an indicator set comes with the prerequisite to establish a methodology for the identification of sustainability indicators from the project management point of view (Fernández-Sánchez and Rodríguez-López, 2010). According to Ugwu and Haupt (2007), an effective way to accomplish this is through effective stakeholder participation. Under the same philosophy, Shen et al. (2011a) developed a set of indicators to assess the sustainability of construction projects. They categorized the indicators found into environmental, economic, engineering, and social categories. Their research method followed the content analysis to reveal relevant indicators to assess the sustainability of infrastructure projects. Banks et al. (2011), to conclude into similar findings, reviewed current sustainability indicators within the context of major infrastructure projects to develop a sustainability enhancement framework. The research method conducted, included intensive interviews with stakeholders of all kinds who participated in the case study project. On a similar research path, Karji et al. (2019) identified 33 sustainability indicators related to the social dimension of the TBL. Four major categories derived through this extensive research; namely a.) community and construction Interactions; b) health, safety, and risk; c) liveability; and d) neighbourhood characteristics. The results of this research not only contribute to the overall body of literature related to sustainable PM practices in the construction industry, but also fill a gap in knowledge of the principal indicators leading to sustainable projects.

The indicators analysed in this study, are dependent on the project execution process, outcomes, and the operating environment of a construction project, which directly impact the TBL scenario of sustainability. Due to the fact that the construction industry is project-focused, project managers that seek sustainability attributes, need to track indicators such as economic volatility, social acceptance, and eco-efficiency. According to Baccarini (2003) and Kiani Mavi and Standing (2018) CSFs constitute a means to perform a project faster, more effectively and closer to its initial planning. In this regard, project managers have the chance to prioritize construction activities, evaluate risks and proceed to critical decisions that will lead to project success (Carvalho and Rabechini, 2017). Literature reveals that there is a growing interest of studies in developing indicators of sustainable PM (Maqbool, 2018). Nevertheless, a relatively small amount of studies targets the usage of such indicators for construction projects (Aigbavboa et al., 2017, Banihashemi et al., 2017). By following this philosophy, this study accounted for the linkages between stakeholders and the evaluation of sustainable PM indicators for construction projects.

According to the Project Management Institute (PMI) Standards Committee, project stakeholders are the "*individuals and organizations who are active in the project, or those whose interests may be affected by project implementation or successful completion of the project*" (PMI, 2004). Yang Rebecca and Shen Geoffrey (2015), distinguished 14 stakeholder categories for construction projects namely, clients, contractors, consultants, suppliers, end-users, governments, financiers/sponsors, communities, district councils, the general public, competitors, utilities, special interest groups, and the media. Williams and Dair (2007), concluded to four major types of stakeholder groups for sustainable constructions, covering (1) regulators, statutory consultees, service providers and councilors; (2) non-statutory consultees, interest groups and individuals; (3) property developers and their professional advisors and developer interests; and (4) end users. Under the same pattern, for the purposes of this research, seven stakeholder groups related to sustainable construction are identified, namely (1) clients; (2) users; (3) manufacturers; (4) contractors; (5) designers/consultants; (6) authorities/government; and (7) research academics.

Based on extensive literature review, the authors chose to distinguish the abovementioned categories due to the fact that these stakeholders often have ample influence on sustainable construction, and thus, could be considered as the most contributing. A review of stakeholder management performance attributes in construction projects that was made by Oppong et al. (2017) and the analysis on the stakeholder influence in decision/evaluations relating to sustainable construction in China that was made by Li et al. (2018a), align with the choice made by the authors of this study.

Stakeholder theory specifies that, in order to attain a sustainable construction, organizations must harmonize all stakeholder benefits (Shen et al., 2011a, Guangdong et al., 2018). Nevertheless, effective stakeholder management can become a problematic task, as it must entail reliable and effective information exchange (Williams and Dair, 2007). Retrieving the most fitting sustainable PM indicators for constructions and analysing stakeholders' views on the matter (information exchange), can become a way of reaching the abovementioned goal.

4.1.5 Research methodology

This research, which is part of a wider research endeavor, employs a quantitative research method. The study is based on Knowledge-Based Theory (KBT) and follows a sequential approach in steps, as shown in Figure 1. Qualitative and quantitative data from previous research findings (light blue) were used as input in this study.

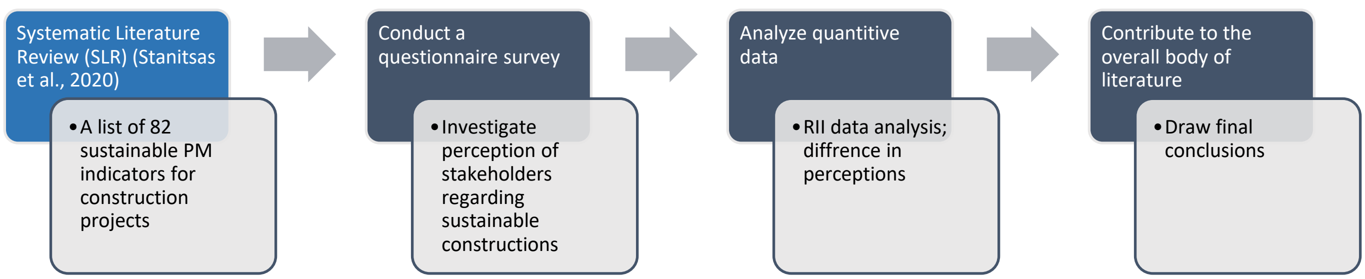


Figure 1: Research design.

This research aims to identify the most fitting sustainable PM indicators for construction projects. A list of 82 indicators was derived, after the Systematic Literature Review (SLR), combined with semi-constructed interviews, that Stanitsas et al. (2021) conducted. Two main reasons were the drivers of this process. First, while such indicators list was built by the same authors through a SLR; the authors also underlined that this list can be applied to various contexts (widely accepted set), or in specific cases adjust accordingly. This is also confirmed by (Fernández-Sánchez and Rodríguez-López, 2010) who also argued that sustainable PM indicators in construction projects should be adjusted depending the concept. Second, the authors chose interviewees (field experts with 10+ years of experience) to furtherly validate the final set of indicators. Therefore, their opinions add an extra value in the practicality of the set.

The research includes an online questionnaire survey to investigate the stakeholders' beliefs (the stakeholder categories were recognized in Section 2) around the importance of the predefined indicators. The specific research method serves the purpose of gathering data from a large sample on a global scale Furthermore, it is less intrusive and cost effective when compared to other methods; it presents practicality and relative simplicity, as all the returned answers can be easily analysed; and it assists in reducing the bias that may be introduced by researchers' verbal and visual clues, respectively (Gunduz, 2016, Jarkas and Younes, 2012). The questionnaire comprised an ordinal measurement scale (Likert scale) ranking the importance level of each indicator in an "ascending" order from 1 to 5. Previous literature indicates that the questionnaire survey method was often adopted in previous research on similar topics (Torabizadeh et al., 2020, Qiu et al., 2020, Mapar et al., 2017, Heravi et al., 2015).

Finally, data collected through the questionnaire were analysed to measure the significance of the 82 indicators. The relative importance index (RII) formula was used for this purpose. RII is a non-parametric technique commonly operated by construction and sustainability management scientists. This technique is quite useful when there are data involving ordinal measurement of attitudes (stakeholders' views, expressed via structured questionnaire responses) (Waris et al., 2014, Kometa et al., 1994).

4.1.6 Instrument and respondents' profile

The questionnaire survey was designed around the 82 indicators as these were identified by Stanitsas et al. (2021) (TBL attributes and categorization) and can be seen in Tables 1, 2, and 3. The questionnaire asked the participants to define the importance of each sustainable PM indicator for construction projects on the basis of a Likert scale (1 to evaluate the indicator presented as slightly important; to 5 to evaluate it as very important). A pilot questionnaire was administered to safeguard the clarity and sensibleness of the designed questions. The questionnaire was designed using Google forms to help organize, distribute, collect responses, and categorize the collected data. The data were collected from relative to the theme experts worldwide. The stakeholders' profiles were identified through LinkedIn, Research Gate, and Facebook. The research was carried out in a period of 8 months. The final number of completed questionnaires was 200 responses out of which 157 were finally used for analysis. The filtering of the 43 unused responses realized based on the fact that some of the responses were found to be incomplete and some others presented lack of knowledge in at least one of the three themes analysed (sustainability, PM, construction projects). The statistics for each stakeholder category can be seen in Figure 3. The total numbers exceed 100% and 157 total responses, as the respondents had the chance select more than one stakeholder group.

Waris et al. (2014), clearly indicate in their study that "*the importance of demographic information cannot be undermined for a meaningful quantitative analysis*". Based on that, the authors paid extra attention to the background and general demographic information of the respondents, as it was conducted in the first section of the questionnaire survey. As the aim of research is focusing on exploring and ranking the relative importance of the principle sustainable PM indicators contributing to construction projects, considering views of all construction project stakeholders; it is of vital meaning that stakeholders should possess satisfactory professional experience. Figure 2 displays the summary of the respondents' demographic information and their relative familiarity to the study themes. Despite the fact that some of the respondents had significant working experience in sustainability, PM and/or constructions, the fact that their answer was negative towards their knowledge on sustainable PM strategies in construction projects, led the authors in excluding them for the final sample that was analysed. Figure 3 reveals the stakeholder category they belong to and their previous continent experience. Additionally, knowledge of sustainable PM strategies and their opinion on the doubtful theme of what sustainability truly aims for, was revealed through a five-scale question where 1 stood for environmental protection and conservation and 5 for the lengthened TBL scenario. The overwhelming majority of the respondents (80.5% in total) replied number 4 and 5.

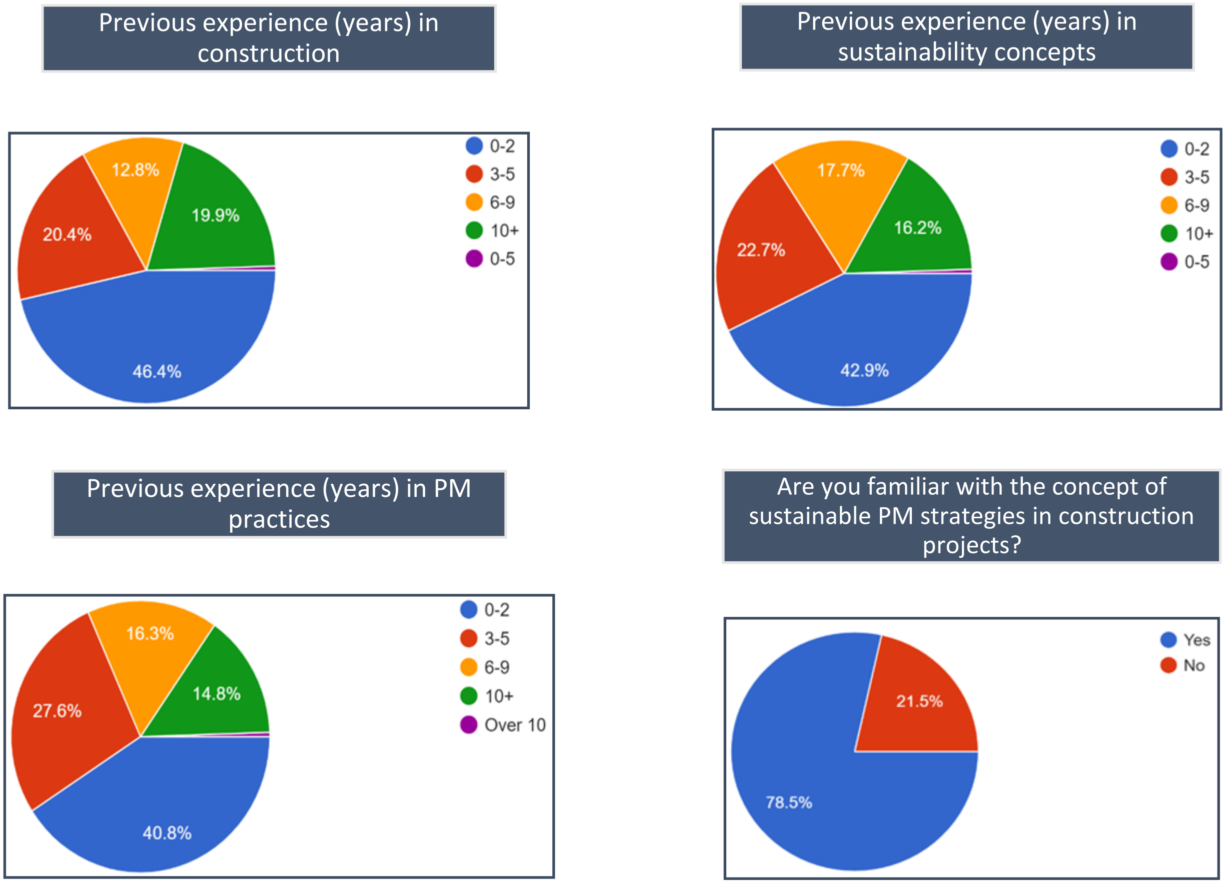
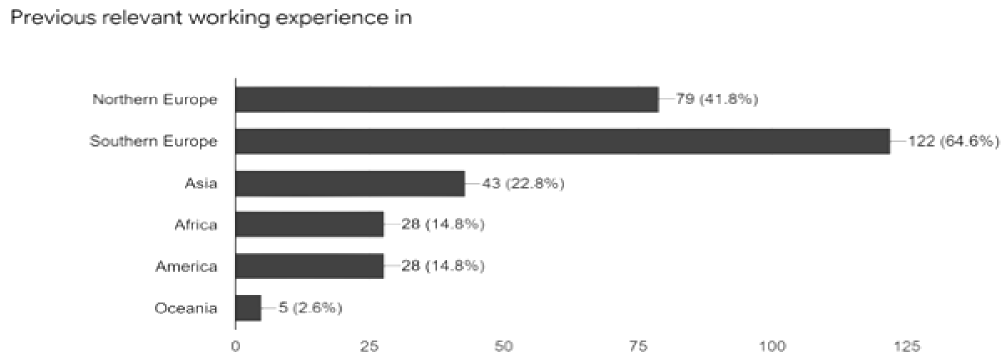


Figure 2: Questionnaire data / previous experience on the themes analysed.



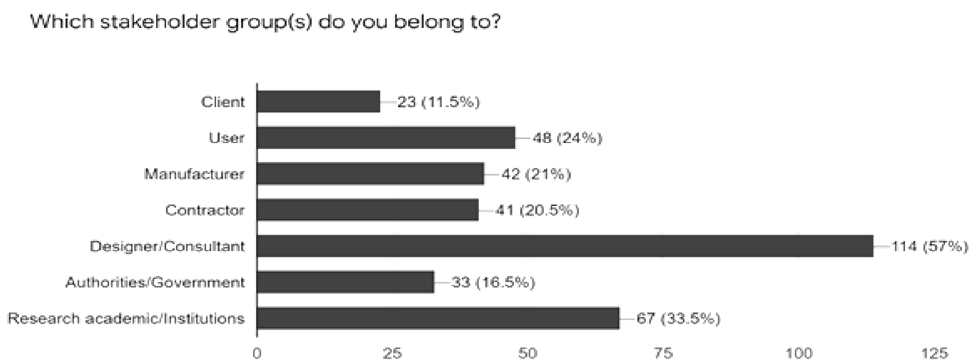


Figure 3: Questionnaire data / continent experience and stakeholder categories.

Further analysis of the responses indicates that the respondents are mainly from the private sector (job position and stakeholder group questions) with significant working experience. The respondents' demographic data reveal that they possess the adequate topic familiarity for providing valuable feedbacks for the outcome of this study.

4.1.7 Data analysis (RII)

Following the data collection/processing from all the experts, the RII method was used for determining the relative importance of the sustainable PM indicators. For the second part of the questionnaire, the five-point Likert scale was implemented to evaluate the importance of each indicator. The feedback from the respondents has been analysed using Microsoft Excel application. Equation 1 displays the formula which was used to find out the relative index (Olomolaiye et al., 1987, Jarkas and Younes, 2012, Waris et al., 2014).

$$\mathrm{RII} = \frac{\sum_{i=1}^{5} w_i n_i}{A*N} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5*N} \qquad (1)$$

- W shows the weighting value of each indicator, given by the respondent
- A is the highest weight
- N is the total number of respondents

- n_i is the total number of responses that were evaluated with the number i (i= 1 to 5 / Likert scale)

The RII value outlines the level of importance for each indicator. High RII values are equivalent to more important indicators for sustainable construction projects, according to the respondents. The ranges of the RII values are 0 to 1, with 0 not inclusive. Akadiri (2011), in line with Chen et al. (2010), designate the resultant RII importance levels as follows:

- High (H): 0.8 < RII < 1.0
- High-Medium (H-M): 0.6 < RII < 0.8
- Medium (M): 0.4 < RII < 0.6
- Medium-Low (M-L): 0.2 < RII < 0.4
- Low (L): 0 < RII < 0.2

Tables 1, 2, 3 reveal the list of the 82 indicators, their derived RII values, their corresponding ranking and their importance level. The economic, environmental, and social/management categorization of the indicators in the following Tables was made by the authors in an effort to engage a better understanding of their underlying characteristics. Literature reveals that aspects of construction projects can be understood in a better way when the TBL scenario is present (Goel et al., 2019c, Shen et al., 2011a).

Table 1: Pool of sustainable PM indicators for construction projects of economic sustainability.

Economic (ECO) sustainability indicators				
Indicator	RII	Ranking by category (ECO)	Overall ranking	Importance level
ECO1: Financial/Economic performance	0.871	2	7	H
ECO2: Economic and Political stability	0.820	13	31	H
ECO3: Stakeholder involvement/ participation	0.847	9	19	H
ECO4: Innovation management/new product development	0.855	6	14	H
ECO5: Target marketing and benefits	0.765	22	63	H-M
ECO6: Effective Project Control	0.856	5	12	H
ECO7: Best practice strategy	0.850	7	16	H
ECO8: Efficient allocation of resources	0.873	1	5	H
ECO9: Customer-relationship management/ Access to a range of customers	0.755	24	67	H-M
ECO10: Scope control through managing changes	0.762	23	64	H-M
ECO11: Business ethics	0.775	18	56	H-M
ECO12: Facility management technologies/ general improvements	0.784	16	51	H-M
ECO13: Cost management plan	0.869	3	8	H
ECO14: Resource planning	0.846	10	20	H
ECO15: Supply chain collaboration	0.774	19	57	H-M
ECO16: Effective strategic planning	0.828	11	26	H
ECO17: Organizational culture	0.772	20	58	H-M
ECO18: Project outputs emphasis	0.780	17	53	H-M
ECO19: Developing efficient “iron triangle” parameters by the Project Management Team (PMT)	0.766	21	61	H-M
ECO20: Ability to pay and affordability	0.848	8	18	H
ECO21: Environmental/economics accounting	0.865	4	10	H

ECO22: Developing an efficient risk management plan by the PMT	0.802	15	41	H
ECO23: Implementing an effective change management strategy	0.802	14	40	H
ECO24: Efficient data processing for decision-making practices	0.821	12	30	H
ECO25: Bureaucratic streamlining	0.752	25	68	H-M
ECO26: Internationalization	0.712	26	78	H-M
ECO27: Targeted incentives	0.667	27	80	H-M

Table 2: Pool of sustainable PM indicators for construction projects of environmental sustainability.

Environmental (ENV) sustainability indicators				
Indicator	RII	Ranking by category (ENV)	Overall ranking	Importance level
ENV1: Energy efficiency	0.880	3	3	H
ENV2: Available - fitting renewable energy resources/fossil fuels	0.855	8	13	H
ENV3: Eco-efficiency	0.885	2	2	H
ENV4: Consistent and predictable load	0.721	18	75	H-M
ENV5: Sustainable use of natural resources	0.901	1	1	H
ENV6: Up to date environmental construction technologies and methods	0.872	5	6	H
ENV7: Environmental responsibility/justice	0.862	7	11	H
ENV8: Construction water quality impact	0.823	12	29	H
ENV9: Environmental impact assessment project report	0.875	4	4	H
ENV10: Environmental management systems/policy implications	0.854	9	15	H
ENV11: Identify and address choke points	0.735	17	73	H-M
ENV12: Climate change adaptation/disaster risk management	0.803	15	39	H
ENV13: Appropriate and flexible environmental design details and specifications	0.840	10	22	H
ENV14: Project biodiversity	0.815	14	34	H
ENV15: Environmental education and training	0.869	6	9	H
ENV16: Sustainable project delivery through project stakeholder management	0.795	16	45	H-M
ENV17: Considering the life cycle of products and services to reduce environmental impacts	0.834	11	24	H
ENV18: Environmental management plan for impacts by the PMT	0.817	13	33	H

Table 3: Pool of sustainable PM indicators for construction projects of social/management sustainability

Social/Management (SOC) sustainability indicators				
Indicator	RII	Ranking by category (SOC)	Overall ranking	Importance level
SOC1: Social responsibility	0.812	9	36	H
SOC2: Social action funding/Concepts of social justice	0.738	31	72	H-M
SOC3: Corporate sustainability and organizational culture	0.796	14	44	H-M
SOC4: Labor practices	0.812	8	35	H

SOC5: Needs assessment of society/people	0.788	17	48	H-M
SOC6: Sustainable employment	0.828	4	25	H
SOC7: Community relationships and involvement	0.776	22	55	H-M
SOC8: Human rights	0.843	2	21	H
SOC9: Employee commitment/commitment in the workplace	0.799	12	42	H-M
SOC10: Public acceptance towards the project	0.823	6	28	H
SOC11: Stakeholder engagement/management	0.809	10	37	H
SOC12: Project independence of political factors	0.734	32	74	H-M
SOC13: Social impact reports	0.761	26	65	H-M
SOC14: Transparent and competitive procurement processes	0.784	19	50	H-M
SOC15: Absence of bureaucracy from the workplace	0.789	16	47	H-M
SOC16: Contractor - supplier relationship	0.786	18	49	H-M
SOC17: Commitment to the stakeholders' needs	0.777	21	54	H-M
SOC18: Well-defined project scope and project limitations	0.848	1	17	H
SOC19: Holistic view of benefits	0.840	3	23	H
SOC20: Product - service systems	0.771	23	59	H-M
SOC21: Emphasis on high quality workmanship	0.790	15	46	H-M
SOC22: Encourage competition	0.651	36	81	H-M
SOC23: Implementing a quality management system	0.807	11	38	H
SOC24: First mover advantage	0.645	37	82	H-M
SOC25: Culture of accountability	0.751	28	69	H-M
SOC26: Comprehensive contract documentation	0.757	27	66	H-M
SOC27: Diversification	0.741	29	70	H-M
SOC28: Competitive tendering/comprehensive pre-tender investigation on project	0.712	34	77	H-M
SOC29: Adaptability in project environment	0.826	5	27	H
SOC30: Intangible asset management	0.714	33	76	H-M
SOC31: Multidisciplinary /competent PMT	0.707	35	79	H-M
SOC32: The role of trust within the PMT	0.765	25	62	H-M
SOC33: Following project management phases/processes	0.781	20	52	H-M
SOC34: Project manager's leadership style	0.799	12	42	H-M
SOC35: Employing of operational decision-making techniques by the PMT	0.741	29	70	H-M
SOC36: Project monitoring and evaluation by the PMT, through previous experiences in projects (access to relevant experience)	0.766	24	60	H-M
SOC37: Managing knowledge and awareness to promote sustainable project delivery (PMT)	0.817	7	32	H

It is evident from the ranking Tables that all indicators were identified as "High" and "High-Medium" importance which showcases their important role for sustainable construction projects. The range for the "High" importance indicators fluctuates between 0.802 and 0.901. These high-ranking indicators occur from all the three dimensions of the TBL. This result indicates that the stakeholders' beliefs of sustainable development practices in construction projects derive through TBL implementations.

This study's stakeholder analysis found that designers/consultants are the most familiar with sustainable PM practices. On the contrary, authorities/government related stakeholders present to be the least familiar with such kind of strategies. Governments around the world should adopt more incentive policies to support these strategies

(Guangdong et al., 2018). Many indicators related to environmental policies showcase an important value for all stakeholder groups. Compared to other stakeholders, contractors and manufacturers pay more attention to economic related indicators, such as ECO1: Financial/Economic performance and ECO13: Cost management plan. This may be related to contractors' profit strategies as a result of rapid urbanization / population increase in large cities and their inability to adapt to environmentally sustainable constructions (Mensah et al., 2018). Users seemed to appreciate the value of social related indicators, though they presented the lowest rankings in the overall ranking. Research academics, in their vast majority perceived the sustainability concept as an environmental related attribute, resulting in considering environmental related indicators as the most important for attaining sustainable constructions. The Clients group intensively differentiated from the other groups by assigning high scores in indicators of all three categories. Indicators such as ECO8: Efficient allocation of resources, ENV3: Eco-efficiency and SOC8: Human rights, were among the preferred.

Four environmental related indicators, namely "ENV5: Sustainable use of natural resources", "ENV3: Eco-efficiency", "ENV1: Energy efficiency" and "ENV9: Environmental impact assessment project report" obtained respectively the four highest priority rankings among all indicators (Table 2). They were deemed as the most important considerations for attaining sustainable constructions. According to Ding (2008), environmental concerns on sustainable constructions can lead to project success. The respondents seem to strongly agree with this statement, appearing to be more concerned towards the environment. The present concern to minimize the detrimental effects of construction projects on the natural environment has certainly influenced experts' PM practices.

In terms of the average RII per TBL dimension, economic related indicators report a RII equal to 0.804, environmental related indicators a RII of 0.835 and social/management related indicators a RII of 0.775. It can be concluded, once again, that most of the respondents proceed to counteractive management actions to ensure that the environment remains as unaffected as possible.

The correlation coefficients among all stakeholder categories were tested via Spearman's Rank Correlation Coefficient. Spearman's Rank correlation coefficient is a technique which can be used to summarise the strength and direction (negative or positive) of a relationship between two variables. Spearman's rank correlation coefficient, also referred to as "Spearman r" (r_s), is a non-parametric measure of statistical dependence (Musarat et al., 2020, Jarkas and Younes, 2012). This was the preferred test as it was used to compare the ranks among different stakeholder groups. Spearman r value varies between +1 and -1, where +1 implies a perfect positive relationship or "agreement" (high correlation), while -1 value indicates a perfect negative relationship or "disagreement" (low correlation) (Borkowf, 2000). Spearman r (rs) is calculated via Equation 2.

$$r_s = 1 - \frac{6\sum d_i^2}{n\,(n^2-1)} \quad (2)$$

- d_i is the difference between ranks assigned to variables
- n is the number of variables.

The excel software was used to calculate the Spearman correlation coefficients between stakeholders' perceptions.

4.1.8 Results and discussion

The perceived stakeholder views of the 82 sustainable PM indicators, contributing to construction projects, were determined. Qualitative information obtained from the questionnaire survey helped in understanding the stakeholders' beliefs and attitudes when in seek of sustainability attributes in the construction sector. The relative importance indices and ranks are presented in Tables 1, 2, and 3.

In accordance with the overall perceived importance of indicators investigated, the results obtained show that the principal considerations for sustainable constructions exist in the following sustainable PM indicators:

1. ENV5: Sustainable use of natural resources
2. ENV3: Eco-efficiency
3. ENV1: Energy efficiency
4. ENV9: Environmental impact assessment project report
5. ECO8: Efficient allocation of resources
6. ENV6: Up to date environmental construction technologies and methods
7. ECO1: Financial/Economic performance
8. ECO13: Cost management plan
9. ENV15: Environmental education and training
10. ECO21: Environmental/economics accounting

Once again, the environmental concerns of the respondents and their attention to this matter is confirmed. Six out of ten indicators refer to environmental attributes and four to economic related ones. As previous literature reveals (Fantini et al., 2013, Vallance et al., 2011), and is furtherly strengthened by the results of this questionnaire survey, much consideration has been given to environmental and economic issues, along with the intersection amongst them. The social aspect of sustainability has been considered as the least described dimension (Zuo et al., 2012). On the trail of this observation, this study contends that considerations should be led towards the practical and operational aspects of social sustainability, in a way of perceiving how this concept is interpreted by project managers and used as validation for taking actions for their projects. Woodcraft (2015), indicates in his study, that there is not a conclusive understanding of the relationship between the three TBL dimensions. The lack of awareness is typically more intense in the social dimension where beneficial social attributes vary around societies (inconsistent multiple concepts) (Sierra et al., 2018b). Murphy (2012), claims that any attempts to create socially sustainable societies should include the perquisite of defining the "type" of society analysed. The questionnaire survey included respondents from all around the world and the indicators analysed were not specific to a certain society/city/country. Thus, it was already expected that social/management related indicators would be the ones that would present the more intense differentiation in terms of importance between the stakeholder groups.

With an overall RII of 0.901, "ENV5: Sustainable use of natural resources", ranks 1st among all indicators explored. This outcome is in agreement with the findings of Rist et al. (2007), and Kolstad and Krautkraemer (1993) whose works identified this aspect among the critical causes of project development. This indicator refers to minimizing resource usage, primary material input and output, waste recovery and disposal operations (Stanitsas et al., 2021). The result is comprehensible as materials are essential to the construction process, and therefore directly dependable to the project (Waris et al., 2014). Consequently, resource shortage leads to disruption of the momentum and progress of activities (negative impact on project performance).

The second highest ranking indicator was "ENV3: Eco-efficiency" with an RII value of 0.885. This indicator refers to "green" business orientation, regarding services and products, construction materials, environmental footprint, and energy consumption in built (Stanitsas et al., 2021). This issue seems to be ascribable to the existing trend in the sustainable construction industry, where, "green" operations constitute the leading priority (Gray and Zarnikau, 2011).

"ENV1: Energy efficiency" with an RII value of 0.880 was considered as the 3rd most important indicator among all stakeholders. It refers to efficient production, use, distribution, and transmission of energy to provide products and services (Stanitsas et al., 2021). Many authors consider energy efficiency as the key to sustainable development (Ayres et al., 2007, Niu et al., 2011). Energy efficiency investments create social welfare in terms environmental advancements, increased employment and reduced energy imports. They also bring financial returns to investors, private and public owners as well as asset operators (Belke et al., 2011, Ayres et al., 2013). Therefore, such an indicator, address contributions to all three TBL dimensions.

A RII value of 0.875 was given to indicator “ENV9: Environmental impact assessment project report”, classifying it in the 4th place. Such reports refer to the process of evaluating the likely environmental impacts of a project (Stanitsas et al., 2021). Chang et al. (2018), describe this indicator as “one of the most important means of environmental management worldwide, and the environmental impact assessment follow-up is one of the crucial measures to ensure the concrete implementation of the assessment”. The stakeholders’ views consent with this statement and recognize its value.

Coinciding with the outcomes of Ihuah et al. (2014) and Songer and Molenaar (1997b) whose studies found that efficient allocation of resources is among the prominent aspects of a project, ECO8 with a RII of 0.873 ranks in the 5th place of the respondents’ views. ECO8 refers to the distribution of inputs such that the resources will be efficiently utilized (Stanitsas et al., 2021).

“ENV6: Up to date environmental construction technologies and methods”, with an overall RII of 0.872, comes 6th in rank among the indicators explored. It refers to resource-efficient and environmentally responsible processes in order to ensure lifetime sustainability of the project. This finding agrees with the outcomes of Banihashemi et al. (2017), where the effect of this indicator was found to be among the most important sustainability attributes.

Supporting the results obtained by Stanitsas et al. (2021) and Martens and Carvalho (2017), whose research has identified “ECO1: Financial/Economic performance” (RII = 0.871), “ECO13: Cost management plan” (RII = 0.869), “ENV15: Environmental education and training” (RII = 0.869), and “ECO21: Environmental/economics accounting” (RII=0.865), as the salient concepts affecting sustainable PM practices, and hence, the performance of construction projects, rank 7th, 8th, 9th , and 10th among the 82 indicators, respectively. ECO1 constitutes an objective measure that concerns the return on investments, the creditworthiness, the viability, and the cash flow of a project. ECO13 concerns the process of planning and controlling the cost associated with the resources of a project and the other costs. ENV15 involves skills like critical thinking, problem-solving, and effective decision-making, are cultivated through education and training, in order for individuals to expand their viewpoint around environmental issues. Finally, ECO21 is all about environmental/economics accounting: Integration of economic and environmental data to reach project success.

Through this analysis, the authors also tried to recognize in some point the significance of each indicator per stakeholder group for the construction sector per continent. For instance, a large number of designers/consultants (57% of the total number of respondents) indicated the noteworthy value of “SOC18: Well-defined project scope and project limitations” (ranked 1st among social/management related indicators and 17th among all indicators with a RII of 0.848). This was mainly the case for those who had relative previous experience in Northern Europe. As Petersen and Heurkens (2018) briefly describe in their study, northern European designers/consultants tend to give emphasis in their social implementations in construction projects. The value of urban renewal practices for social sustainability, is also confirmed by Yıldız et al. (2020) questionnaire survey where designers/consultants were amongst the stakeholder groups analysed. Fatourehchi and Zarghami (2020) furtherly justify the designers’/consultants’ attention towards a socially well-defined project scope/limitation. Due to modern societies’ value orientation, this aspect requires even more attention in terms of residential buildings, since this sector can have a significant social impact on urban areas.

Research academics (33.5% of the total number of respondents) seemed to strongly connect the sustainability concept with environmental attributes and thus giving environmental related indicators the highest scores. This was mainly the case for those who had relative previous experience in Northern and Southern Europe. Newly oriented “green” Europe (policies, guides, practices) seems to strongly affect academics’ researches (Wagner, 2015). “Connecting research and education to problem-solving is particularly important in the field of environmental sustainability as we face crises such as global warming, biodiversity loss, and toxic pollution of ecological systems” (Nowotny et al., 2018).

Users, as the ones who benefit from the use of a sustainable construction (or already utilized one), were the 3rd larger stakeholder group (24%). They perceived sustainable contributions in terms of a human-centered approach. Respondents that showcased previous experience in all continents gave priority in social/management and environmental indicators.

Manufacturers and contractors expressed similar views (21% and 20.5% of the total number of respondents, respectively). Economic related indicators like “ECO8: Efficient allocation of resources” and “ECO1: Financial/Economic performance” were the most popular among their answers. Nevertheless, there was a slight differentiation on the economic indicators chosen, per continent. While stakeholders with European, American and Oceanian experience focused on economic performance related indicators; the ones with Asia and Africa experience, stated preferences in indicators like “ECO6: Effective Project Control”, “ECO20: Ability to pay and affordability”, and “ECO2: Economic and Political stability”. This outcome can somehow be considered as logical, as Asia and Africa disclose larger political and economic risk compared to other continents (Al-Shboul et al., 2020, El-Sayegh et al., 2018).

Authorities/government related stakeholders paid more attention to economic efficiency, marketing and benefits, and waste recovery associated indicators. As stakeholders with previous working experience in Asia were the ones who expressed this tendency, this may be related to Asia’s rapid urbanization (especially China’s and middle East countries) and increased emphasis on environmental protection (Jarkas and Younes, 2012, Waris et al., 2014).

Finally, clients were the smaller stakeholder group, consisting of 11.5% overall. Environmental and economic related indicators were their primary choices. They presented no intense differentiations among continents, with only exception a fair percentage of respondents with southern European related experience that seemed to pay extra attention in “SOC9: Employee commitment/commitment in the workplace”.

The analysis revealed that designers/consultants demonstrated preferences to social related indicators. This is compatible only with the group of Users. Manufacturers, Contractors, Authorities/government, and a part of Clients, expressed their preferences towards the economic issues. The environmental dimension, as the most valuable input for sustainable constructions was present in all groups, with Manufacturers and Contractors seeming to care the least. One possible explanation for this difference comes with the nature of each group’s work. Designers/consultants tend to be eager to create a human centered building which will be attractive to a potential customer. Furthermore, they are working closely with a team of other professionals such as building service engineers, construction managers, quantity surveyors and architectural technologists; continuously exercising their social/management skills. Most users emphasize in the importance of satisfaction and well-being policies while using a sustainable construction (Othman, 2007); thus their preference appears logical. Manufacturers and Contractors are mainly working around constraining factors such as town planning legislation and project budget and thus they are forced to deliver economically viable solutions. Same motive applies for Authorities/government and Clients (although clients expressed environmental concerns too), who are applying for planning permissions and approve/advice from governmental new build and legal departments. Finally, the dominance of environmental indicators amongst stakeholders finds its roots in the general philosophy of what the sustainability concept represents. Environmental sustainability is directly interacting with the planet to maintain natural resources and avoid jeopardizing the ability for future generations to meet their needs. All the respondents recognized this value.

The need for a widely accepted strategy for implementing sustainability strategies in construction projects was clearly recognized amongst respondents in their additional comments. More than half of the respondents recognized the environmental contribution as the most critical for sustainable projects. This view becomes clear through the RIIs that they showcased in the environmental related indicators.

As previously mentioned, the overall correlation among all respondents, was tested by the Spearman's Rank Correlation Coefficient. The initial stakeholder categories are (1) Clients, (2) Users; (3) Manufacturers; (4) Contractors; (5) Designers/Consultants; (6) Authorities/Government; (7) Research academics.

According to the most widely accepted guide for project management, PMI (2004), stakeholders are "an individual, group or organization that may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project, program, or portfolio". By following this definition and furtherly integrating the views of Winch and Bonke (2002) and (Aladpoosh et al., 2012), the authors grouped the initial 7 categories into two major ones:

- Internal Stakeholders: These are the team members of the project or those who provide for the financing of it; it includes (1) Clients, (3) Manufacturers, (4) Contractors, and (5) Designers/Consultants
- External Stakeholders: people affected by the project in some significant way or affected somehow by the actions and outcomes of the business; it includes (2) Users, (6) Authorities/Government, and (7) Research academics

Each one of those could influence the course of the project at some time. The Spearman's test tested differences between these two major categories. The results per TBL category are presented in Tables 4,5 and 6, while Figures 4, 5, and 6 showcase the scatter charts as a way to compare the relationships between the two sets of RII values.

Table 4: Spearman's Rank Correlation Coefficients among Stakeholders for Economic sustainability indicators.

Economic (ECO) sustainability indicators	Stakeholder category			
	Internal		External	
	Avg. RII	Overall rank	Avg. RII	Overall rank
ECO1: Financial/Economic performance	4.373	8	4.363	17
ECO2: Economic and Political stability	4.098	34	4.163	41
ECO3: Stakeholder involvement/ participation	4.274	17	4.309	24
ECO4: Innovation management/new product development	4.217	21	4.462	12
ECO5: Target marketing and benefits	3.843	57	3.818	69
ECO6: Effective Project Control	4.372	9	4.327	22
ECO7: Best practice strategy	4.277	16	4.436	13
ECO8: Efficient allocation of resources	4.362	11	4.472	10
ECO9: Customer-relationship management/ Access to a range of customers	3.735	70	3.690	76
ECO10: Scope control through managing changes	3.882	54	3.818	69
ECO11: Business ethics	3.901	52	3.763	72
ECO12: Facility management technologies/ general improvements	3.970	46	3.890	64
ECO13: Cost management plan	4.392	5	4.145	43
ECO14: Resource planning	4.254	19	4.166	38
ECO15: Supply chain collaboration	3.772	67	3.981	55
ECO16: Effective strategic planning	4.166	27	4.236	29
ECO17: Organizational culture	3.803	60	3.981	55
ECO18: Project outputs emphasis	4.001	41	3.763	72
ECO19: Developing efficient "iron triangle" parameters by the Project Management Team (PMT)	4.911	1	3.865	67
ECO20: Ability to pay and affordability	4.254	19	4.400	16
ECO21: Environmental/economics accounting	4.376	7	4.563	7
ECO22: Developing an efficient risk management plan by the PMT	3.980	45	4.181	36
ECO23: Implementing an effective change management strategy	3.850	56	4.472	10
ECO24: Efficient data processing for decision-making practices	4.168	26	4.181	36
ECO25: Bureaucratic streamlining	3.764	68	3.890	64
ECO26: Internationalization	3.519	77	3.745	75
ECO27: Targeted incentives	3.284	81	3.545	78
Spearmans Rank Correlation Coefficient (rs)				
0.685				

Table 5: Spearman's Rank Correlation Coefficients among Stakeholders for Environmental sustainability indicators.

Environmental (ENV) sustainability indicators	Stakeholder category			
	Internal		External	
	Avg. RII	Overall rank	Avg. RII	Overall rank
ENV1: Energy efficiency	4.490	2	4.418	14
ENV2: Available - fitting renewable energy resources/fossil fuels	4.362	11	4.363	17
ENV3: Eco-efficiency	4.481	3	4.654	4
ENV4: Consistent and predictable load	3.666	72	3.345	81
ENV5: Sustainable use of natural resources	4.480	4	4.745	1
ENV6: Up to date environmental construction technologies and methods	4.323	14	4.709	2
ENV7: Environmental responsibility/justice	4.326	13	4.618	6
ENV8: Construction water quality impact	4.166	27	4.072	50
ENV9: Environmental impact assessment project report	4.372	9	4.703	3
ENV10: Environmental management systems/policy implications	4.294	15	4.500	9
ENV11: Identify and address choke points	3.617	74	4.163	41
ENV12: Climate change adaptation/disaster risk management	3.950	49	4.109	44
ENV13: Appropriate and flexible environmental design details and specifications	4.118	30	4.509	8
ENV14: Project biodiversity	4.107	32	4.209	32
ENV15: Environmental education and training	4.382	6	4.648	5
ENV16: Sustainable project delivery through project stakeholder management	3.931	51	4.226	30
ENV17: Considering the life cycle of products and services to reduce environmental impacts	4.196	23	4.301	25
ENV18: Environmental management plan for impacts by the PMT	4.098	34	4.296	26
Spearmans Rank Correlation Coefficient (rs)				
0.845				

Table 6: Spearman's Rank Correlation Coefficients among Stakeholders for Social/Management sustainability indicators.

Social/Management (SOC) sustainability indicators	Stakeholder category			
	Internal		External	
	Avg. RII	Overall rank	Avg. RII	Overall rank
SOC1: Social responsibility	4.098	34	4.166	38
SOC2: Social action funding/Concepts of social justice	3.686	71	3.960	59
SOC3: Corporate sustainability and organizational culture	4.002	40	4.203	34
SOC4: Labor practices	4.094	37	4.074	47
SOC5: Needs assessment of society/people	3.990	43	4.073	49
SOC6: Sustainable employment	4.188	24	4.203	34
SOC7: Community relationships and involvement	3.843	57	4.166	38
SOC8: Human rights	4.205	22	4.296	26
SOC9: Employee commitment/commitment in the workplace	3.970	46	4.204	33
SOC10: Public acceptance towards the project	4.117	31	4.333	20
SOC11: Stakeholder engagement/management	4.009	39	4.351	19
SOC12: Project independence of political factors	3.774	65	3.471	79
SOC13: Social impact reports	3.803	60	4.018	54
SOC14: Transparent and competitive procurement processes	3.960	48	3.981	55
SOC15: Absence of bureaucracy from the workplace	3.950	49	4.092	46
SOC16: Contractor - supplier relationship	3.774	65	4.222	31
SOC17: Commitment to the stakeholders 'needs	3.803	60	4.037	53
SOC18: Well-defined project scope and project limitations	4.267	18	4.333	20
SOC19: Holistic view of benefits	4.180	25	4.407	15
SOC20: Product - service systems	3.830	59	4.055	52
SOC21: Emphasis on high quality workmanship	4.001	41	3.903	63
SOC22: Encourage competition	3.178	82	3.396	80
SOC23: Implementing a quality management system	4.100	33	4.096	45
SOC24: First mover advantage	3.336	80	3.092	82
SOC25: Culture of accountability	3.762	69	3.777	71
SOC26: Comprehensive contract documentation	3.891	53	3.759	74
SOC27: Diversification	3.603	75	3.925	61
SOC28: Competitive tendering/comprehensive pre-tender investigation on project	3.590	76	3.592	77
SOC29: Adaptability in project environment	4.140	29	4.277	28
SOC30: Intangible asset management	3.495	78	3.870	66
SOC31: Multidisciplinary /competent PMT	3.470	79	3.944	60
SOC32: The role of trust within the PMT	3.782	64	3.962	58
SOC33: Following project management phases/processes	3.881	55	3.830	68
SOC34: Project manager's leadership style	3.990	43	3.925	61
SOC35: Employing of operational decision-making techniques by the PMT	3.623	73	4.074	47
SOC36: Project monitoring and evaluation by the PMT, through previous experiences in projects (access to relevant experience)	3.792	63	4.070	51
SOC37: Managing knowledge and awareness to promote sustainable project delivery (PMT)	4.049	38	4.314	23
Spearmans Rank Correlation Coefficient (rs)				
0.771				

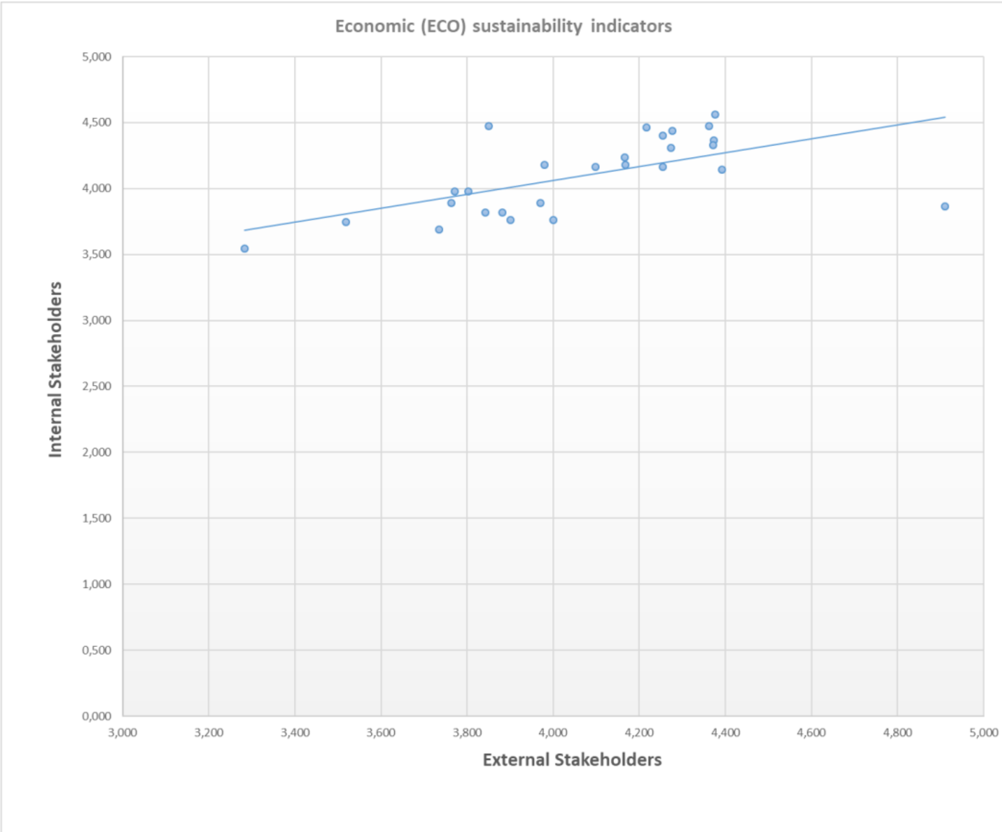


Figure 4: Economic sustainability indicators; RII views between the two major stakeholder groups.

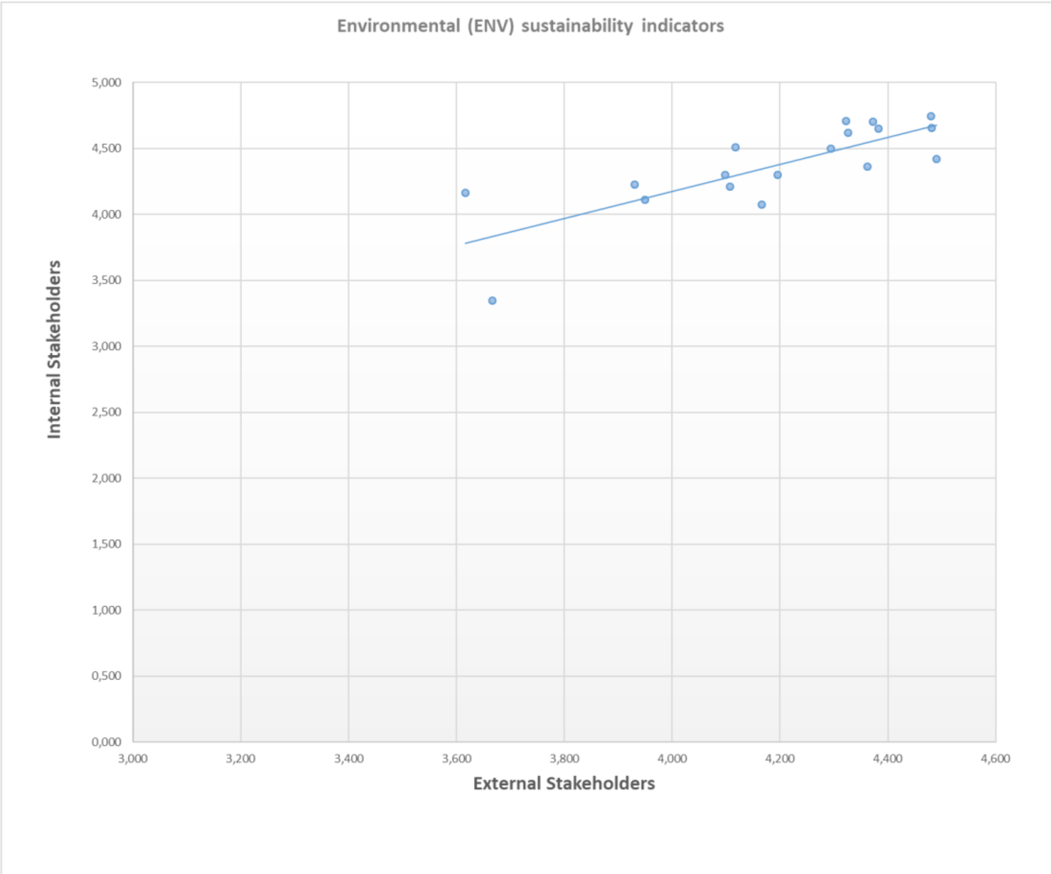


Figure 5: Environmental sustainability indicators; RII views between the two major stakeholder groups.

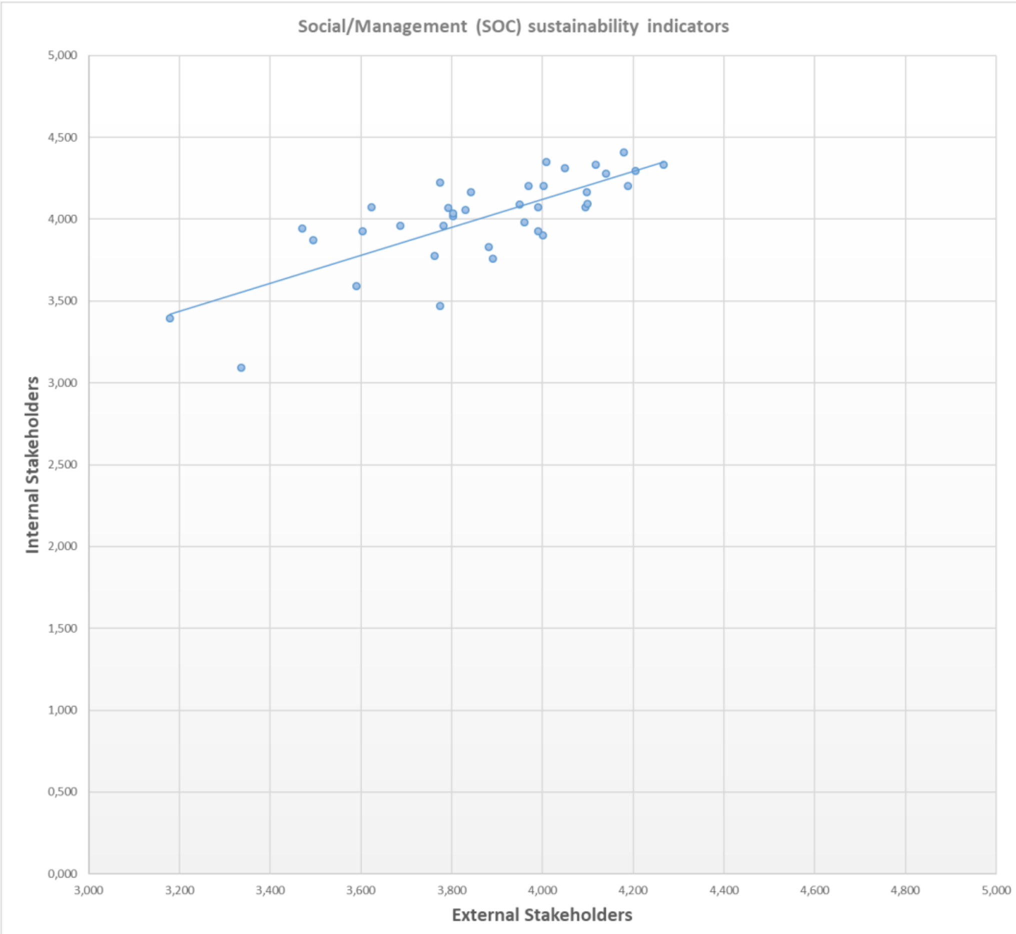


Figure 6: Social/Management sustainability indicators; RII views between the two major stakeholder groups.

The formula returns a coefficient of 0,685 for economic related indicators; 0,845 for environmental related indicators; and 0,771 for social/management indicator s. These results indicate a positive to strong positive correlation between stakeholders and allows us to conclude that there is a high level of agreement between the two groups; signifying the validity, reliability, and consistency of the findings.

The results obtained indicate that, while both, internal and external stakeholders, recognize the contribution to sustainability construction of the environmental related indicators (highest correlation), they seem to lower this value on the other two dimensions. The perception of what sustainable construction projects must have as a priority is, furthermore, evident. As previously mentioned, each of the 7 stakeholder groups which were part of the 2 major ones, pays extra attention to different TBL dimensions, resulting on the abovementioned correlations. The overall respondents' perception was based on the quantified cumulative average RII for each of the 2 major groups.

4.1.9 Conclusion and recommendations

The aim of this research is to explore and rank the relative importance of the principle sustainable PM indicators contributing to construction projects, considering views of all construction project stakeholders. This study illustrated the development of a set of sustainable PM indicators for construction projects. A total of 82 indicators were identified based on an in-depth literature review. Relative index analysis was used to determine the relative ranking of the indicators. These rankings enabled the authors to cross-compare the relative importance of the indicators as perceived by the respondents of the questionnaire survey. Ranking analysis showcased that all indicators were highlighted at “high” or “high-medium” important levels. A total of 42 indicators were highlighted at the “high” important level. Based on the overall indicator ranking, environmental related indicators lead the way. The respondents agreed that these are the most important indicators when it comes to sustainable construction projects.

The results of this research not only contribute to the overall body of literature related to sustainable PM practices in the construction industry, but also fill a gap in knowledge of the principal indicators leading to sustainable projects. This research also broadened the standpoints concerning the sustainable construction concept through a list of sustainability indicators. The results can be used to provide guidance for focusing, acting upon, and controlling the most significant indicators perceived by stakeholders to influence the progress of projects, hence, attaining sustainability in constructions. Additionally, this study revealed stakeholders’ preferences towards sustainable PM related indicators for construction projects. This can help sustainable PM practitioners assign the most fitting roles to stakeholders who possess important links to key indicators, improving their ability to effectively contribute, and further improving the sustainability of construction projects.

Based on the results of the questionnaire survey, the following recommendations for further sustainable development strategies of construction projects can be drawn: (1) Governments should adopt more incentive-based policies to protect the environment; (2) the creation of socially sustainable societies should independently analyse each type of society; (3) the implementation of existing PM strategies leads to the success of sustainability goals. (4) Better insight is needed on the adaptation of credits allocated to environmentally sustainable construction.; (5) The development of communication between stakeholder groups considerably improves the contributions of social ethics.

Limitations of this study come with the fact that some of the respondents may possess inadequate professional experience in properly evaluating all the indicators. Future studies should focus on gathering more wide-ranging data by more respondents. Furthermore, combining two or more multiple-criteria decision-analysis methods (i.e., PROMETHEE, AHP, etc.) for validation and ranking of alternatives will result to a more robust research. Another possible limitation that may spark further research is that while the final number of respondents involved in this study reveals previous relevant experience to all continents, a country-based study could fine tune the results for the specific context.

The findings are helpful for improving the measurement and management of sustainable projects through indicators, in construction projects. They can be used to evaluate the sustainability performance. These indicators incorporate not only the major international sustainability metrics (TBL) but also linkages to stakeholders’ views. Practitioners can look upon these indicators when in seek of sustainable results in construction projects.

4.2 Underlying factors for successful project management to construct sustainable built assets

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4.2.1 Abstract

Purpose – This study aims to investigate the underlying factors that give rise to the set of sustainability indicators which are used for the implementation of sustainable construction projects and eventually the production of sustainable built assets.

Design/methodology/approach – To accomplish the purpose of this research, an online questionnaire survey was administered to a sample of 200 experts. By employing the statistical method of exploratory factor analysis, five distinct dimensions (factors) of stakeholders' attitudes were revealed.

Findings – The findings indicate that the sustainability indicators are based on five underlying factors, namely (1) Sustainable competitiveness; (2) Stakeholder engagement; (3) Sustainable economic growth; (4) Social sustainability; and (5) Resource conservation and environmental policy.

Research limitations/implications – More studies would be welcome to verify the underlying factors revealed in this paper.

Practical implications – The knowledge of the underlying factors enables senior management to maintain a balance of choices during the project management phase in order to implement and deliver sustainable construction projects. Furthermore, the findings deepen the understanding towards sustainable project management practices by providing insights on its core attributes.

Originality/value – As a theoretical contribution to knowledge, this study enhances the body of knowledge by revealing the underlying factors that give rise to the predefined set of the 82 sustainability indicators which are used to enable sustainable construction projects. In practice, the findings aid senior management in adopting strategies that enhance the delivery of sustainable construction projects.

4.2.2 Keywords

Sustainability; Indicators; Project management; Construction; Questionnaire survey; Factor analysis

4.2.3 Introduction

Sustainable development (SD) in the construction sector is arguably one of the most significant features of modern societies (Goel et al., 2019b). As Durdyev et al. (2018) mention in their study, "it is perceived to be a holistic and integrative concept striving to restore harmony and balance between the environment, economy and society". SD has become an integral strategic part of many organizations that pursue sustainable construction (Sánchez, 2015). Literature also indicates the importance for constructions of relating SD with performance and financial reports that contain insights into "(1) management, organization and staffing; (2) client interface; (3) planning and programming; (4) design and engineering; (5) procurement; (6) construction; (7) industrial relations; (8) environmental management; (9) financial and contract administration; (10) completion commissioning and hand-over; and (11) risk and opportunities" (PMI, 2017).

The way to achieve sustainability in construction projects comes through project management (PM) practices (Kivilä et al., 2017). A large number of studies emphasizes the necessity of combining the promising fields of sustainability and PM (Silvius, 2017a, Stanitsas et al., 2019). Project managers can greatly improve their sustainable strategies when considering certain critical success factors (CSFs) / indicators that lead to project success. The focus of this research is on revealing in what way construction projects address the triple bottom line (TBL) provisions (sustainability attributes) that ascend through the analysed indicators.
While the utilization of indicators related to sustainability in construction projects is still a relatively new concept with plenty of gaps, there are studies in the field that reveal the need to move towards this direction (Martens and Carvalho, 2017, Stanitsas and Kirytopoulos, 2021). The findings supported the observation in previous studies on the impediments related with the lack of a widely accepted set of sustainability indicators for construction projects. Construction practitioners' main concern is situated towards time and cost requirements of projects, for which they are prepared to expense sustainable constraints (Martens and Carvalho, 2017). To overcome these concerns, plenty of studies have provided sustainability indicators for construction projects (Banks et al., 2011). However, the underlying factors that dictate the use of these indicators is yet to be explored.

This study contributes to the literature by exploring this gap. The need for studies on the converging theme of sustainability indicators for construction projects, linked with the increasing academic/scientific interest on these themes, drove the development of this study. The aim of this study is to investigate the underlying factors that give rise to the set of sustainability indicators which are used for the implementation of sustainable construction projects and eventually the production of sustainable built assets. The research problem of this paper comes with the need to understand which are the underlying factors that give rise to the set of sustainability indicators which are used to provide sustainable construction projects. To address this, this study examines the beliefs and attitudes of the stakeholders who adopt the sustainability indicators appearing in the literature. The beliefs and attitudes of the stakeholders are expressed through the score they gave to individual indicators. To achieve this the authors administered an online questionnaire survey. The indicators chosen for evaluation appear in the study conducted by Stanitsas et al. (2021). The results deepen the understanding towards sustainable PM practices by providing insights on its core attributes. This study brings practical implications as well, since it enables senior management to maintain a balance of choices in order to deliver sustainable construction projects.

4.2.4 Sustainability indicators for ensuring sustainable construction

The introduction of sustainability in construction projects comes with the need to develop sustainable societies (Karunasena et al., 2016). Literature reveals various research papers towards this direction (Ugwu et al., 2006). Over the last years, the construction sector is evolving towards the TBL attributes (social, economic, environmental) (Zhang et al., 2008). The need for the definition of an indicator set comes with the prerequisite to establish a methodology from the PM point of view (Fernández-Sánchez and Rodríguez-López, 2010). According to (Ugwu and Haupt, 2007), an effective way to accomplish this is through effective stakeholder participation. Shen et al. (2011a) developed a set of indicators to assess the sustainability of construction projects. The researchers categorized the indicators found into environmental, economic, engineering, and social groups. Banks et al. (2011) reviewed current indicators within the context of major infrastructure projects to develop a sustainability enhancement framework. The research method conducted, included intensive interviews with stakeholders of all kinds who participated in the case study project. Shen et al. (2011a) reviewed the sustainability attributes of various types of infrastructure projects in China. Their research method followed the content analysis to reveal relevant indicators to assess the sustainability of infrastructure projects.

The use of sustainability indicators combined with early collaboration among stakeholders can lead to sustainable projects (Thomson and El-Haram, 2019). Literature reveals the need for project managers to better understand how sustainability indicators enhance sustainable construction (Yunus and Yang, 2012). Additionally, stakeholders must be the ones who determine potential project difficulties and set achievable targets under the sustainable viewpoint (Sertyesilisik, 2017). According to Silvius and Schipper (2014b) and Marcelino-Sádaba et al. (2015), the "path" towards SD comes from PM practices and this is the starting point of the sustainability implementation in construction projects.

The indicators analysed in this study, are reliant to the project implementation process. By analyzing the existing literature, it can be concluded that relevant indicator lists are typically large and comprise several indicators under various categories that sometimes reach beyond the TBL constraint. Several indicators have been identified via literature review on sustainable construction projects (Fernández-Sánchez and Rodríguez-López, 2010, Banihashemi et al., 2017). Few studies attempt to explore the underlying relationships of indicators by dividing them under the TBL scenario and by exploring the stakeholders' views (Banks et al., 2011). However, to the authors' best knowledge, no study has yet achieved to dig into the underlying factors that dictate the use of those indicators. The present study is one of the few attempts in academic literature to analyse an extended set of 82 sustainability indicators, for the implementation of sustainable construction projects and eventually the production of sustainable built assets. Clustering the factors for construction projects and determining the path towards sustainability drove the development of the study. This study attempts to bridge this gap. According to Li et al. (2018b), most researchers hypothesize that various indicators are independent of each other and have no inter-relationships. This assumption can lead to deceptive conclusions as sustainability is directly linked with all 3 dimensions (TBL). Most of the indicators analysed in this study, are actually related to some others (Stanitsas et al., 2021). This paper, therefore, attempts to explore the perceptions on 82 indicators and condense this list into fewer explainable groupings.

Literature reveals that meeting modern sustainability requirements presents a challenge to construction, as there are not many official guidelines that constitute a construction project as sustainable. Most studies propose that sustainability derives when the project improves in all three SD dimensions (Aigbavboa et al., 2017). Stanitsas et al. (2021) identified the analysed set of the 82 indicators for construction projects in relevant literature and this study focuses on investigating the underlying factors that give rise to this set by contributing towards the implementation of sustainable construction projects. It should be noted that the creation of a universal set of indicators for any type of construction project is a very ambitious endeavor. Consequently, the set of indicators proposed by Stanitsas et al. (2021) is more of a super-set from which project managers will have to choose amongst the most suitable indicators and shape according to the type of projects at hand, the goals of the construction companies involved and the context of work. The method for selecting among these indicators would be beyond the scope of this paper that is to analyse the underlying factors of the superset.

4.2.5 Methodology

Design, instrument, and approach

The use of sustainability indicators is not a widely experienced practice within the context of construction projects. Therefore, it is considered as an innovative concept that necessitates further research (Delmonico et al., 2018). In order to attain sustainability in projects, identifying factors/indicators is particularly valuable as it brings structural clarity and enables proper management (Banihashemi et al., 2017). In view of the prementioned arguments and by following the aim of this study, the questionnaire survey method was chosen and planned as the theoretical point of departure and the basis for development of the factor analysis. Questionnaires can be considered as an advanced statistical technique for analysing data. They disclose validity, reliability, and statistical significance. (Fox et al., 2000).

The survey is designed around the 82 indicators as identified and reported by Stanitsas et al. (2021). In that research, a pilot questionnaire was administered to safeguard the clarity and sensibleness of the designed questions. The researchers carefully selected a small group of potential respondents/reviewers to assess the precision and the relevance of the survey. The questionnaire consisted of three parts: Part 1: Questions concerning the respondents' demography and their level of experience and background (construction experience, geographical working area and their indicated level of expertise on the topics of sustainability and PM). Part 2: Evaluative questions concerning the level of significance of the predefined sustainability indicators (list of the indicators along with a brief description, where the respondents were called to evaluate the significance of each indicator, based on a Likert-type scale of 1-5 (1 = not at all important and 5 = very important), plus a "cannot tell" option (0 value)). Part 3: Writing space for additional comments or suggestions by the respondents. Based on the results of that questionnaire, in this paper, which is part of the overall research endeavor about the new trends of sustainability in construction projects, we explore the underlying factors that give rise to the set of the 82 sustainability indicators on which the implementation and delivery of sustainable construction projects is based.

While many studies use population-based sampling (random group of participants), the survey study that this paper is based on uses convenience sampling, which involves targeted participants who are selected based on the professional relativity, the ease of recruitment and willingness to participate (Brodaty et al., 2014). The researchers have concluded towards this type of research as a statistically random sample could not have been guaranteed due to the complex synthesis of the population. The sampling technique used has proved in the past to be useful in detecting relationships among the sustainability and PM disciplines (Marnewick et al., 2019).

The targeted respondents were asked to participate in the research questionnaire only if they had previous experience in the examined scientific fields of sustainability, PM and construction, from previous or current projects. The respondents were called to evaluate the level of significance for construction projects amongst all the indicators based on their previous experience. The participants belong to various stakeholder groups, namely client, user, manufacturer, contractor, designer/consultant, authorities/government, research academic/institutions. The stakeholders' profiles were identified through LinkedIn, Research Gate, and Facebook. To evaluate the fittingness of the respondents, the researchers conducted the following systematic process: (1) searching for experts in PM, sustainability and construction in the aforementioned social media; (2) studying the professional and academic experience of the selected profiles; and (3) sending through email or through inbox service a link invitation with the questionnaire survey and a small text that kindly asks their help in the research. This process guided the researchers through the private sending of the individual invitations to experts (step 3). However, the survey was also posted in various groups in LinkedIn such as "Sustainability experts", "Project Management Professionals", etc., where members of the groups were asked to participate. To increase awareness, the questionnaire was promoted via relative Facebook groups as well. Consequently, almost one thousand individual invitations were sent to the selected experts (stakeholders), asking them to fill out the online questionnaire. It was carried out from March to November 2019. The final number of completed questionnaires was 200 responses out of which 157 were finally used. Some of the responses were found to be incomplete. The designed questionnaire was sent as a web link form, using Google forms application to collect data, store and perform the statistical analysis, mainly due to the large sample of respondents and their different geographical location. The researchers chose to design the questionnaire survey in a form that does not take longer than twenty minutes to be completed, having in mind the psychological limit of not spending over two minutes for each answer (Haan et al., 2018).

Validity can be described as the extent to which a test measures what it is intended to measure. (Field, 2009b). Content validity concerns the capability of the researchers towards the measurement items (questionnaire survey), to sufficiently cover the content field to be measured (Wiese et al., 2015b). The content validity of the questionnaire survey was based on the already identified indicators as these occurred by Stanitsas et al. (2021). The methodology used to extract these factors follows a systematic literature review, along with interviews from experts to furtherly validate the research. Thus, it is concluded that all the variables had content validity.

To retain consistency and to avoid confusion, a clarification of the terms: "indicator", "variable" and "factor" is deemed necessary for the context of this study. Consequently, the term "indicator" refers to the original 82 predefined sustainability indicators to describe their broader stance in PM for sustainable construction projects. For the needs of the forthcoming factor analysis (Section 4), the initial "indicators" constitute the "variables" under examination. Thus the 82 observed variables are subjected to analysis. Factor analysis groups these variables in sets which we call "factors". Five distinct factors finally emerged.

Participants' profile

Stakeholder participation can be used as a method to investigate considerations of how different groups perceive and define the analysed themes. Thus, the authors chose to include in the questionnaire survey both academics and industrial practitioners with previous experience in the fields of sustainability, PM and construction. The total number of questionnaires returned derived from 200 respondents, comprising of 7 stakeholder categories. All the stakeholder categories, in addition to their professional background can be seen in Figure 1. Some of them present a significant experience around the examined relevant issues with a considerable number of 63 experts having more than 10 years of experience in at least one of the examined scientific fields (construction, sustainability, PM). The respondents present prior working experience from all the continents.

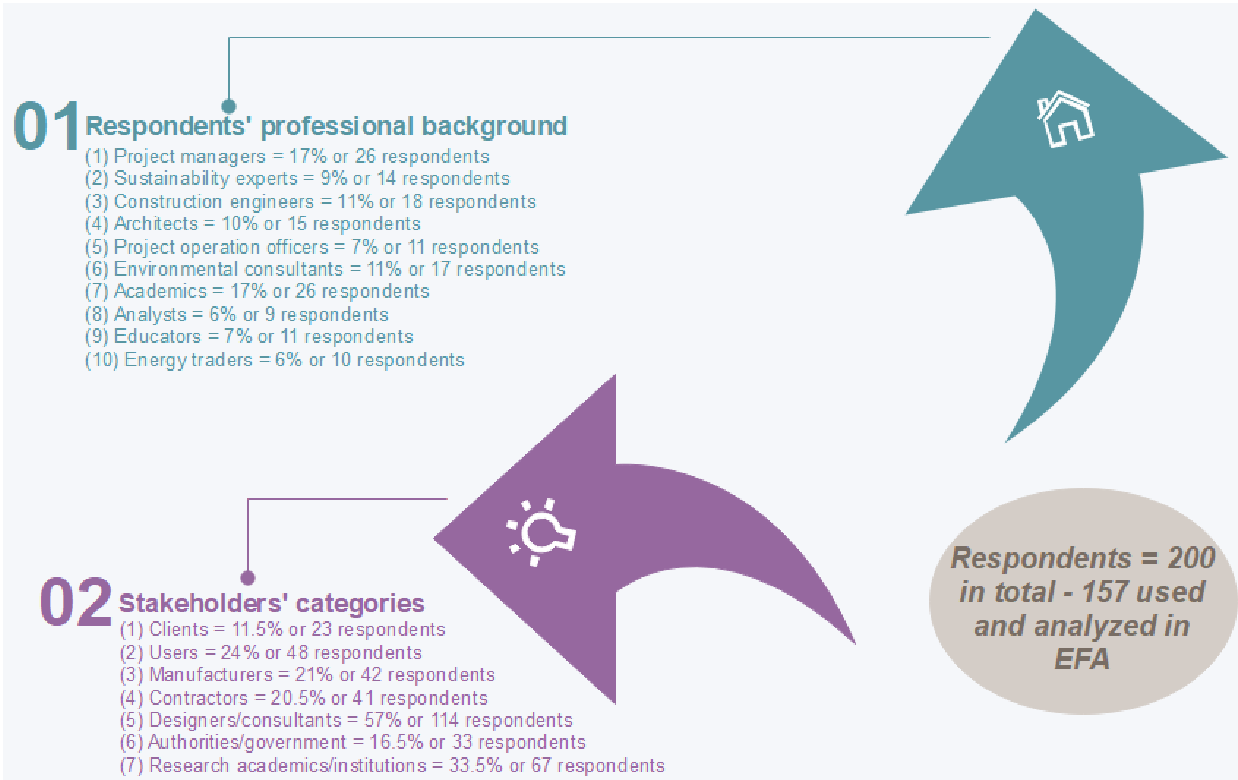

Figure 1: Respondents' professional background.

As previously mentioned, in order to obtain a diverse sample in the questionnaire, the identified stakeholders were from all the continents. Through this strategy the authors were able to reach to a more representative conclusion which was based on the following criteria: (1) knowledge in all three relative themes of the study (sustainability, PM, construction); (2) belonging in one of the abovementioned stakeholder groups.

The number of respondents who showcased their prior working experience per continent was concluded as follows: Northern Europe (79 or 41.08%), Southern Europe (122 or 64.6%), Asia (43 or 22.8%), Africa (28 or 14, 08%), America (28 or 14.08%) and Oceania (5 or 2.6%). Each respondent had the opportunity to choose more than one continent, depending on his/her prior working experience. Even though the authors tried to obtain a substantial representation in the sample of all the continents, this could not be accomplished for the Oceania region. Besides, the information retrieved concerning the background of the stakeholders, results concerning the average working experience in years (in PM, sustainability, construction or a combination of them) and the total ratio, were revealed. Furthermore, knowledge of PM factors leading to sustainability and their opinion on the doubtful theme of what sustainability truly aims for, was revealed through a five-scale question where 1 stood for environmental protection and conservation and 5 for the lengthened TBL scenario. This general information of the respondents is displayed in Figure 2.

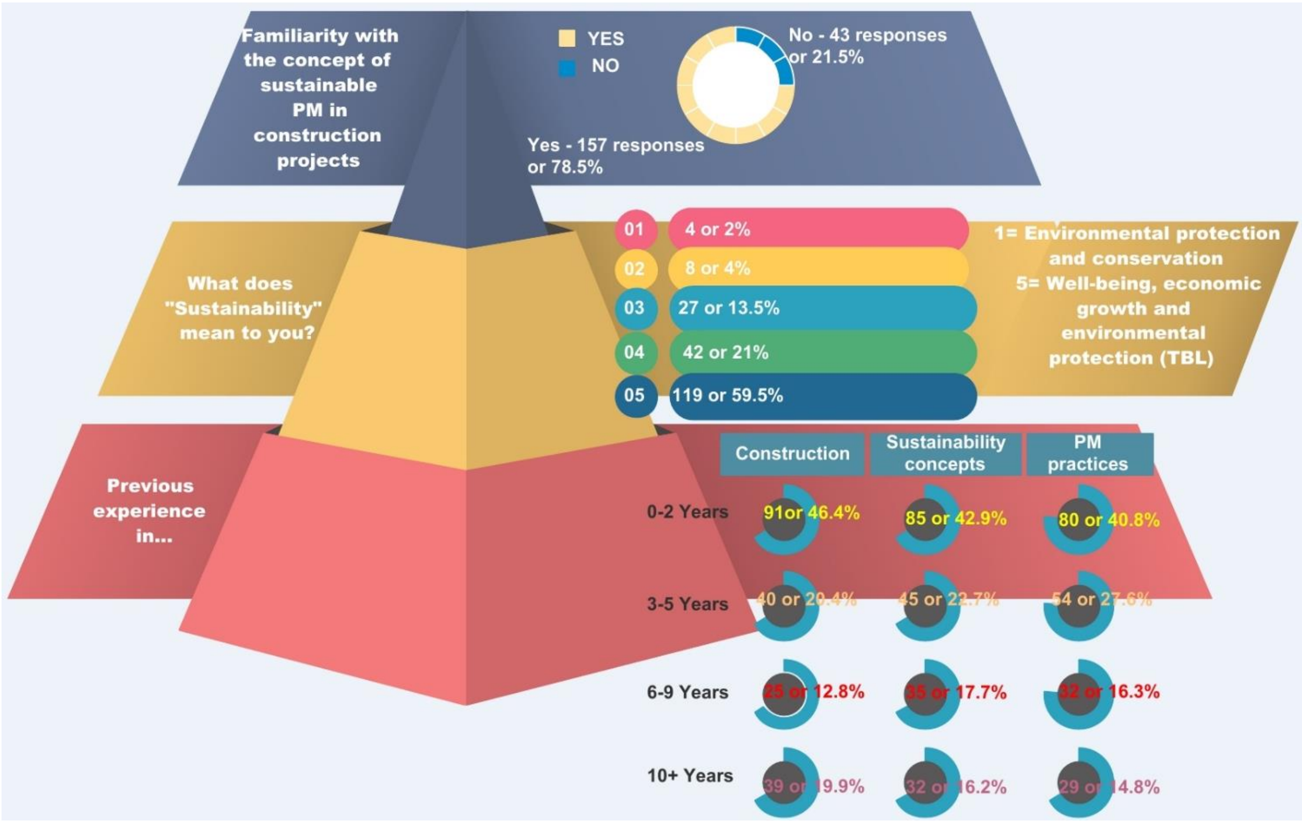

Figure 2: General information as extracted from the questionnaire survey.

The first question of the pyramid in Figure 2 (Familiarity with the concept of sustainable PM - i.e. use of sustainability concepts and sustainability indicators - in construction projects) was critical for the inclusion of the responses into the factor analysis process. Despite the fact that some of the respondents had significant working experience in sustainability, PM and/or constructions, the fact that their answer was negative towards their knowledge on sustainable PM concepts in construction projects, led the authors in excluding them for the final sample that was analysed. Thus, the initial 200 usable responses were decreased into 157 (43 responses were excluded from factor analysis).

Missing data

Missing data reduce the representativeness of the sample and can therefore cause distortions (Lavrakas, 2008). Missing values have been excluded from this analysis.

In this study, the authors hypothesized that the missing values mechanism is MCAR (values missing completely at random - missingness occurs only by chance). Accordingly, investigation on the effects of missingness on the questionnaire structure was completed through the analysis of two fundamental features that impact the structure: (1) the percentage of missingness; and (2) missing imputation methods. According to Bennett (2001), single imputation method (replacing missing values) constitutes a way to handle missing values when these are less than 5% of the total sample (which was the result in our case), and the study hypothesizes that the missing values are MCAR or MAR (values missing at random - missingness depends on characteristics of the observed data as well). Dong and Peng (2013) explain that the total impact by using this method under these circumstances is inconsequential. Thus, the authors chose to implement this method through the relative SPSS option. Responses that exceeded the 5% limit of missing values were fully deleted (listwise deletion method).

The “cannot tell” responses that the questionnaire survey included (although they are not considered as missing values) were not included in any way in the Exploratory Factor Analysis (EFA) process due to the fact that they are a result of “absence of knowledge” on the given theme rather than contributing (if considered as missing values) (Krosnick et al., 2002).

4.2.6 Data analysis–factor analysis

The need for factor analysis

The data analysis of all the information extracted from the questionnaire survey was performed with the help of the software program Statistical Package for Social Sciences (SPSS). The authors chose to use the statistical method of Factor Analysis (FA). In this research analysis, the authors use principal component analysis as a useful technique for analysing the large dataset by increasing its interpretability while minimizing information loss.

The EFA is employed to reveal the fundamental concepts of a large set of variables in order for researchers to understand the factor structure of the data (Umar Abdullahi et al., 2019). The application of EFA for sustainability indicators seems promising since most of the variables involved are not quantifiable. This proves to be particularly useful in this study, since a qualitative approach seems to be a fitting technique for collecting data or measures, while quantitative analysis enables better reporting (Oller, 2014). Variables such as best practice strategy, project biodiversity and social impact reports (one from each TBL category out of the 82 in total) need to be measured through observed variables (Chang et al., 2016). Additionally, EFA helps in reducing the large number of variables into a limited set of factors based on correlations between variables (Maskey et al., 2018). Thus, the authors chose to follow the EFA technique for the purposes of this study.

Preliminary analysis and factor extraction

Following Delmonico et al. (2018) research path for conducting the EFA technique through the IBM SPSS software, two tests were performed to identify whether EFA is suitable: (1) the Kaiser–Meyer–Olkin (KMO) test for determining sample sufficiency and (2) the Bartlett’s sphericity test to examine the variables’ relationship, adequacy and sphericity. The KMO value was 0.774 and the Bartlett’s sphericity test was significant ($p<0.001$), which reveals that the sample size is adequate; so, the EFA technique can be employed (Haan et al., 2018). This is further supported by the fact that the anti-image correlations for all pairs of variables in the anti-image matrix were above 0.520 which is higher than the satisfactory limit of 0.5 (Field, 2009b).

Results from the questionnaire survey pointed out that the majority of the variables (65 indicators) were very important, 12 indicators were specified as fairly important, and 5 indicators as important, which indicates the valuable contribution of the sustainability indicators for sustainable construction projects. According to Field (2009b), a sample size of even less than 100 responses appears to be sufficient for extracting useful results if, as in Jung (2013) all variables have communalities above 0.6 or overall communality above 0.7. In this study (157 responses), communalities of all variables appear to be between 0.663 and 0.827.

Table I: KMO and the Bartlett's sphericity test.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,774
Bartlett's Test of Sphericity	Approx. Chi-Square	7700,367
	df	3321
	Sig.	,000

The total number of factors (5) was determined through the analysis of the Scree plot as suggested by Yalegama et al. (2016) and Pallant (2007). As Field (2009b) indicates in his research, the Kaiser's criterion proves to be precise when the sample size exceeds 250 or when the set has less than 30 variables with communalities less than or equal to 0.6. Due to the lower number of the sample size in this research the scree plot was used. The Scree plot in Figure 3 supports the existence of five main factors as indicated by a clear break after the fifth component. Therefore, five factors were carefully chosen for further analysis.

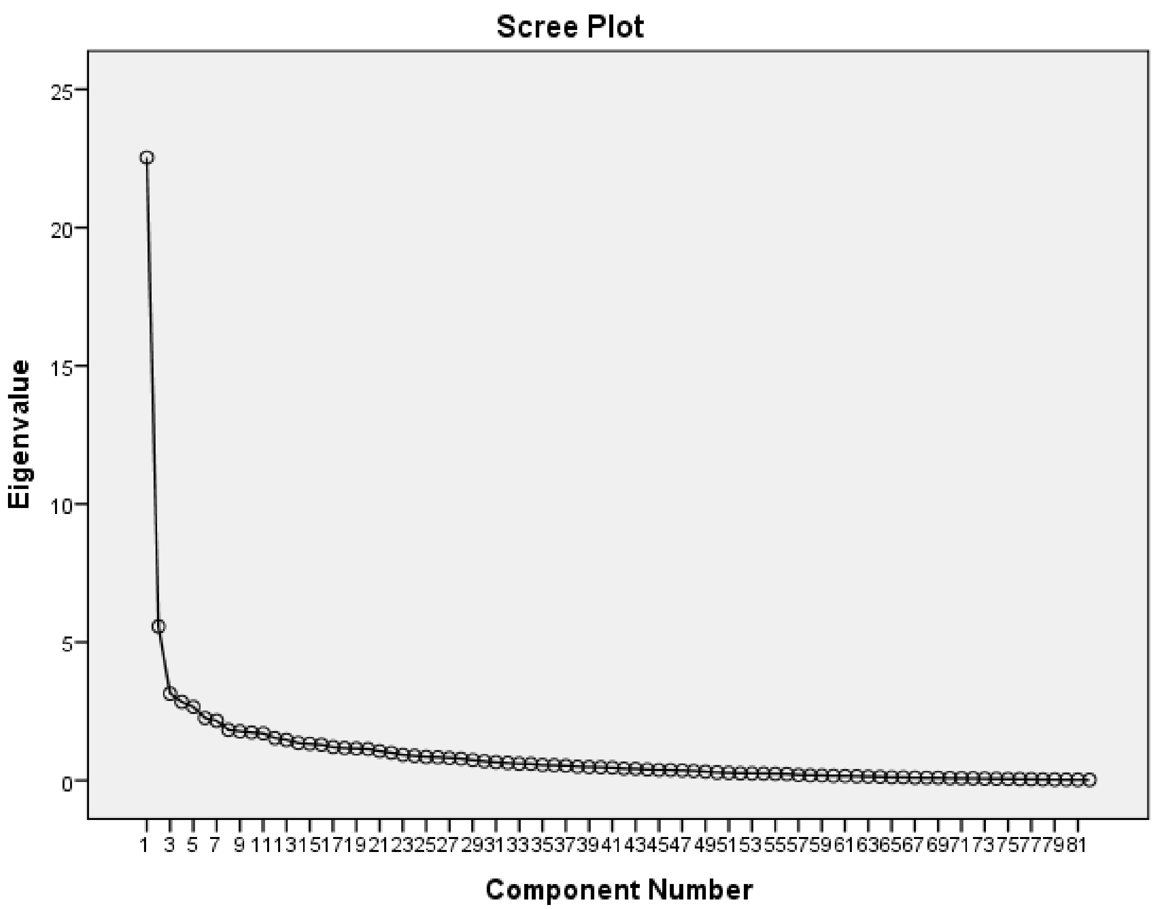

Figure 3: The Scree plot.

Through the EFA, five distinct dimensions (factors) underlying the initial set of 82 variables were revealed. These five dimensions were: (1) Sustainable competitiveness; (2) Stakeholder engagement; (3) Sustainable economic growth; (4) Social sustainability; and (5) Resource conservation and environmental policy (Table 2).

As a theoretical contribution, this study provides a summary of predefined variables according to the extant literature and presents initial insights into the use of sustainability indicators for sustainable construction projects. Additionally, it examines stakeholders' beliefs and attitudes who adopt sustainability approaches in the construction sector through survey-based research. As a result, the five aforementioned distinct dimensions (factors) stood out, explaining such perspectives. The naming of the five factors was formulated by the authors in an attempt to reflect the strategic perspective of the TBL, while encapsulating the underlying concepts (content) of the 82 predefined indicators (variables included in each factor). (1) Sustainable competitiveness describes the establishment of policies, regulations, management tools, and visions that allows an organisation to sustain inclusive wealth. (2) Stakeholder engagement as a process, allows organisations to interact with their stakeholders. Effective engagement helps translate stakeholder needs into organisational goals. (3) Sustainable economic growth is an approach to economic planning that attempts to adopt sustainable progress. (4) Social sustainability is a process for identifying society's needs to promote wellbeing. (5) Resource conservation and environmental policy is related to rational use and skillful management and preservation of the natural environment with all its resources. The stakeholders' beliefs and attitudes revealed all the indicators related to the underlying concept of each factor as described above.

Table II: Summary of the EFA.

Factor dimension	Highest factor loading	Number of items
1. Sustainable competitiveness	0.676	36
2. Stakeholder engagement	0.698	7
3. Sustainable economic growth	0.602	9
4. Social sustainability	0.603	16
5. Resource conservation and environmental policy	0.608	14

Factor loadings are the correlations of the factors (factor dimension) with the variables (Costello and Osborne, 2005). In this study, the minimum factor loading is 0.401; within the 157 responses in total.

Factor rotation

According to Field (2009b), the findings of the correlations amid the variables must occur through the use of the orthogonal (Varimax) rotation and oblique rotations that permit the analysed variables to freely correlate and decide on the location of factor space. Thus, after conducting the oblique rotation, the authors noticed a trivial correlation among the extracted factors and thus the second step of orthogonal (Varimax) rotation was performed. The orthogonal (Varimax) rotation (factor analysis) transformed the initial variables into new ones (Table 3) that are easier to interpret. At the end of the rotation, all variables were categorized into five new factors. The internal consistency analysis was conducted with the help of Cronbach's coefficient alpha. Table 4 shows the α values for the final five factor dimensions. These α values were at an acceptable level, making all factors reliable.

Table III: Factors in sustainable PM for sustainable construction projects – Internal consistency.

Factor	Factor interpretation	Indicator (variable) included in the factor	Factor loading	Variance explained percentage	Cumulative percentage
F1	Sustainable competitiveness	SOC24: First mover advantage	0.464	27.478	27.478
		SOC30: Intangible asset management	0.629		
		SOC25: Culture of accountability	0.556		
		SOC31: Multidisciplinary /competent PMT	0.561		
		SOC27: Diversification	0.486		
		SOC26: Comprehensive contract documentation	0.618		
		SOC22: Encourage competition	0.455		
		SOC28: Competitive tendering/comprehensive pre-tender investigation on project	0.676		
		SOC20: Product - service systems	0.646		
		ECO18: Project outputs emphasis	0.555		
		ECO23: Implementing an effective change management strategy	0.657		
		SOC35: Employing of operational decision-making techniques by the PMT	0.663		
		SOC34: Project manager's leadership style	0.552		
		SOC36: Project monitoring and evaluation by the PMT, through previous experiences in projects	0.617		
		SOC37: Managing knowledge and awareness to promote sustainable project delivery (PMT)	0.543		
		SOC32: The role of trust within the PMT	0.630		
		SOC18: Well-defined project scope and project limitations	0.629		
		ECO16: Effective strategic planning	0.42		
		ECO24: Efficient data processing for decision-making practices	0.574		
		ECO7: Best practice strategy	0.521		
		ECO4: Innovation management/new product development	0.448		
		ECO17: Organizational culture	0.474		
		ECO12: Facility management technologies/ general improvements	0.515		
		ECO25: Bureaucratic streamlining	0.461		
		SOC15: Absence of bureaucracy from the workplace	0.502		
		ECO26: Internationalization	0.542		
		ECO27: Targeted incentives	0.419		
		ECO22: Developing an efficient risk management plan by the PMT	0.471		

		ECO19: Developing efficient "iron triangle" parameters by the Project Management Team (PMT)	0.424		
		SOC19: Holistic view of benefits	0.554		
		ECO2: Economic and Political stability	0.429		
		ENV4: Consistent and predictable load	0.433		
		ECO9: Customer-relationship management/ Access to a range of customers	0.439		
		ENV11: Identify and address choke points	0.417		
		SOC12: Project independence of political factors	0.401		
		SOC29: Adaptability in project environment	0.560		
F2	Stakeholder engagement	SOC11: Stakeholder engagement/management	0.633	6.794	34.272
		SOC17: Commitment to the stakeholders 'needs	0.575		
		ENV16: Sustainable project delivery through project stakeholder management	0.659		
		ENV18: Environmental management plan for impacts by the PMT	0.644		
		SOC3: Corporate sustainability and organizational culture	0.698		
		ECO3: Stakeholder involvement/ participation	0.402		
		SOC16: Contractor - supplier relationship	0.640		
F3	Sustainable economic growth	ECO13: Cost management plan	0.403	3.835	38.107
		ECO14: Resource planning	0.478		
		ECO20: Ability to pay and affordability	0.499		
		ECO21: Environmental/economics accounting	0.523		
		ECO1: Financial/Economic performance	0.419		
		ECO5: Target marketing and benefits	0.475		
		ECO6: Effective Project Control	0.521		
		ECO8: Efficient allocation of resources	0.490		
		ECO15: Supply chain collaboration	0.602		
F4	Social sustainability	SOC1: Social responsibility	0.511	3.468	41.575
		SOC8: Human rights	0.422		
		SOC6: Sustainable employment	0.424		
		SOC4: Labor practices	0.578		
		SOC5: Needs assessment of society/people	0.545		
		SOC9: Employee commitment/commitment in the workplace	0.518		
		SOC7: Community relationships and involvement	0.572		
		SOC10: Public acceptance towards the project	0.507		
		SOC21: Emphasis on high quality workmanship	0.510		

		SOC33: Following project management phases/processes	0.526		
		SOC23: Implementing a quality management system	0.537		
		ECO10: Scope control through managing changes	0.564		
		ECO11: Business ethics	0.422		
		SOC2: Social action funding/Concepts of social justice	0.603		
		SOC13: Social impact reports	0.478		
		SOC14: Transparent and competitive procurement processes	0.402		
F5	Resource conservation and environmental policy	ENV3: Eco-efficiency	0.528	3.247	44.822
		ENV1: Energy efficiency	0.501		
		ENV2: Available - fitting renewable energy resources/fossil fuels	0.528		
		ENV5: Sustainable use of natural resources	0.525		
		ENV15: Environmental education and training	0.569		
		ENV6: Up to date environmental construction technologies and methods	0.551		
		ENV17: Considering the life cycle of products and services to reduce environmental impacts	0.603		
		ENV10: Environmental management systems/policy implications	0.608		
		ENV7: Environmental responsibility/justice	0.516		
		ENV14: Project biodiversity	0.55		
		ENV13: Appropriate and flexible environmental design details and specifications	0.502		
		ENV8: Construction water quality impact	0.502		
		ENV9: Environmental impact assessment project report	0.580		
		ENV12: Climate change adaptation/disaster risk management	0.438		

Construct validity explains the efficiency of the measurements of the initial objectives of the survey. It indicates whether the underlying concept of a variable harmonises to the theoretical background of the concept analysed (Bolarinwa, 2015). Table 4 showcases the percentage of variance explained, the reliability value (Cronbach's alpha) and the KMO test for all the factors, following Karekla and Michaelides (2017) and Almeida et al. (2016) research "path" for the unifactorial structure of factors (verifying construct validity). The minimum accepted value to verify the construct validity of each factor is 0.5 while factors above 0.7, as in this study (see Table 4), are considered pretty satisfactory (Ghosh and Jintanapakanont, 2004). The KMO test revealed the fittingness of the factors within the range (Field, 2009b). According to Williams (2010), explained variances that capture around 50% shouldn't automatically be considered "low" (45% in this paper), especially if the latent variables used are difficult to identify.

Table IV: Factors in sustainable PM for sustainable construction projects.

Factor	Factor interpretation	Cronbach's alpha	Cumulative Variance explained (%)	KMO
F1	Sustainable competitiveness	0.930	27.478	0.884
F2	Stakeholder engagement	0.823	34.272	0.832
F3	Sustainable economic growth	0.753	38.107	0.768
F4	Social sustainability	0.870	41.575	0.876
F5	Resource conservation and environmental policy	0.910	44.822	0.913

4.2.7 A conceptual model of factors, indicators, and the selection process for delivering sustainable built assets

With the intention of aiding practitioners to understand the core concepts (described here as factors) that give rise to the indicators and the selection process that needs to take place to facilitate sustainable construction management, a conceptual model has been developed (Figure 4). The model's contribution in the use of underlying factors for successful PM to construct sustainable built assets, is twofold: (a) The study confirms the stakeholders' valuable input (beliefs and attitudes as extracted from the questionnaire) as an insight for revealing the five underlying factors which derived from a set of sustainability indicators. The importance of the findings lies in the perspective of adopting sustainability strategies. This observation is also important for understanding stakeholder collaboration in the context of construction. (b) It advances the related body of knowledge as an extension to the study conducted by Stanitsas et al. (2021) in which it was argued that promising results of this unexplored area can be derived through the utilization of indicators that involve stakeholder characteristics and lifecycle management. The model also provides a context for the selection and formulation of a final set of indicators. It strengthens awareness and consideration of the interrelated TBL impacts and stakeholders' valuable insights to meet the aim of the research.

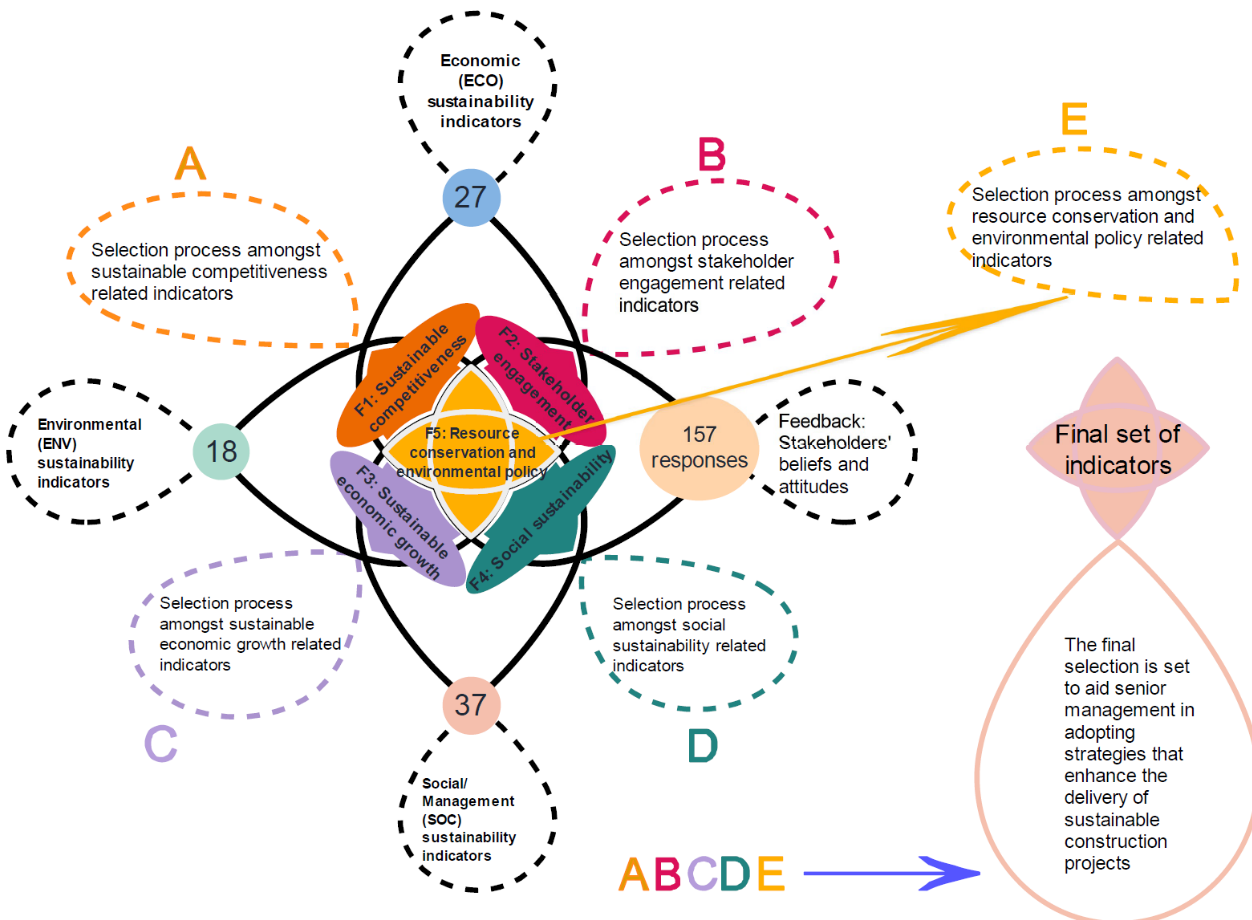

Figure 4: Conceptual model of the study - sustainability indicators based on five underlying factors.

As further guidance to practitioners, a selection protocol can be described for choosing indicators including some of the main criteria that need to be taken into account:

- Step 1: Scope definition: This step is focused on defining the scope for indicator selection, which requires identification, prioritization, and elaboration on TBL initiatives that will deliver the desired result.
- Step 2: Reviewing and selecting relevant indicators: This step necessitates employing the knowledge and expertise about the policy of the organization (e.g., its sustainability priorities, specifics of the sector, facility, process, product).
- Step 3: Composing the final indicator set: Once the indicators are selected, the final indicator set can be composed by prioritizing them for the selected scope.

4.2.8 Discussion and concluding remarks

According to existing research, there is little guidance on what a sustainable construction project might comprise (Athapaththu Kushani and Karunasena, 2018). Most researchers nowadays consider that a project is sustainable when the TBL scenario is employed (Fernández-Sánchez and Rodríguez-López, 2010). However, Bond and Morrison-

Saunders (2011) indicate in their study the complexity of the sustainability concept which cannot be defined just by contemplating the TBL restrictions (singularly or categorically). A way for project managers to guide themselves through this process is via the use of sustainability indicators. The logic is that sustainable processes lead to sustainable projects (Fernández-Sánchez and Rodríguez-López, 2010).

This study aims to investigate the underlying factors that give rise to the set of sustainability indicators which are used for the implementation of sustainable construction projects and eventually the production of sustainable built assets. The authors designed and introduced a succinct, easily understandable questionnaire survey including 82 predefined sustainability indicators for sustainable construction projects. Through the use of EFA, five distinct dimensions (factors) of stakeholders' attitudes were revealed: (1) Sustainable competitiveness; (2) Stakeholder engagement; (3) Sustainable economic growth; (4) Social sustainability; and (5) Resource conservation and environmental policy. The results revealed that the five abovementioned sustainability domains encapsulated all indicators.

In particular, the questionnaire survey and the EFA, which investigate the 82 indicators, contribute in enforcing a solid basis for factor separation. As a unique contribution to knowledge and practice, this study enhances the body of knowledge by revealing the underlying factors that give rise to the set of the 82 sustainability indicators which are used to enable sustainable construction projects. In practice, the findings aid senior management in adopting strategies that enhance the delivery of sustainable construction projects. The "value" for practice of this study is further strengthened as the results are able to provide guidelines for policy makers and organizations. The set of the analysed factors aids understanding in relation to the link between the vital sustainability attributes that require additional efforts and the efficient distribution of resources to provide that effort in order to ensure the delivery of sustainable construction projects and in turn sustainable built assets. Additionally, the results reveal novel insights into the use of sustainable PM related factors and uncover the sustainable attributes that need to be considered for sustainable built assets. As the 82 indicators were concluded from a general literature review on construction projects and since the respondents were experienced in different types of construction projects, it is the authors' belief that the findings can be perceived as a guide that can support the decision-making process of senior management in adopting strategies that enhance the delivery of sustainable construction projects.

Potential impacts that derive in case of unfamiliarity with the results of this study, are related to non-sustainable projects, project delays due to undefined sustainable development goals, and ignorance on stakeholders' perspectives who adopt sustainability approaches.

The authors' intention is to open the discussion towards the creation of a widely accepted set of sustainability indicators that lead to sustainable construction projects via the examination of the stakeholders' beliefs and attitudes who adopt sustainability approaches in the construction sector. The academic contribution of this study centrals in approaching the needed PM context for sustainable construction projects by defining the underlying factors, as they occurred by the stakeholders' perspective, which concluded in the five abovementioned categories. Furthermore, the findings deepen the understanding towards sustainable PM practices by providing insights on its core attributes.

Analysis of participants' TBL behaviour in categorizing the indicators further supported the five distinct factors' worth. Therefore, these findings are helpful for improving the understanding of sustainable construction projects through a set of sustainability indicators. Project managers can look upon these factors and furtherly lead into sustainable results in construction projects.

Limitations of this research come with the fact that the EFA results are based on post hoc analysis and subject to possible errors. Thus, more studies to cross-check the precision and the applicability of the extracted indicators for sustainable construction projects are needed. The cumulative variance explained in this study captures around 45%.

It is widely accepted by literature that relatively low variance implies that multiple variables failed to show salient associations with the underlying factors, and this can also be a limitation of this study.

Finally, future research may focus on the exploitation of these factors by senior management in delivering sustainable construction projects. The results will reveal fitting and utility issues imminent to sustainability, and thus possible factor redeveloping. Correspondingly, fine-tuning of the underlying factors for different types of construction projects would move this research forward. Another line of inquiry for future research could be the analysis of the applicability of these factors before and during the implementation of a project. Further research should be conducted on the identified factors for different types of projects in order to validate their usage as generic or construction-specific. Moreover, additional qualitative research is needed to evaluate the importance of the underlying factors and their management to produce sustainable assets. Researching among non-construction professionals to see if they share the same opinions about sustainability in PM as the construction professionals can also be proved contributing. Finally, while the conceptual model developed here provides a brief description of a selection process amongst the indicators, in-depth analysis of such a method is also another possible inquiry for future research.

4.3 Evaluating Organizational Sustainability: A Multi-Criteria Based-Approach to Sustainable Project Management Indicators

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4.3.1 Abstract

Even though recent studies designate that sustainability should be integrated into project management, this integration remains a complex issue. Hence, there is a need to develop a new approach that would allow assessing the organizational sustainability and reveal under what extent sustainable project management practices are effective. The aim of this research is to propose a Multi Criteria Decision Analysis based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable project management related indicators. By utilising the proposed approach to compare internal organizational structures, the researchers aim to reveal the sustainability integration level within the different business units, in order to allow organizations to make decisions towards sustainable practices. The indicators used in the proposed model are related to key aspects of organizations and they measure how the departments' staff utilize sustainable project management processes in their construction projects. The case study has been conducted in a market-leading design, engineering and project management consultancy organization. Evaluating organizational sustainability can help organizations target their efforts into certain areas (enhancing sustainable outcomes). It can also facilitate data collection, analysis, and future projections.

4.3.2 Keywords

Sustainability; PROMETHEE; Indicators; Project management; Construction

4.3.3 Introduction

During the last decades, the construction industry has been strongly criticized of poor sustainability performance (Švajlenka and Kozlovská, 2020). This offers the construction industry a unique opportunity to contribute in improving global sustainability initiatives (Lee et al., 2019). Literature reveals various approaches that tend to contribute towards this path. Green building technologies (Yin and Li, 2018), energy consumption solutions (Hong et al., 2019) and greenhouse gas elimination techniques (Xu et al., 2020) are some of them. As useful as most of the above-mentioned approaches that focus on technology related developments might be, there is clearly a need for the development of sustainability evaluation systems too (Yu et al., 2018b). Researchers distinguish the importance of developing effective strategies to improve the sustainability of a construction project (Goel et al., 2019c, Yu et al., 2018a). All these strategies include project management (PM) practices (Goel et al., 2019c). Faced to this variety of strategies, the choice of the suitable option is challenging. Essentially, this situation will bring decision-makers to deal with a multi-criteria decision analysis (MCDA).

According to recent studies, sustainable-PM practices should be embraced by organizations that seek modern solutions (Toledo et al., 2019, Chofreh et al., 2019). Therefore, PM in construction companies needs to build competences for sustainability by assessing their organizational sustainability approaches (Barletta et al., 2021). Such policy will enable practitioners to execute sustainable construction projects by evaluating complete and future projects. Given the fact that sustainability factors and indicators are used to assess different aspects of sustainability (Kiani Mavi and Standing, 2018, Banihashemi et al., 2017), the authors decided to develop a MCDA technique to evaluate the organizational sustainability in a large-scale organization via the utilization of sustainable-PM related indicators. The PROMETHEE (Preference Ranking Organization METHod for Enrichment of Evaluations) method was chosen since it provides the required tools to assess several alternatives according to various criteria in an easy and effective way (Brans et al., 1986). Among the sustainable development (SD) studies reported in the literature, only a few ones have focused on sustainability assessments for construction projects (Makan and Fadili, 2020).

Organizational sustainability needs to be developed as a process that will enable SD in projects. Business managers constantly seek ways to enhance sustainable performance in all its dimensions. During the last years, a vast number of policies and management solutions were developed to evaluate and report sustainable organizational structures. The importance of indicators for measuring organizational sustainability has been brought forth by practitioners (Medel-González et al., 2013). Evaluating their utilization often creates the framework for establishing organizational schemes and further comprehend their importance. Sustainable project management indicators can facilitate the evaluation of organizational sustainability and enable the creation of sustainable projects. Furthermore, internal information concerning the data collected built upon the sustainable development practices, can be extracted (Nichioka and Quelhas, 2010). Consequently, such kind of indicators deliver a valuable input for organizations that pursuit sustainable attributes. Regardless of the sustainability indicators reported in literature, the evaluation of organizational sustainability through indicators is still a new concept (Zenya and Nystad, 2018).

The aim of this research is to propose a MCDA based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable-PM related indicators. The difficulty in evaluating the organizational sustainability performance of organizations lies in elements that affect all the three dimensions of the triple bottom line (TBL - economic, environmental, social) scenario. Economic policies/plans, environmental restrictive practices, and complex organizational structures with different business streams, are some of them. This becomes even more complicated when looking upon country or organization levels. Furthermore, perceptions of how individuals/practitioners conceive sustainability performance can greatly vary (Keeble et al., 2003).

The remainder of the paper is organized as follows: Section 2 presents a literature review on the themes related to this research. The methodology and the background details about the case study are described in detail in Section 3. Section 4 refers to the application of the method to the case problem and this is followed by the results of the findings. Finally, conclusion of the research and future directions are recommended.

4.3.4 Literature Review

Review on sustainable construction and organizational sustainability

The introduction of sustainability in construction projects comes with the need to develop sustainable societies (Du Plessis, 2007). The concept of "sustainable construction" was first mentioned in literature at the First International Conference on Sustainable Construction in Tampa, Florida, US in 1994 (Kibert, 1994). It was the beginning of a new era for the construction sector. Various studies started implementing sustainability into their viewpoint when referring to construction projects. Hill and Bowen (1997) put forward the case of a conceptual framework for attaining sustainable construction in terms of four pillars which include the TBL of sustainability and the technical perspectives. Shen et al. (2011a) developed a set of indicators to assess the sustainability of construction projects. They categorized the indicators found according to the TBL scenario and they include variables of project cost, health and safety, and environmental protection. Banihashemi et al. (2017) conclude that sustainable PM practices into the construction phases of a project can be done via the utilization of critical success factors (CSFs). Internationally recognized assessment systems for buildings are also showing the way towards sustainability (Mohamed, 2019).

Nevertheless, focus on sustainability issues in construction, needs to be developed even further (Dobrovolskienė and Tamošiūnienė, 2016a). Goel et al. (2019c) highlight the past and current situation of the construction industry and argue for the adoption of a sustainable project portfolio management. Szekely and Knirsch (2005) share the idea of integrating sustainability into construction through sustainability indices and performance indicators that measure sustainability performance and conclude that this is where researchers should undertake extensive research. Yu et al. (2018b) emphasize the importance of developing an appropriate sustainability evaluation system for construction projects. By reviewing previous literature, they conclude in four key points that will constitute such a plan possible; (1) a comprehensive approach of sustainability, including product organization, key stakeholders, and economic concerns; (2) a small number of indicators for practical and cost-effective implementation; (3) a lifecycle concern; and (4) project focus.

According to the Chartered Institute of Personnel and Development (CIPD, 2012), the organizational sustainability context arises from the development of the TBL philosophy within business operations. In line with this viewpoint Wales (2013) research introduces the TBL concept for organizations endeavoring for sustainability. Eccles et al. (2012), indicate in their research the importance of the "culture of sustainability" within organizational structures that also derives through the TBL scenario. They also mention that the organization's objectives should be connected to the whole sustainable philosophy (values and beliefs) in order to achieve substantive changes in business processes. Following their research results, it is revealed that "*high sustainability companies significantly outperform their counterparts over the long-term, both in terms of stock market and accounting performance*."
According to Wales (2013), organizations nowadays tend to participate more into sustainability incentives increasing the number of professionals that possess sustainability skills and knowledge. They tend to adjust into a more sustainable internal organizational approach. Many studies propose the use of factors/indicators for assessing the sustainable index, under the TBL context, for relating the sustainability performance of organizations and their projects (Martens and Carvalho, 2017, Colbert and Kurucz, 2007, Porter and Kramer, 2007). Though the use of sustainable-PM factors/indicators, the researchers examine the sustainable development benefits associated with all parts of an organization to improve its sustainability policies.

Review on MCDA methods in sustainable construction projects

MCDA methods have been widely used to make comparisons based on multiple criteria within a set of distinct alternatives (De Montis et al., 2005). These models can lead to high quality decisions especially when the number of factors are important, and the number of alternatives are reasonable. The main category of MCDA methods that most researchers rely on when following sustainable practices in construction, are the outranking methods.

Outranking methods are based on pairwise comparisons of the alternatives against each other according to the assessment criteria.

Sustainable construction projects are designed by following the philosophy of creating a more advanced society with favorable health conditions, a viable economy and environmental-friendly conditions inside and outside urban areas (TBL). Therefore, practitioners tend to turn their focus into methods that can successfully deliver such projects. MCDA methods are able to collect and analyze the basic measures that lead towards the SD path and deliver robust results that will guide practitioners towards sustainable construction projects. In view of the extracted results and by adopting fitting sustainable policies and guidelines, they often attain their sustainable goals.

Vinodh and Jeya Girubha (2012) selected a MCDA method to reveal the best sustainable orientation among many construction projects. Polatidis et al. (2006) used MCDA to rank renewable energy construction projects. They analyze different MCDA techniques and develop a conceptual framework for choosing the appropriate MCDA method. Jayal et al. (2010) utilize similar optimization techniques and dive into sustainable constructions to evaluate sustainability at the product, process and system level. Wu et al. (2018b) employed a hybrid MCDA method to select the optimal waste to-energy construction based on sustainability perspective.

The authors chose to implement the PROMETHEE method in order to better correspond to the aim of the research. The distinguished elements for choosing the specific MCDA method are:

- PROMETHEE has the ability to effectively allocate alternatives, even though they seem difficult to be compared due to their ambiguous qualities.
- It can adequately handle qualitative, quantitative and missing values data.
- The choice of being able to view the final rankings in a variety of charts and tables. (Brestovac and Grgurina, 2013).

Review on applications of PROMETHEE method

The PROMETHEE method was first developed by Brans and Vincke (1985). PROMETHEE provides insights into comparisons between alternatives which are difficult to differentiate. The method is widely used in previous literature for multi-criteria assessments and has a robust presence in sustainability evaluations (Makan and Fadili, 2020, Vinodh and Jeya Girubha, 2012).

Gurumurthy and Kodali (2008) utilize the PROMETHEE method to select the best concept amongst manufacturing systems to be implemented into the case study. Vinodh and Jeya Girubha (2012) dig into the same method to select the best sustainable concept considering criteria all TBL perspectives. Under the same methodology pattern, Zhao et al. (2019) rank and evaluate sustainable energy technologies. Kolli and Parsaei (1992) classified advanced manufacturing technologies centered in multiple criteria. The authors used the PROMETHEE method (outranking method) to avoid using a single criterion in this context. Advanced manufacturing technologies are based on multiple criteria due to their complexity. On the same page, Wiguna et al. (2016) studied renewable energy site projects by using a combination of AHP and PROMETHEE methodology. Salminen et al. (1998) compared three MCDA methods, namely PROMETHEE, ELECTRE, and SMART to evaluate their fittingness in the environmental perspective. Another sustainability assessment, this time through the spectrum of the social side of the TBL, was conducted by Wu et al. (2017), who utilized PROMETHEE to analyze hydropower projects. TBL aspects were considered into their analysis. Chen et al. (2014) developed their own ranking method, which was based on PROMETHEE, to select an optimal site of landfill plant.

Applications of PROMETHEE method showcase the importance of implementing sustainable construction projects. While literature reveals a large number of MCDA methods, it can be concluded that PROMETHEE can provide robust results when it comes to sustainability concepts. Nonetheless, a few studies have been focused in the utilization of PROMETHEE for evaluating organizational sustainability via the use of sustainable-PM indicators.

Literature gap

This paper attempts to bridge the research gap in the application of a MCDA based method, namely PROMETHEE, to assess the integration of the sustainability philosophy in large-scale organizations, via the utilization of sustainable-PM indicators. While MCDA methods have been previously used in sustainable concept selection problems (Vinodh and Girubha, 2012, Vinodh and Jeya Girubha, 2012), the utilization of sustainable PM indicators to evaluate the organizational sustainability is still a relatively new concept with plenty of gaps (Kiani Mavi and Standing, 2018, Wales, 2013).

Wang et al. (2014) describe in their study that "*assessment of sustainability performance is the foundation to make the studied objective more sustainable*". In assessing sustainability, relative indicators have been proven quite useful (Martens and Carvalho, 2017, Yu et al., 2018a). The indicators used in this study are related to parameters that reveal trends or modifications of one or more TBL aspects. In most cases, assessment methods are designed for evaluating different types of projects, and thus the selection of the most appropriate path can become problematic (Bond and Morrison-Saunders, 2011). This fact may imply that there is a need to establish an approach to accurately assess the organizational sustainability of organizations. By comparing internal organizational structures, the researchers aim to reveal the sustainability integration level within the different business units, in order to allow organizations to make decisions towards sustainable practices.

4.3.5 Materials and Methods

Instrument of the study

In this section, the materials and method used during the overall steps of this study are presented in detail. In the context of the current research a structured questionnaire was created and disseminated to selected participants.

The questionnaire sent to the interviewees consists of three parts:

Part 1: An introductory sheet including aim and scope, ethical considerations and an outline of the survey procedure.
Part 2: Questions concerning the respondents' background information (role in the practice and the market sector they belong to).
Part 3: Evaluative questions of the predefined sustainability indicators in consideration to the organizational performance of the department the interviewees are part of. This was practically consisting of the list of the indicators along with a brief description, where the respondents were called to evaluate the performance value of each indicator, based on a scale of 1-9 (1 = poor performance and 9 = highly efficient performance). One important consideration at this point is that the proposed method is relevant to each Organization's maturity level regarding sustainable project management. That is, "poor performance" for a highly efficient in sustainability Organization may mean a complete different thing than "poor performance" for a low efficient Organization. In view of that, the proposed method works better in the inter-departmental comparison within an Organization (as in this case study) rather than in inter-Organizational comparisons.

It is also worth noting that the total number of the indicators included in the survey were 41 and not 82 as Stanitsas et al. (2021) enumerate in their study. The diminution of the initial list of indicators was based on the study that Stanitsas and Kirytopoulos (2021) conducted. In their research, they explored and ranked the relative importance of the principal sustainable project management indicators of Stanitsas et al. (2021) considering the views of construction project stakeholders. This ranking revealed the relative importance index (RII) of each of the 82 predefined indicators. Thus, the authors of this study chose to pick the most important ones according to the stakeholders' views. The main criterion in which the selection was based was the RII. Consequently, 41 indicators presented a RII score higher than 0,80. Other criteria that directed to this selection were centred towards the purpose of this questionnaire. The authors targeted in: (1) delivering simplicity, proper description, comprehensibility, and suitability to the aim of the research; (2) high response rate for the questionnaire; and (3) quick completion time.

The PROMETHEE method

Literature reveals a large number of MCDA methods for pair wise comparison alternatives (De Montis et al., 2005, Wiguna et al., 2016). PROMETHEE is a widely applied and trusted method among academia, especially for comparing alternatives in each separate criterion (Brans et al., 1986, Vinodh and Jeya Girubha, 2012). The application of the method can be presented in six steps (Makan and Fadili, 2020):

- Step 1: Input data: This step entails the pairwise comparisons between alternatives for all the analyzed criteria.
- Step 2: Deviation calculation: In this step the deviation between alternatives is calculated.
- Step 3: Preference function evaluation: Selection and application for each criterion.
- Step 4: Global preference index calculation: During this step, definition of the preference index is undertaken.
- Step 5: Computation of positive and negative outranking flows: This step reveals a first glimpse of the potential ranking based on the positive and negative outranking flows of each alternative.
- Step 6: Computation of net out flow: This step determines the final ranking of the alternatives by adding the negative ranking flow and the positive ranking flow for every pair wise comparison.

The PROMETHEE method comprises six types of preference functions (equations) to express the significance of the alternatives for a certain criterion/factor; and weights to reveal the relative importance of the criterion.

The six types of the preference function are described as follows (Brans et al., 1986) cited in (Vinodh and Jeya Girubha, 2012):

- “*Type I (usual criterion): It is a basic type without any threshold. No parameter to be determined.*
- *Type II (quasi criterion): It is always used for qualitative criteria and it uses a single indifference threshold and it should be fixed.*
- *Type III (V-shape criterion): Criterion with linear preference up to a preference threshold and it is to be determined.*
- *Type IV (level criterion): It is always used for quantitative criteria and it uses additional indifference. The indifference and a preference threshold which must be fixed; between the two, preference is average.*
- *Type V: (V-shape criterion): Criterion with indifference and linear preference. Both should be fixed; between the two, preference increases.*
- *Type VI (Gaussian criterion): It is seldom used. Preference increases and it follows normal distribution, the standard deviation of which must be fixed.*”

Case study description

The case study has been conducted in a market-leading design, engineering and project management consultancy organization with headquarters in Europe. The organization is already developing and implementing comprehensive sustainability approaches to meet international sustainable design standards for their buildings and structures. Furthermore, it aspires the sustainable philosophy and corporate responsibility in its internal structures resulting in a very high level of organizational sustainability. Organizational sustainability and sustainable policies are very important in achieving sustainable constructions (Goel et al., 2019a).

The application of the proposed method in the case study Organization was conducted in order to show opportunities for even further enhancement of sustainability approaches within the different departments of the Organization. Through decision making the PROMETHEE method was used for assessing the integration of the sustainability philosophy of each department via the utilization of sustainable-PM related indicators, and the inputs have been gathered via a questionnaire survey. By using a set of indicators, the “path” towards establishing a better organizational and professional competence is revealed. The survey adopted the indicators identified in Stanitsas et al. (2021) (TBL attributes and categorization). The interviewees were all in managerial key positions and responsible for implementing sustainable concepts in their projects. In total, 6 professionals, from 6 key departments of the Organization, filled the survey.

The criteria considered for the orientation selection and their brief description are presented in detail in the next Section.

4.3.6 Assessing the Sustainability Integration of a Large-Scale Organization Via the Utilization of Sustainable-PM Indicators

This Section presents the research process / methodological approach followed in this study. The research was performed with a series of activities organized in phases as Figure 1 presents. The key steps concern: (1) The case study which has been conducted in a market-leading design, engineering and project management consultancy organization. The selection of the case study derived through the identification of the Organization and further the identification of its key departments and departments' leaders. The departments chosen were set as the alternatives for the PROMETHEE method; (2) The questionnaire survey which was designed around the 41 indicators as these were extracted from previous studies using excel spreadsheets to help organize the questions. The data were collected from experts that hold key positions in the case study Organization, in a period of 1 month (during June 2021). The results of the survey were used to assess each alternative against each criterion (indicators identified from previous study). The questions included 3 Tables with all the indicators and a brief description and next to them an empty cell where the respondents had to make a true statement according to their views. The ranking had to be done in consideration to the organizational performance in the department they are part of; (3) The selection of the MCDA based method, namely PROMETHEE, to assess the integration of the sustainability philosophy of each department via the utilization of the sustainable-PM related indicators. This method is based on the analysis of different scenarios that include all possible TBL combinations to reach robust results; (4) The final ranking order of each department per scenario analyzed; and (5) the final considerations (conclusions and further research).

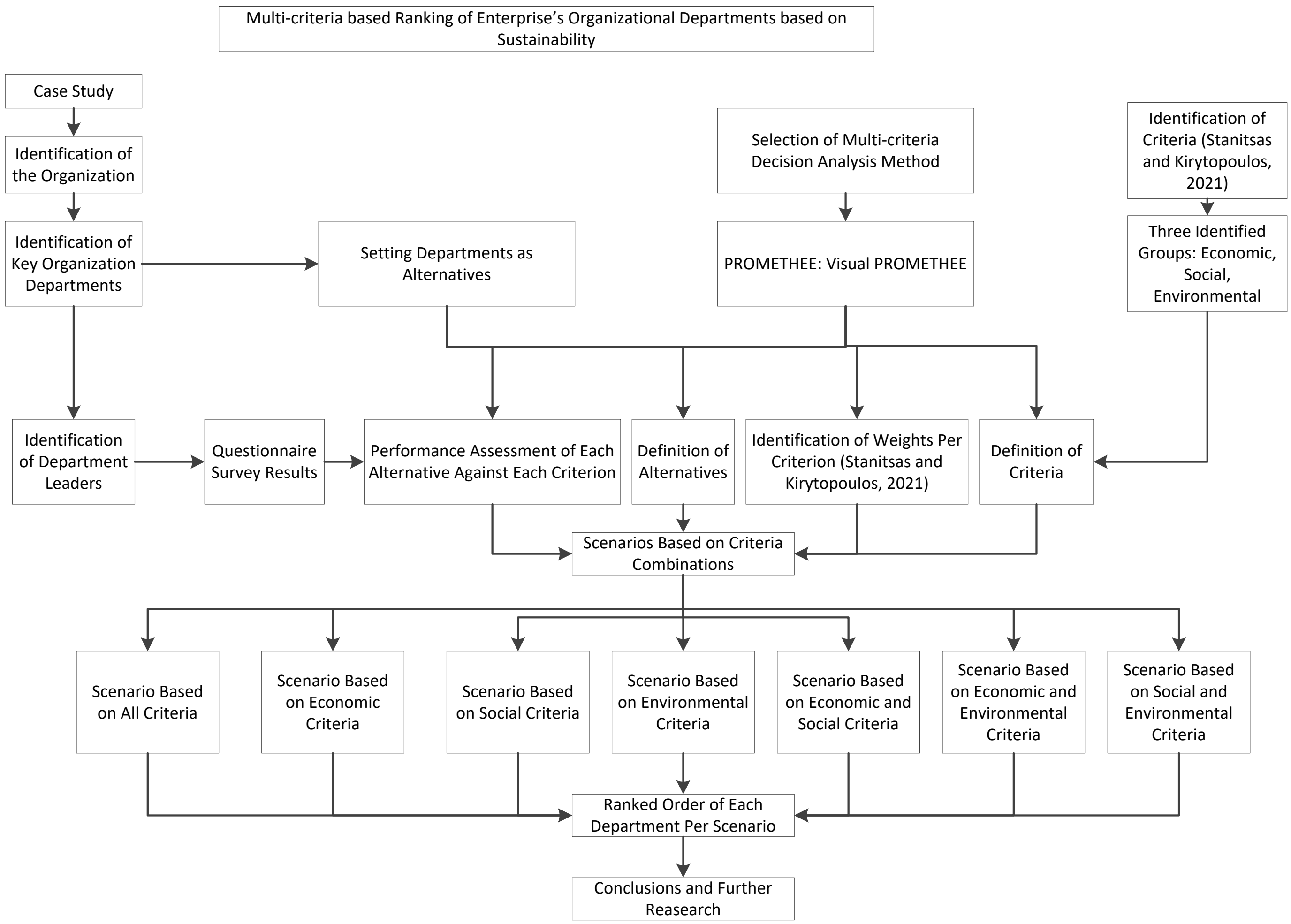

Figure 1. Research process / methodological approach of the study.

Input details & findings

The input details with reference to the comparison of internal organizational structures to reveal the sustainability integration level within the different business units, have been composed.

The scenarios created for the analysis aimed to help Organizations focus their actions in specific aspects of sustainability depending on the Organization's goals. Simply put, the parameters/scenarios for the alternative approaches constitute a business approach for creating long-term value by taking into consideration internal TBL related operations. Organizations can therefore identify opportunities for enhancing the sustainability processes among their departments and thus the overall Organizational sustainability attributes.

Table 1 presents the considered alternatives. The departments of the Organization are used in the method as the alternatives. The actual names of the departments have been masked in this paper for confidentiality purposes. The targeted departments along with the respondents from each department are: (1) Infrastructure & Transportation - Associate Architect; (2) Urban Development - Project architect; (3) Urban Planning - Associate Director; (4) Social construction - Technical Director; (5) Computer enabled design - Associate Director; (6) Innovation, Research, IT – Digital Strategy Lead, Building Design Expert. The targeted interviewees were all in managerial key positions and responsible for implementing sustainable concepts in their projects. Under this notion and with the valuable contribution from the Organization's experts, the final ranking of the departments occurred. The researchers aim to reveal the sustainability integration level within the different departments, in order to allow organizations to make decisions towards sustainable practices.

The parameters/scenarios for the alternative approaches are based in the TBL scenario of sustainability and include: (1) All criteria; (2) Economic related indicators (ECO); (3) Environmental related indicators (ENV); (4) Social related indicators (SOC); (5) Economic & Environmental related indicators; (6) Economic & Social related indicators; (7) Social & Environmental related indicators. The specific scenarios based on criteria combinations occurred through the authors' intention to cover the full spectrum of the TBL scenario, in an attempt reveal valuable outcomes that reveal the sustainability integration level within the different departments. Covering all possible combinations, it can be extracted under what extent the departments' staff utilize sustainable PM processes in their construction projects.

Table 1. Selected alternatives for the MCDA based method.

Codes	Alternatives
A1	Infrastructure & Transportation - Associate Architect
A2	Urban Development - Project architect
A3	Urban Planning - Associate Director
A4	Social construction - Technical Director
A5	Computer enabled design - Associate Director
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert

The assigned weights of the considered criteria have been extracted from Stanitsas and Kirytopoulos (2021) and can be seen in Tables 2-4.

Table 2. Weighting factors for ECO.

Economic (ECO) sustainability indicators	Weights
Indicator	
ECO1: Financial/Economic performance	0,871
ECO2: Economic and Political stability	0,820
ECO3: Stakeholder involvement/ participation	0,847
ECO4: Innovation management/new product development	0,855
ECO6: Effective Project Control	0,856
ECO7: Best practice strategy	0,850
ECO8: Efficient allocation of resources	0,873
ECO13: Cost management plan	0,869
ECO14: Resource planning	0,846
ECO16: Effective strategic planning	0,828
ECO20: Ability to pay and affordability	0,848

ECO21: Environmental/economics accounting	0,865
ECO22: Developing an efficient risk management plan by the Project Management Team (PMT)	0,802
ECO23: Implementing an effective change management strategy	0,802
ECO24: Efficient data processing for decision-making practices	0,821

Table 3. Weighting factors for ENV.

Environmental (ENV) sustainability indicators	Weights
Indicator	
ENV1: Energy efficiency	0,880
ENV2: Available - fitting renewable energy resources/fossil fuels	0,855
ENV3: Eco-efficiency	0,885
ENV5: Sustainable use of natural resources	0,901
ENV6: Up to date environmental construction technologies and methods	0,872
ENV7: Environmental responsibility/justice	0,862
ENV8: Construction water quality impact	0,823
ENV9: Environmental impact assessment project report	0,875
ENV10: Environmental management systems/policy implications	0,854
ENV12: Climate change adaptation/disaster risk management	0,803
ENV13: Appropriate and flexible environmental design details and specifications	0,840
ENV14: Project biodiversity	0,815
ENV15: Environmental education and training	0,869
ENV17: Considering the life cycle of products and services to reduce environmental impacts	0,834
ENV18: Environmental management plan for impacts by the PMT	0,817

Table 4. Weighting factors for SOC.

Social/Management (SOC) sustainability indicators	Weights
Indicator	
SOC1: Social responsibility	0,812
SOC4: Labor practices	0,812
SOC6: Sustainable employment	0,828
SOC8: Human rights	0,843

SOC10: Public acceptance towards the project	0,823
SOC11: Stakeholder engagement/management	0,809
SOC18: Well-defined project scope and project limitations	0,848
SOC19: Holistic view of benefits	0,840
SOC23: Implementing a quality management system	0,807
SOC29: Adaptability in project environment	0,826
SOC37: Managing knowledge and awareness to promote sustainable project delivery (PMT)	0,817

The average assessment of each indicator of the structured questionnaire that was sent to experts for evaluating the performance-effectiveness of each approach against each criterion can be seen in Tables 5-7.

Table 5. Effectiveness per description criteria - ECO.

Criteria	ECO1	ECO2	ECO3	ECO4	ECO6	ECO7	ECO8	ECO 13	ECO 14	ECO 16	ECO 20	ECO 21	ECO 22	ECO 23	ECO 24
Average score	8	7	8	7	7	7	8	7	7	8	8	6	7	7	6

Table 6. Effectiveness per description criteria – ENV.

Criteria	ENV1	ENV2	ENV3	ENV5	ENV6	ENV7	ENV8	ENV9	ENV 10	ENV 12	ENV 13	ENV 14	ENV 15	ENV 17	ENV 18
Average score	6	5	7	6	7	6	7	6	7	5	6	5	6	7	6

Table 7. Effectiveness per description criteria – SOC.

Criteria	SCO1	SOC4	SOC6	SOC8	SOC10	SOC11	SOC18	SOC19	SOC23	SOC29	SOC37
Average score	8	8	7	8	8	8	7	7	8	8	6

The theoretical background of PROMETHEE as already described in Section 3.1, is necessary for comprehending the ranking of the alternatives and for the results based on the considered scenarios and criteria of the analysis (Zafirakou et al., 2018).

Computational steps
Choosing the Alternatives

The choice of the alternatives derived through the consideration of the aim of the study. Given the fact that the aim involves the assessment of the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable-PM related indicators, the alternatives had to embrace the consideration of the TBL indicators. Thus, a combination of all possible routes derived (Section 4.1) and analyzed in the multi-criteria analysis.

Criteria Weights and effectiveness per description criteria

This study utilized the Visual PROMETHEE Academic Edition program. The alternatives and the evaluation criteria were carefully chosen by the authors in an attempt to reach the aim of the study. As previously mentioned, the assigned weights of the considered criteria have been extracted by the research that Stanitsas and Kirytopoulos (2021) conducted and analyzed through the SPSS program (Statistical Package for Social Sciences). The average score for each criterion (effectiveness/performance) occurred through the distributed questionnaires to experts in which they had to rate their preferences using values from 1-9. Visual PROMETHEE software used all these inputs for assessing which alternatives are considered best with respect to the aforementioned criteria per scenario. Tables 5–7, present the mean values of the effectiveness per criterion as returned from the questionnaire.

4.3.7 Results and Discussion

The purpose of developing sustainable projects is to enhance environmental awareness and protection, to safeguard social welfare, and to create economic initiatives that will lead towards new attainments (Silvius and Schipper, 2020). Under this notion, the main focus of this study leads towards evaluating organizational sustainability that can help organizations target their efforts into certain aspects (enhancing sustainable outcomes) based on a MCDA based method. The proposed model demonstrates that such an approach can provide useful insights for Organizations into the use of sustainable-PM indicators for projects that pursuit sustainable outcomes. Developing and applying the proposed method can enable practitioners to analyze scenarios in a transparent way and to promote schemes that will improve the overall organizational sustainability. The proposed method presents prominent advantages and the most significant one is its simplicity.

The PROMETHEE method was used to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable-PM related indicators. By comparing internal organizational structures, the researchers aimed to reveal the sustainability integration level within the different business units. Based on the input data as presented in the Tables of Section 4.1, the internal organizational departments were evaluated using PROMETHEE (calculation and the analysis are carried out using Excel spread sheets). According to Urošević and Marinović (2021), "*PROMETHEE is based on the calculation of positive and negative flows for each alternative according to the weight of each criterion*". Positive outranking flow (Phi+) expresses the degree in which the alternative outranks other alternatives (Abdullah et al., 2019). The case study, that was used in this study to illustrate the proposed method, positive outranking flow (Phi+) revealed the degree to which one department is dominating others in terms of usage of the aforementioned sustainable-PM indicators into its organizational processes and thus degree of utilization by the departments' staff. On the opposite side, negative outranking flow (Phi-) expresses the degree in which the alternative (each department in our case) is outranked by all other alternatives. In this study, it shows the degree of the department being dominated by other departments, denoting a truncated integration/utilization of the sustainable-PM indicators to reach its sustainability goals and at the same time an opportunity for further integration/utilization of the sustainable-PM indicators to promote its sustainability goals. The net preference flow (Phi) is calculated by adding the positive (Phi+) and negative (Phi-) flows. To better understand the usefulness of the method, it needs to be taken into account that the alternative analyzed presents superior features if Phi is higher. Tables 8-14 showcase the Phi values (the results of Visual PROMETHEE software for the seven scenarios).

Table 8. Alternatives' ranking – Scenario 1: All actions criteria.

Codes	Departments	Phi+	Phi-	Phi
A1	Infrastructure & Transportation - Associate Architect	0,578	0,1676	0,4104
A2	Urban Development - Project architect	0,5133	0,2182	0,2951
A3	Urban Planning - Associate Director, International Urbanism Lead	0,4535	0,2891	0,1645
A4	Social construction - Technical Director	0,3626	0,3604	0,0022
A5	Computer enabled design - Associate Director	0,208	0,276	-0,068
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert	0,0244	0,8285	-0,8041

Scenario 1 (Table 8) includes all TBL criteria comprising all sustainable-PM indicators, namely economic, environmental and social. Infrastructure & Transportation department exhibits the higher score. As an inference, the analyzed sustainable-PM indicators are highly integrated into the internal organizational processes of this department in its way to attain its sustainability goals. It seems that the department's staff utilize these indicators in their everyday tasks, constituting them familiar with their qualities. Infrastructure & Transportation projects often involve significant land exploitation (natural resources), long-term investment plans and social acceptance (Amiril et al., 2014). These elements constitute some examples of TBL inquiries that need careful consideration by the departments' staff. Therefore, the involvement of such departments towards SD efforts is intensive and challenging.

Table 9. Alternatives' ranking – Scenario 2: Economic criteria.

Codes	Departments	Phi+	Phi-	Phi
A1	Infrastructure & Transportation - Associate Architect	0,6642	0,1742	0,49
A2	Urban Development - Project architect	0,5902	0,1965	0,3938
A3	Urban Planning - Associate Director, International Urbanism Lead	0,4245	0,3488	0,0757
A5	Computer enabled design - Associate Director	0,3975	0,441	-0,0435
A4	Social construction - Technical Director	0,3608	0,4386	-0,0778
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert	0,027	0,8652	-0,8381

Scenario 2 (Table 9) includes the economic criteria comprising just the ECO related indicators. Once again, the Infrastructure & Transportation department exhibits the higher score, followed by Urban Development and Urban Planning departments. Considering the development of modern cities that formulate necessary to secure employment, financial resources, and a trustworthy economic pattern, it is vital that the departments that pursuit SD in cities to consider economic related indicators into their processes. Practitioners pursuit projects that make sustainable economic development possible (Tescașiu et al., 2018).

Table 10. Alternatives' ranking – Scenario 3: Environmental criteria.

Codes	Departments	Phi+	Phi-	Phi
A3	Urban Planning - Associate Director, International Urbanism Lead	0,5075	0,2398	0,2677
A2	Urban Development - Project architect	0,4645	0,2024	0,2621
A1	Infrastructure & Transportation - Associate Architect	0,4773	0,2282	0,2491
A4	Social construction - Technical Director	0,3648	0,3562	0,0085
A5	Computer enabled design - Associate Director	0	0	0
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert	0	0,7874	-0,7874

Scenario 3 (Table 10) includes the environmental criteria comprising just the ENV related indicators. Following the results of this scenario, the Urban Planning department comes first, followed by the Urban Development department. It seems that the current environmental complications have turned into a worldwide concern directing organizations towards the development of eco-friendly urban projects (Mersal, 2017). It is of vital meaning for the department's staff to study environmental related indicators that will direct them towards improving the overall sustainability of their projects.

Table 11. Alternatives' ranking – Scenario 4: Social criteria.

Codes	Departments	Phi+	Phi-	Phi
A1	Infrastructure & Transportation - Associate Architect	0,5996	0,0729	0,5266
A2	Urban Development - Project architect	0,4746	0,2708	0,2038
A3	Urban Planning - Associate Director, International Urbanism Lead	0,4179	0,2751	0,1428
A4	Social construction - Technical Director	0,362	0,2571	0,1049
A5	Computer enabled design - Associate Director	0,2369	0,435	-0,1981
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert	0,0552	0,8353	-0,78

Scenario 4 (Table 11) includes the social criteria comprising just the SOC related indicators. While in this scenario someone would expect the Social construction department to be the first one in the list, it seems that the Infrastructure & Transportation department scores once again higher than the rest. It seems that the staff of the Social construction department do not consider the aforementioned indicators into their processes as much as the departments that scored better. This occurrence can be interpreted into two possible ways. The first one is that the staff of this department rely on other social related indicators that possibly consider much more contributing towards social sustainability. The second one is that the department overlooks the importance of the social attributes as a way to achieve sustainability in their projects. Thus, it can be considered as a field for improvement in their way to increase the overall organizational sustainability.

Table 12. Alternatives' ranking – Scenario 5: Economic & Environmental criteria.

Codes	Departments	Phi+	Phi-	Phi
A1	Infrastructure & Transportation - Associate Architect	0,5703	0,2013	0,3689
A2	Urban Development - Project architect	0,5271	0,1995	0,3276
A3	Urban Planning - Associate Director, International Urbanism Lead	0,4662	0,294	0,1722
A5	Computer enabled design - Associate Director	0,1977	0,2194	-0,0216
A4	Social construction - Technical Director	0,3628	0,3972	-0,0344
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert	0,0134	0,8261	-0,8127

Scenario 5 (Table 12) includes the combination of economic (ECO) and environmental (ENV) criteria. Infrastructure & Transportation and urban related development departments are the dominant in this occurrence. Recent years have distinguished significant efforts in ameliorating the economic and environmental part of sustainability in projects. Practitioners tend to perceive these pillars as the most vital in delivering extensive welfare. Social sustainability is the most neglected component of sustainability (Boström, 2012, Kandachar, 2014). Developing the economic and environmental components of sustainability (SD) derives as an outcome of population explosion in large cities where the ecological footprint radically augmented combined by resource damage. This called for urgent actions from practitioners.

Table 13. Alternatives' ranking – Scenario 6: Economic & Social criteria.

Codes	Departments	Phi+	Phi-	Phi
A1	Infrastructure & Transportation - Associate Architect	0,6372	0,1319	0,5053
A2	Urban Development - Project architect	0,542	0,2275	0,3145
A3	Urban Planning - Associate Director, International Urbanism Lead	0,4218	0,3181	0,1037
A4	Social construction - Technical Director	0,3613	0,3629	-0,0016
A5	Computer enabled design - Associate Director	0,3305	0,4385	-0,108
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert	0,0388	0,8527	-0,8139

Table 14. Alternatives' ranking – Scenario 7: Environmental & Social criteria.

Codes	Departments	Phi+	Phi-	Phi
A1	Infrastructure & Transportation - Associate Architect	0,528	0,1638	0,3643
A2	Urban Development - Project architect	0,4687	0,2308	0,2379
A3	Urban Planning - Associate Director, International Urbanism Lead	0,4703	0,2544	0,2159
A4	Social construction - Technical Director	0,3636	0,3151	0,0485
A5	Computer enabled design - Associate Director	0,0983	0,1805	-0,0822
A6	Innovation, Research, IT – Digital Strategy Lead, Building Design Expert	0,0229	0,8073	-0,7844

Scenario 6 (Table 13 - economic (ECO) and social (SOC) criteria) and scenario 7 (Table 14 - environmental (ENV) and social (SOC) criteria) present exactly the same view as scenario 5. Infrastructure & Transportation and urban related development departments lead the way to sustainability. Their considerations into all TBL related indicators constitute them as the most contributing towards the overall organizational sustainability development (SD).

The complete classification enabled by the PROMETHEE reveals that the Rail / Transportation / Infrastructure department is designated as the one with the highest integration of the defined sustainable-PM indicators into its processes when introducing sustainability in projects. Taking into consideration all results, it can be noticed that the Research and Innovation department has the lowest score in all 7 scenarios presenting always a negative net flow. The main scope of this department lies in the development of information technology (IT) applications that will simplify the internal activities of all the other departments. Thus, it has less opportunities to implement sustainability tactics into its internal daily operations as delivering sustainable IT projects might require additional resources. However, it is worth noting that the highest Phi score was observed in the scenario of the social related criteria. It can be assumed that the staff of this department define and implement corporate social responsibility business strategies and operations as a large-scale organization. Following the results of the scenarios for the Building information model (BIM) department, it is perceptible that zero values were taken as inputs. The Associate Director who responded to the distributed questionnaire, informed the authors about his/her unfamiliarity with the environmental related indicators and the internal organizational tactics taken by the environmental related department's staff. As a result, the respondent preferred not to answer this part of the questionnaire. Thus, as expected due to lack of values, the ranking of this department was amongst the lowest ones

4.3.8 Conclusion

In the present study, the aim was to propose a MCDA based method, namely PROMETHEE, to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable-PM related indicators. By using the Visual PROMETHEE software, the alternatives (departments of the organization) were ranked with respect to the abovementioned TBL criteria. According to Zafirakou et al. (2018), even for relatively small data sample, as it is in our case, "*the PROMETHEE method is capable of completing the analysis and provide reliable results.*" The basic input data for the analysis were the weights of the criteria which have been extracted by previous research and the results of the questionnaire survey that distributed to experts of a large-scale organization. The theoretical background of the PROMETHEE method is briefly described, essential for understanding the ranking of the departments. The dominance of the Rail / Transportation / Infrastructure department alternative is evident constituting the use of the predefined sustainable-PM indicators by the department's staff as a requisite for attaining sustainable projects. Evaluating organizational sustainability can help organizations target their efforts into certain aspects (enhancing sustainable outcomes). Such aspects are also considered the departments that scored lower values in the analysis, meaning that there is room for development in their internal organizational sustainability policies. Enhancing their sustainability attributes, without doubt, overall organizational sustainability is heightened. Sustainable-PM indicators that embrace the TBL spectrum can help towards this direction while determining key facets of sustainability to allow organizations to make decisions about how best to become more sustainable. The results can also help with data collection, analysis, and future projections.

Following the results of the research as occurred from the MCDA, it can be concluded that the proposed method can be used as a decision support tool in dealing with organizational sustainability assessment. The PROMETHEE method constitutes a useful basic and simple tool to conduct an unbiased evaluation of the departments who turn their focus into specific group of indicators (e.g. Urban Planning and Design department favors environmental related indicators) through a high level of transparency in decision-making processes related to integration of sustainable-PM indicators in a manner that will allow organizations to make decisions towards sustainable practices.

All Scenarios analyzed include all possible TBL criteria combinations comprising all sustainable-PM indicators, namely economic, environmental and social. Infrastructure & Transportation department showcases its dominance in implementing sustainable-PM indicators into its internal organizational practices to attain its sustainability goals. It seems that the department's staff utilize these indicators in their everyday tasks, constituting them familiar with their qualities. The rest of the departments also involve significant TBL attributes in their projects that require careful consideration by the departments' staff. Urban development related departments also reveal high scores, disclosing noteworthy efforts in ameliorating the sustainability in urban projects. An important element for modern cities.

A typical limitation of case studies is that their outcomes cannot be generalized unless repeated to numerous cases. However, in our case the use of the case study is not to come up with general conclusions about the level of integration of sustainability aspects in organizations but to illustrate how the proposed method will be implemented in order to help organizations identify opportunities for enhancing the sustainability processes among their departments.

Future research may focus in analyzing more large-scale organizations so that a greater sample will lead to more robust results. Another line of inquiry for future research could be the increase of the sustainable-PM indicators which can be concluded through interviews with practitioners. Moreover, additional qualitative research and the analysis of additional scenarios is needed to evaluate the effectiveness of the internal organizational structures in delivering sustainable projects. Finally, while the PROMETHEE method developed in this paper provides an assessment of the alternatives, the combined use of additional ranking methods is also another possible inquiry for future research.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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5. Discussion

5.1 Introduction

This chapter highlights the study's main findings and critically analyses them, involving a comparison to previous relevant research, providing vital conclusions. The structure of the discussion chapter progresses around the research aim and objectives.

This discussion includes reviewing the outputs from the SLR, semi-structured interviews, questionnaire surveys, and MCDA methods. It examines and reviews the key findings from the different lines of inquiry that the research was designed to explore, namely:

- Sustainable PM indicators for construction projects (comparison with state-of-the-art sustainable PM practices).
- Stakeholders' beliefs and attitudes when in seek of sustainability attributes in the construction sector.
- Underlying factors that give rise to the set of sustainability indicators that are used for the implementation of sustainable construction projects and eventually the production of sustainable built assets.
- Assessment of the integration of the sustainability philosophy in large-scale organizations via the utilization of the sustainable PM-related indicators.

5.2 Sustainable PM indicators for construction projects

The final set of sustainable PM Indicators used as the basis for this research has been extracted from previous studies that refer to sustainable construction projects. The research path that led to the utilized indicator set included the SLR method. The reasoning behind the perceived sustainable PM indicators for construction projects encompassed the enclosure of the whole spectrum of the analyzed theme. The purpose of this review was to synthesize the relevant literature and retrieve the final "superset" (which included both quantitative and qualitative attributes) that will help project managers to understand the areas that they should consider in order to deliver sustainable projects.

Previous empirical studies on indicators, sustainability, PM, and construction area themes guided this research. Indicators have previously been mentioned as important key features that lead to sustainable projects (Banks et al., 2011, Chan et al., 2004b, Heravi et al., 2015). A series of tools for evaluating and classifying construction projects based on sustainability-related indicators have been identified (Feil et al., 2015, Fernández-Sánchez and Rodríguez-López, 2010, Gavrilidis et al., 2019). The prevailing trend towards developing sustainable construction projects was outlined by Silvius and Schipper (2020), who highlighted the need to integrate sustainability practices into project management. However, to attain such a goal, context-specific indicators/CSFs need to be introduced to assist project managers (Gan et al., 2015, Pade et al., 2008). According to Martens and Carvalho (2017), CSFs play a crucial role in enabling and smoothing the process of sustainable PM practices. In essence, integrating and choosing the right mix of sustainable PM indicators/CSFs can become a valuable input for attaining sustainable construction projects (Joung et al., 2013).

However, sustainable PM indicators have remained an overlooked area in literature (Dobrovolskienė and Tamošiūnienė, 2016c), presenting numerous issues that might affect the whole process that leads to sustainability attributes. According to Šaparauskas (2007) and (Fernández-Sánchez and Rodríguez-López, 2010), uncertainty and subjectivity, predomination of environmental aspects when evaluating the sustainability of buildings, and lack of participation of all the stakeholders involved in the project life cycle are some of them. This research intended to broaden the standpoints concerning the sustainable construction concept through a list of sustainability indicators that will overcome previous literature gaps. The result was an extensive record of indicators extracted from earlier studies which were significantly reduced in 127 indicators, given the analyzed theme. Field experts then filtered the selected 127 indicators in a way to retrieve the ones that provided the most valuable input for delivering sustainable construction projects, through interviews. Based on their previous experience, the interviewees concluded in reducing the final list to 82 indicators. This reduction occurred by merging two or more indicators with similar content. To provide clearance of the view of the final set, a further categorization that trailed the TBL philosophy was built as a novel contribution to the overall body of knowledge. The categorization into economic, environmental, and social/management sustainability indicators was made with the help of the interviews and after reviewing their way of usage in previous literature. By revealing the most contributing indicators, project managers who seek sustainability attributes in their projects gain an in-depth understanding of achieving their sustainability plans. Following the TBL scenario to categorize the indicators, practitioners can fully perceive the sustainability philosophy. This study demonstrates that project managers can significantly improve and expand their original methods by adhering to the identified indicators within the suggested taxonomy, increasing their chances of sustainability success. The results of this research contribute to the overall body of literature related to sustainable PM practices in the construction industry and fill a gap in knowledge of the identified indicators leading to sustainable projects.

5.3 Stakeholders' beliefs and attitudes when in seek of sustainability attributes in the construction sector

In order to attain sustainability in construction, it is vital for project managers to select the proper set of indicators that best fit their needs (Martens and Carvalho, 2017). Accordingly, it is critical to reveal the appropriate set of indicators to disclose the stakeholders' beliefs and attitudes when seeking sustainability attributes in the construction sector. This is further supported by Aladpoosh et al. (2012), who highlight the need to include these parameters under the indicators "umbrella" in successfully achieving sustainability in projects. Stakeholder theory specifies that, in order to attain a sustainable construction, organizations must harmonize all stakeholder benefits (Shen et al., 2011b). Under this philosophy, this research targeted showcasing views of international experts (stakeholders of construction projects) so that the findings will contribute to establishing a widely accepted set of sustainable PM indicators for construction projects.

The perceived stakeholder views of the final list of the 82 sustainable PM indicators contributing to construction projects were determined via a questionnaire survey. The data gathered has been analyzed through the RII approach. By undertaking the specified research methodology, it has been revealed that amongst the "superset," environmental-related indicators were the most contributing to delivering sustainable construction projects.

Sustainable PM Indicators like "*ENV5: Sustainable use of natural resources*", *"ENV3: Eco-efficiency", "ENV1: Energy efficiency," and "ENV9: Environmental impact assessment project report"* were ranked in the first places of the respondents' preferences. Following the environmental sensitivities of the respondents for delivering sustainable construction projects, economic-related indicators followed the list. Six out of the ten top-ranked indicators referred to environmental attributes and four to economic-related ones. The questionnaire was distributed to experts of different nationalities, and the indicators analyzed were not specific to a particular society/city/country. Thus, it was already expected that the social related indicators would be the ones that would present the more intense differentiation in terms of importance between the stakeholder groups.

The analysis also uncovered the significance of each indicator per stakeholder group for the construction sector per continent. For instance, many northern European designers/consultants indicated the considerable value of social indicators. In contrast, northern and southern European research academics favored environmental-related indicators with the highest scores.

As many studies describe the social dimension of sustainability as the "neglected" one (Zuo et al., 2012), the stakeholders' beliefs and attitudes confirm this statement through their answers. The importance of the social dimension is vital when it comes to sustainable projects, as sustainability cannot be attained without all three pillars of the TBL scenario (Aarseth et al., 2017). Thus, considerations should be led towards the practical and operational aspects of social sustainability to understand and measure the social outcomes for further implementation into construction projects.

Stakeholders had the chance to state their thoughts in a separate additional comments field. They highlighted the need for a widely accepted strategy for implementing sustainability strategies in construction projects. Another statement that was clearly indicated was the nature of a sustainable project. Each of the seven stakeholder groups, namely (1) clients; (2) users; (3) manufacturers; (4) contractors; (5) designers/consultants; (6) authorities/government; and (7) research academics, which were part of the two major ones (internal and external stakeholders), focuses to different TBL dimensions, resulting on varied correlations (analysis and findings section).

5.4 Underlying factors that give rise to the set of sustainability indicators

The final set of indicators extracted through the SLR (82 sustainable PM indicators) relied on the sustainability and PM attributes specifically for the construction sector. The previous literature search revealed that relevant indicator/CSFs lists are typically large and comprise several indicators/CSFs under various thematic areas that sometimes reach beyond the TBL constraint (Zhong and Wu, 2015). This is the case, especially in engineering-related studies that focus on knowledge development, analyzing the possible optimization of different types of previously mentioned indicators to achieve enhancements in the way the sustainability philosophy is perceived (Tseng et al., 2020). While indicators around the vast field of sustainable PM seem to gain interest amongst researchers during the last years (Al-Saleh and Taleb, 2010), few attempts in academic literature summarize such extended sets into smaller underlying factors (Banihashemi et al., 2017), easing practitioners towards their sustainability targets. Clustering the factors for construction projects and determining the path towards sustainability drove the development of this step of this research. According to Li et al. (2018b), most researchers hypothesize that sustainability-related indicators have no inter-relationships (TBL concerns), resulting in long lists with various thematic patterns. This assumption can lead to deceptive conclusions for practitioners that seek sustainability attributes in their construction projects, as all three dimensions of the TBL scenario are directly or indirectly connected (Elkington, 2004). Therefore, revealing the underlying factors that give rise to the set of the sustainability indicators attempts to explore the stakeholders' perceptions on the 82 indicators and condense this list into fewer explainable groupings.

The underlying factors that give rise to the set of sustainability indicators used for the implementation of sustainable construction projects and eventually the production of sustainable built assets was revealed through stakeholder feedback of the previously mentioned questionnaire. The data extracted was used to conduct the methodological approach of the EFA. Five distinct factors of stakeholders' attitudes were revealed: (1) Sustainable competitiveness; (2) Stakeholder engagement; (3) Sustainable economic growth; (4) Social sustainability; and (5) Resource conservation and environmental policy. The revealed factors summarized all indicators. In practice, the findings aid senior management in adopting strategies that enhance the delivery of sustainable construction projects. Furthermore, it provides guidelines for policy makers and organizations. It reveals novel insights into the use of sustainable PM-related factors uncovering the sustainable attributes that need to be considered for sustainable built assets.

The methodological approach of EFA was selected as the most fitting method for revealing the fundamental concepts of a large set of variables (indicators) in order to provide an understanding of the factor structure of the data. This method proves to be effective in cases where the variables involved are not quantifiable (as in this study) (Williams, 2010). Additionally, EFA helped in reducing the large number of variables into a limited set of factors based on correlations between variables.

A conceptual model was developed to illustrate better the underlying concepts (described here as factors) that drive the performance and selection processes needed to promote sustainable PM for construction projects. The contribution of the model lies in the adoption of sustainable development strategies. To this end, the indicator selection protocol is further described, including some key criteria to be considered. Practitioners enhance even more their understanding of sustainable construction projects.

5.5 Assessment of the integration of the sustainability philosophy in a large-scale organization

The sustainability philosophy has become a valuable asset for large-scale organizations during the last few years (Thaher and Jaaron, 2022). However, integrating sustainability attributes into their internal and external policies is an issue far from maturing (Ceschin and Gaziulusoy, 2016). Efforts in academia and in practice have been directed towards the development of sustainability-related indicators in the measurement, prevention, and classification of sustainability, to guide practitioners towards the TBL path that best serves their needs (Vivas et al., 2019). However, the conducted literature review process revealed that indicators alone (especially the ones that do not fall under the TBL scenario agenda) might not be enough to guide practitioners towards delivering sustainable projects.

Organizations need to integrate sustainable PM indicators into their internal processes that take into account all three dimensions of the TBL scenario, and not just the economic dimension of traditional cost minimization techniques, which is usually the case (Afful-Dadzie et al., 2016). A series of methods and models have been employed in previous literature to assess the sustainability philosophy in organizations. However, according to Vivas et al. (2019) and Mura et al. (2018), most of these designs appear insufficient for a complete sustainability assessment, especially models based only on one of the three TBL attributes. Vinodh and Jeya Girubha (2012) employed the PRMETHEE method to reveal the best sustainable orientation among many construction projects. Longaray et al. (2019) developed a MCDA method to assess the organizational performance of industries operating at Brazilian maritime port terminals. Murcia et al. (2022) approached strategic management in organizations by developing a framework using the MCDA approach.

In most cases, assessment methods are designed for evaluating different types of projects (van Eldik et al., 2020). This fact, along with the lack of more comprehensive models for measuring sustainability, has led to the development of an approach to assess organizational sustainability accurately. By comparing internal organizational structures, the research path revealed the sustainability integration level within the different business units of a large-scale organization to allow practitioners to decide towards sustainable practices.

Based on an MCDA-based technique, an assessment of the integration of the sustainability philosophy in a large-scale organization was undertaken under the philosophy of supporting organizations towards focusing their efforts on particular sustainable characteristics (delivering sustainable results). The suggested extracted methodology provides vital insights to organizations that seek the utilization of sustainable PM indicators for construction projects. Practitioners can gain insights into the concept of organizational sustainability and thus develop approaches to improve the organization's overall sustainability.

The PROMETHEE method, along with valuable questionnaire insights, was used for this purpose. The research revealed the sustainability integration level within the different business units by comparing internal organizational structures. Based on the input data as extracted from the questionnaire survey, in which key experts from internal organizational departments were participated, views into the departments’ staff utilization of sustainable project management processes in their construction projects were revealed.

Scenarios that include all or some of the TBL criteria (all possible combinations) comprising all sustainable PM indicators highlighted the involvement of the analyzed departments in sustainability efforts. The targeted departments along with the respondents from each department were: (1) Infrastructure and Transportation—Associate Architect; (2) Urban Development—Project Architect; (3) Urban Planning—Associate Director; (4) Social Construction—Technical Director; (5) Computer-Enabled Design—Associate Director; (6) Innovation, Research, IT—Digital Strategy Lead, Building Design Expert. The Infrastructure and Transportation Department ranked first in most cases (results revealed through the MCDA method), uncovering the department's staff's extensive use of sustainable PM indicators. While the rest of the departments also demonstrated a significant preference towards sustainability attributes for their projects, they could not reach the implementations of the Infrastructure and Transportation Department.

5.6 Summary

This chapter has brought together the outcomes of the SLR, semi-structured interviews, questionnaire surveys, and MCDA methods and briefly discussed the findings of these research methods, as they were thoroughly revealed in the Analysis and Findings chapter. The discussion was based on the research aim and objectives.

The insights from the discussions were based on the final set of indicators as these were revealed through the SLR and interviews, which were furtherly used as input for the rest of the findings. The stakeholders’ beliefs and attitudes toward sustainability attributes in the construction sector were described through the distributed online questionnaire and the RII method. Additionally, the underlying factors that give rise to the set of sustainability indicators that are used for the implementation of sustainable construction projects and eventually the production of sustainable built assets were based on the same questionnaire and the EFA. Finally, a second questionnaire was distributed to experts of key departments of an organization. The MCDA method, namely PROMETHEE, was used to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of the sustainable PM-related indicators.

The discussions from this chapter on all the research outcomes in response to the Analysis and Findings chapter shaped the "path" towards contributions to the overall body of knowledge and directions for future research.

6. Conclusion

6.1 Introduction

This chapter concludes the research into the sustainable project management practices that lead to sustainable construction projects. Chapter 4 presented an analysis, based upon this research, that would guide practitioners seeking achievements in the sustainable construction sector by focusing, acting upon, and controlling their strategies. The mixed-method approach followed in this research concludes that there is significant potential to enrich, execute, deliver sustainable construction projects, and maintain a balance of options during the project management phase. Furthermore, the findings contribute to a better understanding of sustainable project management practices by offering insights into their core attributes.

The research has highlighted four distinct interpretations for sustainable project management issues. The unraveling of the 82 most contributing indicators for sustainable PM practices for delivering sustainable construction projects; the significance of these indicators for promoting sustainable construction project management according to stakeholder views; the formation of the five underlying factors for successful project management to construct sustainable built assets; and the use of an approach that uses the indicators for evaluating organizational sustainability. The research path provided a walkthrough specifically designed to inform and assist project managers that seek sustainability attributes in their projects.

The rest of the chapter is structured as follows. This introduction is followed by a summary of the research findings that discusses how the questions and objectives of the research have been achieved; the third section elucidates the overall contribution to knowledge and presents the implications to sustainable project management practices; the fourth section identifies the research limitations and finally, section 5 provides recommendations for further research.

6.2 Summary of the Research Findings

This research aims to contribute towards the holistic view of sustainability in project management, especially for construction projects, by delivering the principal sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders.

The four research objectives (RO) to achieve the aim were:

1. Explore the state of the art for sustainability in project management via the identification of sustainability indicators into project management for the construction industry.
2. Explore and rank the relative importance of the retrieved sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders.
3. Identify the underlying factors that give rise to the set of sustainability indicators that are used for the implementation of sustainable construction projects and eventually the production of sustainable built assets and propose a conceptual model of sustainability indicators based on underlying factors.
4. Propose a Multi-Criteria Decision Analysis-based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable project management-related indicators.

This research using a mixed-methods approach has addressed the abovementioned objectives, as described in the following sub-sections.

6.2.1 RO1: Explore the state of the art for sustainability in project management via the identification of sustainability indicators into project management for the construction industry

A systematic literature review was conducted throughout academic literature towards surveying the state of the art for sustainability in project management. The SLR included an original sample of 4.227 documents (books, journals, and conference papers). A total of 1.237 documents were collected after excluding duplicate papers (the same paper retrieved from separate databases). These were reduced to 613 after title consideration and further to 338 following abstract consideration. Finally, a further reduction to 133 was achieved based on the full-text reading. As a result, 133 articles were evaluated in their entirety. The documents highlighted the utilization of sustainable PM indicators as distinguished in previous studies from the construction projects standpoint in general.

The systematic review of the available online academic literature on sustainable project management practices and the use of indicators for such purposes resulted in providing the insights to explore the state of the art for sustainability in project management via the identification of sustainability indicators into project management for the construction industry. Thus, eighty-two (82) sustainability indicators related to project management practices in construction projects were finally identified. According to the TBL scenario (economic, environmental, and social/management sustainability indicators), their further categorization was accomplished through semi-structured interviews with field experts.

6.2.2 RO2: Explore and rank the relative importance of the retrieved sustainable project management indicators contributing to sustainable construction projects, considering the views of all construction project stakeholders

To explore and rank the relative importance of the principal sustainable project management indicators, as these were identified through RO1, contributing to sustainable construction projects, considering the views of all construction project stakeholders, data collected through a questionnaire survey were analyzed to measure the impact. The relative importance index (RII) formula was used for this purpose. By investigating the perception of stakeholders from the construction sector regarding the usage of sustainable project management indicators when in seek of sustainability attributes, findings identified the most contributing indicators towards achieving sustainable construction projects. Relative index analysis determined the relative ranking of all the indicators. All indicators were highlighted as important, revealing their overall contribution to delivering sustainable construction projects. Based on the overall indicator ranking, environmental-related indicators were perceived as contributing most to delivering sustainable construction projects. Through this analysis (stakeholders' preferences towards sustainable PM-related indicators for construction projects), additional guidance for practitioners was provided for focusing, acting upon, and controlling the most significant indicators as to attain sustainability in their projects. They will be able to improve the measurement and management of their projects through the analyzed indicators and further evaluate the sustainability performance.

This analysis was the link between the retrieved sustainable PM indicators (indicators that incorporate the major international sustainability metrics related to TBL), as these were validated through the SLR and interviews (RO1) and the stakeholders' views. Practitioners can also look upon these indicators to evaluate the sustainability performance of their projects.

6.2.3 RO3: Identify the underlying factors that give rise to the set of sustainability indicators that are used for the implementation of sustainable construction projects and eventually the production of sustainable built assets and propose a conceptual model of sustainability indicators based on underlying factors

The questionnaire survey results explored to attain RO2 were also valuable input for RO3. The questionnaire survey method was chosen and planned as the theoretical point of departure and the starting point for further developing the factor analysis that identified the underlying factors. The 82 predefined sustainability indicators for sustainable construction projects were the basis for evaluation from the stakeholders' part. Through the use of the exploratory factor analysis method, five distinct factors of stakeholders' attitudes were drawn: (1) Sustainable competitiveness; (2) Stakeholder engagement; (3) Sustainable economic growth; (4) Social sustainability; and (5) Resource conservation and environmental policy.

The data analysis - factor analysis of all the information extracted from the questionnaire survey was implemented through EFA as the most fitting method for this case scenario. The goal was to reveal the fundamental concepts of a large set of variables (sustainability indicators not quantifiable in their majority) in order for researchers to understand the factor structure of the data. Two tests were performed to identify whether EFA is suitable: (1) the

Kaiser–Meyer–Olkin (KMO) test for determining sample sufficiency and (2) Bartlett's sphericity test to examine the variables' relationship, adequacy, and sphericity.

The conclusion that can be drawn from the identification of the five underlying factors that give rise to the set of sustainability indicators serves as a unique contribution to knowledge and practice. The findings aid practitioners and provide guidelines for policy makers and organizations in adopting strategies that enhance the delivery of sustainable construction projects.

A conceptual model has been developed to provide further guidance towards the identified factors that give rise to the indicators and the selection process that needs to be conducted by the practitioners. The model's contribution in using underlying factors for the successful PM to construct sustainable built assets is to provide a selection protocol for choosing indicators, including some of the main criteria that need to be considered.

Depending on the perception, the findings could support the decision-making process of senior management in adopting novel sustainability schemes. The final five factors were central in approaching the needed PM context for sustainable construction projects and deepening understanding of sustainable PM practices by providing insights into its core attributes.

6.2.4 RO4: Propose a Multi-Criteria Decision Analysis-based method to assess the integration of the sustainability philosophy in large-scale organizations via the utilization of sustainable project management-related indicators

Integrating the sustainability philosophy in large-scale organizations via the utilization of sustainable project management-related indicators was perceived through a newly structured questionnaire that was disseminated to selected participants of the organization investigated (case study). The survey practically consisted of a list of indicators and a brief description. The respondents were called to evaluate the performance value of each indicator based on a scale of 1–9 (1 = poor performance and 9 = highly efficient performance). The evaluation was conducted in relation to the organizational performance of the department that the interviewees were part of. The main difference between this questionnaire and the previously used in RO2 and RO3 was the total number of indicators used. In this survey, 41 indicators were used and not 82 as the initial recognition was. The diminution of the initial list of indicators was based on the findings derived through RO2. Through the RII scores of the principal sustainable project management indicators, the most contributing ones were chosen according to the stakeholders' views. Subsequently, 41 indicators were above the specified RII score of 0.80. The reasons behind this diminution of the principal list of indicators included the readiness to accomplish a high response rate and a quick completion time of the questionnaire survey.

By using all the information as extracted from the survey, a Multi-Criteria Decision Analysis-based method, namely PROMETHEE, was employed to rank the alternatives (departments of the organization) with respect to sustainability's TBL criteria. After thoroughly reviewing recent literature, it was concluded that the PROMETHEE method could complete such an analysis and provide reliable results. The primary input data for the analysis were the weights of the criteria, as these were identified during RO2 and the questionnaire survey results.

The Rail/Transportation/Infrastructure Department alternative was clearly the most prominent, with the department's workforce using preset sustainable PM metrics as a requirement for achieving sustainable projects. Organizational sustainability can assist organizations in focusing their efforts on specific issues (enhancing sustainable outcomes). Such factors were also taken into account by departments with lower scores in the analysis, indicating that their internal organizational sustainability policies had room for improvement. Overall organizational sustainability is unquestionably improved by improving its sustainability features. Sustainable PM indicators that incorporate the TBL spectrum can assist in this direction by identifying essential aspects of sustainability, allowing organizations to make informed decisions about becoming more sustainable. The outcomes may also aid in data gathering and analysis. The practical implementation of the conducted MCDA method (case study) derives through the indicators used in the proposed model related to key aspects of organizations and measure how the departments' staff utilize sustainable project PM in their construction projects. Accordingly, organizations seeking the same insights can utilize the proposed approach to compare internal organizational structures, reveal the sustainability integration level within their different business units and thus make decisions towards sustainable practices. By utilizing the proper indicators (depending on the organization), the followed method could provide viable results for the organization that applies it.

6.3 Contribution to knowledge

According to Mauch and Birch (1989), "*to make a contribution, one must discover a hoard of new information, demonstrate a new truth, devise a new instrument, or at least construct and validate an original theory*." The doctoral dissertation is expected to represent independent and original research in the analyzed field. Wobbrock and Kientz (2016) designate in their study the significance of the empirical contribution for the overall body of knowledge to deliver considerations using empirical data in an organized and integrated manner. Adding to the empirical contribution, Colquitt and Zapata-Phelan (2007) address the value of the theoretical contribution for research. Creating a concept and testing it to summarize the relevant indicators/factors/variables and describe or explain the interactions linked to the analyzed theme constitute a noteworthy contribution to knowledge.

This thesis reveals contribution to knowledge through the critical examination of data not previously dealt with and the re-examination of methods from new points of view. Empirical observations, as well as theoretical contributions, can be located throughout the whole thesis. The SLR of previous empirical studies on sustainable PM for construction projects resulted in selecting and categorizing the final set of indicators for construction projects. The literature analysis also indicated the need for more empirical studies on the suggesting topic of sustainable PM indicators in construction projects, as there is currently no widely accepted practice for achieving sustainability in construction projects. Theoretical contributions to knowledge of this thesis involved the reveal of the usefulness of sustainable PM indicators, which are used to enable sustainable construction projects; it examined the stakeholders' beliefs and attitudes who adopt sustainability approaches in the construction sector and showcased the underlying factors that give rise to the set of the 82 sustainability indicators.

The theme analyzed presented sufficient complexity and scope to constitute a subject worth further researching. The conducted SLR revealed limited previous research analysis in the emerging themes of sustainability, PM, and the use of relative indicators for delivering sustainable construction projects. The results of this thesis can be beneficial towards the understanding of the use of sustainable PM indicators to attain sustainable construction projects. It can constitute a useful guide for practitioners who wish to focus their sustainable PM efforts on specific indicators and further proceed to contribute implementations in their projects. Under this philosophy, they will heighten sustainable PM effectiveness and the sustainability realization of construction projects. The fact that this research showcases views of international experts; the findings contribute towards the establishment of a widely accepted set of sustainable PM indicators for construction projects, which is a field that researchers have not profoundly engaged.

Mauch and Birch (1989) developed a series of questions that the researcher needs to successfully address when trying to acquire an original contribution to knowledge in the conducted research. Through the following questions, which have been slightly reformed to reflect the purposes of this chapter, the relative strength of the research is addressed:

1. Is there current interest in this topic in your field?
2. Is there a gap in knowledge that work on this topic could fill?
3. Can you envision a way to study the issue that will allow conclusions to be drawn with substantial objectivity?
4. Is the data collection acceptable by the academic community?
5. Is there a body of literature relevant to the topic?
6. Are there significant problems to be surmounted in working on this topic?
7. Are the needed data easily accessible? Will you have control of the data?

While the first question appears irrelevant to an original contribution to knowledge, it adds additional value to the extracted results as academics seem to showcase other interests to "popular" present fields that embrace society's concerns. As for the analyzed field of sustainable project management, it is undoubtedly a theme of the new era (Jayanti and Rajeev Gowda, 2014, Kivilä et al., 2017, Saunila et al., 2018).

The second question is vital to original contributions to knowledge. The field of sustainable project management in construction projects is still a relatively new concept with plenty of gaps, and there are various studies in the area that reveal the need to move towards this direction (Martens and Carvalho, 2017, Karunasena et al., 2016, Silvius and Schipper, 2020).

Questions 3 to 5 and question 7 are focused on the direction of managing the data pool and the actual research that will enhance the overall body of knowledge. They showcase the constructive nature of the research towards inductively exploring and contributing to the development of the analyzed topic. Furthermore, they act as a key factor in deciding whether the examined theme should be further investigated.

Question 6 centers on the literature review that needs to be conducted systematically to determine the remaining “problem” that needs a solution, which will add as an original contribution to knowledge. In this research context, the conducted SLR revealed a set of sustainable PM indicators that can lead to a sustainable construction project and opened the discussion towards a universal set of indicators for this purpose.

Ultimately, the research encircling “What is an original contribution to knowledge” is quite broad and applying certain criteria can quickly provide evidence that research constitutes an academic contribution to knowledge.

The novel contributions of this research to the topic area are as follows:

1. **The development of a holistic view of sustainability for project management in construction projects** was obtained by revealing a set of sustainable project management indicators, covering the full spectrum of the triple constraint (TBL) and the consideration of the views of all construction project stakeholders to fill a gap in knowledge of the principal indicators leading to sustainable construction projects. This research also broadened the standpoints concerning the sustainable construction concept by revealing the underlying factors that give rise to the set of the already defined sustainability indicators used to enable sustainable construction projects.
2. **The development of a conceptual model for the use of the underlying factors for the successful PM to construct sustainable built assets** was created to confirm the stakeholders’ valuable input (beliefs and attitudes) as an insight for revealing the five underlying factors derived from the set of sustainability indicators.
3. **The development of a decision-support tool in dealing with organizational sustainability assessment** was created by exploring a MCDA method to evaluate organizational sustainability in large-scale organizations via the utilization of sustainable project management-related indicators.

6.4 Research Limitations

Limitations to the research derived from the methodological choices, constraints put on the case study, as well as the vast and vague field of sustainability. The exploratory nature of this research broadly explores and analyzes the quarrelsome topic of sustainable PM.

The first part of this research included the disclosure of the final set of indicators, as these were derived through a SLR and further validated through semi-structured interviews with experts. Despite conducting the research scientifically and systematically, the qualitative approach to retrieve and analyze the final documents that included the set of indicators involved subjectivity attributes by the researcher. Thus, it can be considered as a limitation of this research. Another generic limiting parameter that can be outlined in all research endeavors is the time for conducting research. All the described methodological steps are subject to time duration. Concerning the extracted data from the interviews, the participants had relative previous working experience from only two countries (Greece and the UK), which may be considered as a limitation of this research. Based on the respondents' past construction management experience and present and former working experience; all interviews were semi-structured and centered on the issue of sustainable PM in construction projects.

The second part of this research involved the analysis of the distributed questionnaire to experts (stakeholders) to uncover valuable insights into the analyzed topic. Limitations of the value of the retrieved data as extracted through the online questionnaire survey come with the fact that some of the respondents may possess inadequate professional experience in properly evaluating all the sets of indicators. Another limitation of this survey is that while the final number of respondents involved reveals previous relevant experience to all continents, a country-based study could fine-tune the results for the specific context. Finally, the number of respondents combined with the proper expertise to more accurately correspond to the needs of the study can also be considered as a limitation, as a larger sample can provide more robust results.

Concerning the conducted EFA to reveal the five underlying factors that contribute to sustainable PM practices, limitations come with the fact that the EFA results are based on post hoc analysis and subject to possible errors. The cumulative variance explained in this analysis captures around 45%. It is widely accepted by literature that relatively low variance implies that multiple variables failed to show salient associations with the underlying factors. This can also be a limitation of this research.

The final part of this research involved a case study in a large-scale organization in assessing the integration of the sustainability philosophy via the utilization of the predefined sustainable PM-related indicators. A typical limitation of the case studies is that their outcomes cannot be generalized unless repeated to numerous cases. While in this case, the use of the specific case study was not to reach general conclusions about the level of integration of sustainability aspects in organizations but to illustrate how the proposed method (MCDA) could be implemented in order to help organizations identify opportunities for enhancing the sustainability processes among their departments, additional case studies can provide more robust results.

6.5 Recommendations for further research

As described in the previous chapter, the limitations of this research can open the research agenda for further studies. Based on the research findings, future studies may deductively leverage the descriptive character of this research to focus on direct relationships of influencing sustainable PM indicators for the construction industry. More empirical studies are encouraged towards evaluating or enhancing the contribution of the sustainable PM indicators for delivering sustainable construction projects in order to enhance the generalization and validation of the research outcomes.

Following the results of this research, future opportunities may include the examination of other aspects of sustainable PM via the utilization of indicators, such as stakeholder characteristics and lifecycle management, which can be applied to more countries in order to identify varieties amongst different manufacturing features. Further research should be conducted for different types of projects in order to validate their usage as generic or construction-specific. Thus, more studies are needed to cross-check the precision and applicability of the extracted indicators for sustainable construction projects.

There is currently no commonly recognized approach for attaining sustainability in construction projects, following the results of the conducted SLR; thus, additional empirical studies on the promising use of sustainable PM indicators in construction projects are needed. Accordingly, mapping all feasible control mechanisms for sustainable PM across all types of construction projects, analysis of issues that may arise during project phases, and comparison of the outcomes using the TBL scenario of sustainability might constitute a possible line for future research. Indicators can be quite beneficial in this regard.

Concerning the interview and the questionnaire data, future studies should focus on gathering more wide-ranging data by more respondents from all over the world or country-focused instead. Additionally, researching among non-construction professionals to see if they share the same opinions about sustainability in PM as the construction professionals can also be proved contributing.

The exploitation of the derived indicators and factors (as revealed by the EFA) by senior management in delivering sustainable construction projects should be tested in practice. The results will reveal fitting and utility issues imminent to sustainability, and thus possible factor/indicator redeveloping. Correspondingly, fine-tuning of the underlying factors for different types of construction projects would move this research one step forward. Another line of inquiry for future research could be the analysis of the applicability of these factors before and during the implementation of a project. Moreover, additional qualitative research is needed to evaluate the importance of the underlying factors and their management to produce sustainable assets.

The developed conceptual model for selecting amongst indicators can also be the start for the development of an in-depth analysis of such a method.

The conducted case study in the organization revealed new paths for further research. Supplementary focus on analyzing more large-scale organizations can be piloted so that a larger sample may lead to more robust results. Another line of inquiry for future research can be the analysis of additional scenarios to evaluate the effectiveness of the internal organizational structures in delivering sustainable projects. Finally, while the MCDA method developed, namely PROMETHEE, provides an assessment of the alternatives, the combined use of additional ranking methods (i.e., ELECTRE, AHP, etc.) can also be another possible inquiry for future research.

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