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DEVELOPMENT OF ECO-INNOVATIONS IN CIVIL CONSTRUCTION: A THEORETICAL PROPOSITION

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ABSTRACT

Concern for the environment and the future of the next generations has been increasing in recent years, creating pressure for companies to adopt eco-innovation practices. The construction sector is one of the most responsible sectors in the world for resource consumption, waste production and greenhouse gas emissions. However, the adoption of eco-innovation practices in this sector, especially in developing economies, such as Brazil, remains little explored in the literature. Thus, the present study aims to propose a method for the development of eco-innovations that are capable, throughout their life cycle, of reducing the environmental impact in the sector. To respond to this objective, a Systematic Review of the Literature was carried out through which it was possible to evaluate the state of the art of eco-innovation in civil construction. Subsequently, a complementary review of the literature was carried out to understand how similar development proposals are constructed. With this information, a method was proposed and validated by three doctors who are experts in the area. As a practical implication, the work presents a method composed of five stages of proposed activities that, in a clear and didactic way, allows the creation of a schedule to guide managers in the implementation and management of eco-innovations in the Civil Construction sector. As a theoretical implication, the research aims to advance scientific knowledge on how to implement, manage, and evaluate this type of innovation, filling a gap in the existing literature.

Keywords: Civil construction. Innovation. Eco-innovation.

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INTRODUCTION

For more than a decade, institutions such as the United Nations (UN) have highlighted the impact of climate change on daily life and have influenced the development of international public policies. The impacts of climate change are increasing in terms of severity and reversal is becoming unlikely, driving a paradigm shift in environmental conservation to facilitate inevitable transitions, particularly in more vulnerable areas (Keppel et al., 2024), health impacts are increasing and intensifying with rising global temperatures, necessitating urgent research to emphasize these issues scientifically, politically and technically.

In recent years, the growing global concern with environmental issues, the strict regulations arising from international conventions for sustainability and environmental protection, and an increase in the number of pro-environmental consumers have led industries to dedicate significant efforts to the development of sustainable practices. Until a few years ago, however, the academic community paid little attention to the role of organizations in protecting the environment (Albort-Morant et al., 2017).

In this way, and despite recent attempts by many researchers to understand and explain the subject, the construct of eco-innovation (EI) remains open to interpretation even in relation to its most necessary aspects. aspects, including the definitions or types of innovation, measurement, selection, and management. This ambiguity has led to a significant escalation in the number of research papers, conference sessions, and workshops on EI around the world. Special issues focused on EI are beginning to appear in academic books and scientific articles. The wide variety of studies contributes to the vitality and richness of IE research, but also creates some confusion as to the meaning and usefulness of the construct (Albort-Morant et al., 2017).

Eco innovation aims to improve the environmental performance of organizations by decreasing or changing the consumption of natural resources and reducing negative environmental impacts (Hermosilla et al., 2010), on the other hand Pan et al. (2020) define eco innovation as, an important approach to solve current environmental problems, for Hizarci-Payne et al. (2021) the term eco innovation has been used interchangeably with green innovation and sustainable innovation and state that, Although eco-innovation is considered a category of innovation, it mainly deals with environmental aspects. This article uses the definition that was most repeated throughout the articles researched in the RSL, given by Kemp & Pearson (2007) where, for the authors, EI is defined by the development

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of a product, production process, service or business management methods new to the company, which results, throughout its life cycle, in reducing environmental impact compared to relevant alternatives.

As the sector to be studied in this research, civil construction was chosen because it generates a significant contribution to the sustainable development of the global economy, achieving development objectives, including job creation, redistribution, income generation and production (Durdyev et al., 2017). The construction sector evidently has a strong relationship with sustainable development in a triple result of: economic growth, environmental impact and social progress (Durdyev et al., 2017). The look of sustainability research more focused on industrial or technological sectors, placed the civil construction sector on the margins of research, observing a lack of studies focusing on sustainability in the sector, due to its specific characteristics that make it difficult to collect and generalize data since each product is always different from each other, which makes it difficult to produce more in-depth studies (Lópes Pérez et al., 2024).

However, its harmful effect on the environment should not be disregarded, and can be exemplified by the production of 35-40% of CO2 emissions, consumption of 60% of the raw materials produced, 25% of the total consumption of wood, 40% of the production of solid waste, consumption of 40% of the total energy production and 16% of the use of drinking water worldwide (Lópes Pérez et al., 2024).

This subject has been notably discussed over the past decade, as evidenced in recent literature reviews (Lópes Pérez et al., 2024; Albort-Morant et al., 2017). Part of the work focused on the barriers and drivers for the adoption of EI (Dugonski & Tumelero, 2021; Abdullah et al., 2015; Pourvaziri et al., 2024; and another part, in the factors that determine the success of ECE (Kesidou & Demirel, 2012; García-Granero et al., 2020). There is a need in the literature for a methodological approach to guide the process of selecting and evaluating eco-innovations in companies (Hizarci-Payne et al., 2021).

This article is derived from a doctoral thesis under development by the author Vinícius Rodrigues Silva Pires – Universidade Nove de Julho (UNINOVE), São Paulo with a sandwich period at the Instituto Superior de Economia e Gestão (ISEG), Lisbon, supervised by Professor Claudia Brito Silva Cirani (UNINOVE) and Co-supervised by Professor Graça Maria de Oliveira Miranda Silva (ISEG) with a defense scheduled for the year 2025, develops a methodological framework to support the process of selection, implementation and evaluation of ECE from a theoretical proposal using the *roadmap,* a

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valuable tool for organizations, as it provides guidance to progress from one level to another in the pursuit of specific objectives, resulting in a clear and objective roadmap that can guide managers (Veile et al., 2019). This tool was chosen because it is frequently used in research in the civil construction sector such as: Pires 2021; Jiang et al., 2024; Singh etal., 2023 and Budayan & Okudan 2022, for the development of the method and thus help companies achieve their Sustainable Development Goals (SDGs).

With the result of the Systematic Review of the Literature, it was noted the lack of research on how ECE can be managed in the context of civil construction, thus arising the following research question: How should eco-innovations in the civil construction sector be selected, managed and evaluated? With the general objective of developing a method to implement eco innovations in the civil construction sector and as specific objectives: to synthesize the existing notes in the literature on the barriers and drivers of the implementation of eco innovations, focusing on practices and challenges identified and to develop a method that guides civil construction managers in the implementation, management and evaluation of eco innovations.

This study is justified due to the gradual increase in the importance of ECE in business, especially in a sector as impactful as civil construction (Jiang et al., 2024), in the face of scarcity of resources and misallocation of waste generated in the sector (Singh et al., 2023). Although the academic community has been focusing on innovation for many years (Schumpeter, 1957; Drucker, 1987; Christensen, 1997), studies on eco-innovations still need to be further developed (Rennings, 2000; Kemp & Pearson, 2007).

Based on the Sustainable Development Goals, the research is justified in its items:

- - 8 which discusses the promotion of inclusive and sustainable economic growth, full and productive employment and decent work for all where the improvement in the efficiency of the Civil Construction sector is directly linked to this achievement.
- - 11 which discusses making cities and human settlements inclusive, safe, resilient and sustainable directly linked to the development of more sustainable infrastructure, which is the responsibility of the sector studied.

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THEORETICAL FRAMEWORK

Silva et al. (2006) present innovation as a differential, expansion and customer loyalty, in addition to having the potential to increase profitability, the authors also mention that those who innovate faster obtain competitive advantages.

Barbieri & Simantob (2007) point out that for companies to contribute to sustainability, innovating is essential, establishing new modes of production compatible with a sustainable extraction of natural resources.

The concept of sustainable performance is defined as the combination of the economic, social and environmental performance of companies (Chardine-Baumann & Botta-Genoulaz, 2014). Economic performance is related to the optimization of a company's financial and economic prospects. Social performance refers to the consequences of the company's efforts in managing reputation, social image, and customer relationships (Liu et al., 2023). Social performance is also measured through indicators such as improvement in employee safety and health, improvement in community quality of life, improvement in working conditions (Afum et al., 2021; Abdul- Rashid et al., 2017). Finally, environmental performance addresses an organization's ability to reduce the impact of its activities on the environment. This includes the reduction of solid waste and pollution, unsafe materials, and environmental accidents (Singh & Chakraborty, 2021; Afum et al., 2020).

The company's capacity for innovation determines its ability to adopt environmental practices in management and operational processes (Juarez & Vergara, 2021). Empirical evidence shows that this company's capacity for innovation is crucial to maintaining competitive advantage and influences the company's performance (Juarez & Vergara, 2021).

Innovation and design are two words that must go together when we talk about one of the main drivers of business success (Scarpellini et al., 2020). Innovations become eco-innovations, also known as green innovations, sustainable innovations, and environmental innovations (Hizarci-Payne et al., 2020), when they are inspired by an important concept in this area: ecodesign. According to García-Sánchez et al. (2020), ecodesign is the development and commercialization of technologies, products, and services aimed at mitigating the impact they may cause to the environment.

Hand in hand with ecodesign, we find eco-innovation, a concept that has been discussed numerous times throughout the existing literature and which consists of the use

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of techniques, processes, systems and products in order to reduce or avoid damage and impacts on the environment (Vence & Pereira, 2018), combining innovation with sustainability, resulting in new products or processes (Fussler & James, 1996). The term "eco-innovation" came into use in the mid-1990s, however, this key concept has gained more interest in the last two decades (Hizarci-Payne et al., 2020).

Eco-innovation has a higher level of complexity compared to other types of innovations (Perl-Vorbach et al., 2014). They are motivated by different factors and face the problem of double externality, where involuntary spillovers of knowledge reduce the incentives of firms to invest in eco-innovations (Rennings, 2000).

Eco-innovation aims to improve the environmental performance of organizations by decreasing or changing the consumption of natural resources and reducing negative environmental impacts (Hermosilla et al., 2010). Professional academics see eco-innovation as an important element in the transition to a more sustainable future (Del Río et al., 2015).

The term eco innovation has been used interchangeably with green innovation and sustainable innovation (Hizarci-Payne et al., 2021). Although eco-innovation is considered a category of innovation, it mainly deals with environmental aspects, making changes oriented to the environment, products, services, and marketing strategies (Hizarci-Payne et al., 2021).

Globally, the building construction sector accounts for approximately 50% of the demand for cement and 30% for steel. These factors show the importance of extending the useful life of buildings and replacing their inputs with materials with lower embodied carbon content (GSRBC, 2023).

Civil construction is responsible for the consumption of 12% of the total fresh water on the planet, and the cement industry is responsible for 40% of all waste generated in cities, being one of the most polluting in the world and, according to (Usón et. al., 2011), 60% of the raw materials extracted are used by the sector.

Despite its importance, it is not seen by the consumer as an innovative sector of the economy (Ferreira & Theófilo, 2006), it has specific characteristics that hinder the generation, implementation and management of innovation, such as unique outputs, in addition to having a complex relationship with the production chain depending on other companies and other sectors, in addition to its products having a long useful life (Vergna, 2007).

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Strategies to make buildings net-zero energy and zero-carbon are a key part of the global decarbonization strategy and must become the primary way of constructing buildings in all economies to achieve net-zero emissions by 2050 (GSRBC, 2023).

Global trends such as urbanization, demographic and climate change create a growing demand for housing that meets the needs of current and future societies. The housing sector faces major challenges, such as 3 billion people who will need access to adequate housing by 2030, a doubling of the world's population aged 60 and over by 2050 (WHO, 2015) and the more frequent occurrence of extreme weather events associated with climate change (GSRBC, 2023).

Investing in good quality and affordable social housing can significantly improve the overall health of society. Inadequate housing costs EU economies almost €194 billion a year in terms of healthcare, social costs and lost productivity. It is estimated that bringing the housing standard to an acceptable level across Europe will cost around 295 billion Euros. This implies that the investment can be repaid in just 18 months (GSRBC, 2023).

Global material use is projected to more than double by 2060, and materials used in the construction sector will account for a third of this increase. CO2 emissions will also increase as a result of the use of materials Wilts et al. (2013), which increasingly drives eco-innovations in the sector.

Sustainable building practices were emphasized to start in the planning phase and continue after the completion of a construction project. The implementation of green practices in the construction industry can be influenced by factors such as demographics, culture, norms, and government policies and may vary between regions and countries (Karji et al., 2020).

Most of the current literature on green practices focuses on developed countries, highlighting the need to pay more attention to the case of developing countries Zaidi et al. (2019) since, the excessive rate of construction in developing countries leads to various sustainable construction management problems, resulting in environmental and ecological problems (Chang et al., 2016).

Initially, approaches to sustainable construction were more concerned with technical issues (resource efficiency and reducing the environmental impacts of construction) than with the economic and social aspects of sustainability. The basics of sustainability are still in their infancy. For example, in developed countries, efforts are focused on using resources efficiently while reducing environmental impact, while developing countries have

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a lower degree of achievement (i.e., the lack of energy codes for buildings), which makes the adoption process challenging (Chang et al., 2016).

In addition, it was discovered that a common problem among stakeholders, the lack of knowledge about sustainability, where, surprisingly, the construction sector was considered the least informed. Various sustainability assessment tools and methods have been introduced, especially by advanced countries and some developing countries, to assess the sustainability of ventures (Wang & Kim, 2015).

For the construction of the model proposed by this article, the roadmap structure was chosen because it is a flexible technique widely used in the industry to support strategic and long-term planning. The approach provides a structured (and often graphic) means to explore and communicate the relationships between markets, evolving and developing products, and technologies over time. The *roadmap* can help companies survive in turbulent environments by providing a focus for scanning the environment and a means of tracking the performance of individual technologies, including potentially innovative and disruptive technologies. Technology roadmaps are seemingly simple in terms of format, but their development poses significant challenges. In particular, the scope is generally broad, encompassing a range of complex conceptual and human interactions (Phaal, 2004).

The *roadmap* is complex and constantly evolving, it is a process that involves many parameters at the same time. For example, it should be related to the company's interests and limitations and government rules, to scientific or technical needs, and to current public requests (Viola et al., 2020).

Being a set of activities aimed at identifying and selecting technologies, mission concepts, and organizational capabilities according to specific strategic plans, from the definition of a set of goals to be achieved, the process identifies the critical requirements of the system, the product to be achieved, the process to be developed and the technological alternatives to achieve the goals, being thus chosen in this research (Viola et al. 2020).

METHODOLOGY

To synthesize the existing knowledge about the barriers and drivers that lead companies to adopt eco-innovations and to discover the research gaps that could be worked on, an RSL can be defined as a process whose objective is, through basic and reproductive methods, to identify, evaluate and summarize primary studies related to a

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specific topic (Cerchione & Esposito, 2016). This review method is useful for compiling research efforts on emerging topics in addition to identifying challenges for future studies (Potrich et al., 2019).

The string The search engine was formed from the keywords: "Eco Innovation barriers and drivers" and their synonyms, aiming to cover as many possibilities as possible, since, by restricting the keywords to the specific sector of the research, not enough results were found for analysis, Chart 1 describes the research protocol applied.

Chart 1 - RSL Research Protocol

Research Protocol	Description
Databases	Scopus and Web of Science
Publication type	Articles
Languages	English
Period	There was no restriction regarding the period
Search field	Title, abstract and keywords (*Scopus*) and topic (*Web of Science*)
Search term	In the Scopus database 267 documents ("eco-innovations" OR "sustainable innovations" OR "ecological innovations" OR "Green innovations") AND ("drivers" OR "motivating factors" OR "impetuses") OR ("barriers" OR "obstacles" OR "challenges") AND ("companies" OR "construction industry" OR "civil engineering" OR "building sector") Limiting filters: Areas: Business, Management and Accounting; Environmental Science and Social Science Document Type: Article; Publication stage: Final; Language: English and Portuguese.
Search term	In the Web of Science database 225 documents ("eco-innovations" OR "sustainable innovations" OR "ecological innovations" OR "Green innovations") AND ("drivers" OR "motivating factors" OR "impetuses") OR ("barriers" OR "obstacles" OR "challenges") AND ("companies" OR "construction industry" OR "civil engineering" OR "building sector") Limiting filters: Categories: Management, Environmental science, Construction building technology and Green Sustainable Science Technology; Document Type: Article; Language: English and Portuguese.
Inclusion criteria	Empirical and theoretical articles, in English, field of study in private and public capital companies, articles that evaluate eco-innovations in general in companies as well as articles that evaluated their barriers and drivers of driving and articles that used quantitative, qualitative and mixed methods.
Exclusion criteria	Articles that mistakenly use the term eco-innovations, or that discuss eco-innovations in other contexts of application that differ from the research question of this study, articles that discuss sustainability

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	practices and not eco-innovations, book chapters, articles published in a language other than English.

Source: Prepared by the author (2024).

The search resulted in 1,145 articles, of which 458 were obtained from the *Scopus database* and 687 from the *Web of Science* database. The filters described in table 1 were applied to the raw results found, resulting in 492 articles that were listed in Excel, the repeated articles were excluded, allowing a first filtering by reading titles and abstracts. By the filtering processes demonstrated, 935 studies were cut, leaving 210 studies selected to contribute to the research in development.

We began by searching for the original and complete texts of the 210 articles for the reading of abstracts and keywords in order to eliminate studies that:

- - Were not peer-reviewed
- - The content diverged from the research of this RSL, such as studies that did not contain the barriers or drivers for eco-innovations as well as studies that used the term as sustainability practices.

This process of prior reading of the studies discarded 168 articles, resulting in 42 studies, after each filtering phase according to the recommendations of the PRISMA protocol (Page et al., 2020).

For the second stage of the research, the definition of the expected results and the objectives that the solution should present, a complementary literature review was carried out focusing on models already proposed similar to the objective of the article, evaluating their scope, their form of construction as well as their effectiveness.

For the complementary review, the search string was formed from the keywords: "Eco Innovation, models, *framework* and *roadmap*" and their synonyms, with the objective of finding proposed models with the same or similar themes, which can guide the construction of the proposed model, chart 2 demonstrates the protocol followed, similar to that of the RSL.

Chart 2 - Research Protocol of the Complementary Review of the literature

Research Protocol	Description
Databases	Scopus and Web of Science
Publication type	Articles
Languages	English
Period	There was no restriction regarding the period
Search field	Title, abstract and keywords (*Scopus*) and topic (*Web of Science*)
Search term	In the Scopus database 167 documents

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	("eco-innovations" OR "sustainable innovations" OR "ecological innovations" OR "Green innovations") AND ("model" OR "framework" OR "roadmap") AND ("companies" OR "construction industry" OR "civil engineering" OR "building sector") Limiting filters: Areas: Business, Management and Accounting; Environmental Science and Social Science Document Type: Article; Publication stage: Final; Language: English.
Search term	In the Web of Science database 135 documents ("eco-innovations" OR "sustainable innovations" OR "ecological innovations" OR "Green innovations") AND ("model" OR "framework" OR "roadmap") AND ("companies" OR "construction industry" OR "civil engineering" OR "building sector") Limiting filters: Categories: Management, Environmental science, Construction building technology and Green Sustainable Science Technology; Document Type: Article; Language: English and Portuguese.
Inclusion criteria	Empirical and theoretical articles, in English, field of study in private and public capital companies, articles that contained proposals for models for the implementation and development of innovations and eco-innovations.
Exclusion criteria	Articles that mistakenly use the term eco-innovations, or that discuss eco-innovations in other contexts of application that differ from the research question of this study, and articles in languages other than English.

Source: Prepared by the author (2024).

The search resulted in 302 articles, 167 of which were obtained from the *Scopus database* and 135 from the *Web of Science* database. The filters described in table 2 were applied to the raw results found, resulting in 84 articles that were listed in Excel, repeated articles were excluded, which then allowed filtering by reading titles and abstracts, at this stage another 50 articles were discarded because they did not present similar characteristics with the research proposal.

The original and complete texts of the remaining 34 articles were found for full reading, in order to identify and eliminate studies in which the content diverged from the research, such as studies that did not propose the development of new models for selection, implementation or management.

This process of complete reading of the studies discarded another 24 articles, resulting in 10 studies, which were used as a complementary reference for the development of the model proposed by the article.

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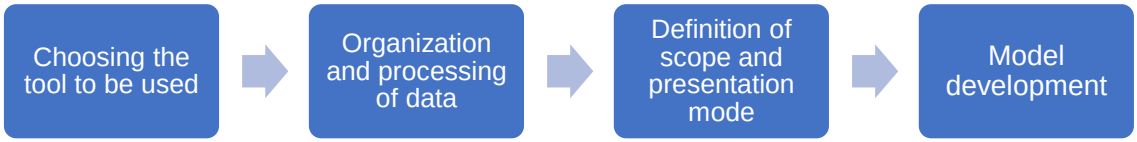
The third stage of the project involved the planning and development of the artifact, the planning took place in four stages where, step one corresponded to the choice of the tool that would be used, step two the organization and treatment of the data for inclusion in the tool, step three the definition of the scope and way in which the tool would be presented, by observing the existing tools presented and in step four the development of the model as in figure 1.

Figure 1 - Model construction



Source: Prepared by the author (2024).

In step one, the choice of the *roadmap* as a tool to be used was for some reasons, such as the author's experience with the tool already used in the development of other projects, familiarity of the target sector with the tool, since sectoral publications such as CBIC (2022) present this tool to managers, academic publications focused on the topic such as Pires 2021; Jiang et al. 2024; Singh etal., 2023 and Budayan & Okudan 2022 and no less important, the fact that the *roadmap* is a clear and objective tool because it presents a graphical approach, presents the information in a logical way and provides ease of management of the objective by managers (Phaal, 2004).

In the second stage of the artifact development process, the data were organized and treated, taking into account the result of the RSL, the data resulting from the research were selected according to the company's possibilities of action, where the barriers considered were: Organizational Capabilities, Demand, Information, Financial Resources and Human Resources, and Public Policies were excluded, since, The company has no control over this. As drivers: Relationships, Organizational Direction and Demands, excluding Government Incentives and Financial Advantages, one outside the company's control and the other a result of work.

The strengths of the use of the tool found in the RCL were added, described in the results, such as: logical organization of the data collected and clarity and simplification of the demonstration of the objectives to be achieved.

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Concomitantly with the results of the bibliographic research, the premises of the tool were also taken into account for the construction of the article's *roadmap* proposal . For Phaal (2004), the *roadmap* should contain an overview of the project, a schedule, steps to be followed, means of evaluations throughout the process, in addition to demonstrating the necessary resources and stakeholders, and it also needs to be flexible, so that it can be changed if new demands arise throughout the process.

In the third stage, to define the scope and mode of presentation, the models exposed in the Complementary Literature Review were taken into account, their positive points and limitations were discussed, where a sequential method was proposed, with verification steps along the way, which could encompass as much as possible what was generated in the bibliographic research and was in accordance with the trend of the literature exposed in the RSL and RCL.

In the fourth step, the model was generated using a free online tool, Lucidchart, to draw the *roadmap* presented in the results.

For its presentation, the *generated roadmap* went through a *checklist* to check if it contained the results of RCL's RSL as well as if it met the premises of a *roadmap* found in the literature, thus being described in detail in the results. At the end of the previous stage, the proposed model and its description were sent to three PhDs who are specialists in the area and involved with the research, by e-mail, with a request for them to evaluate the positive points, the limitations, as well as suggestions for possible improvements, which were promptly incorporated into the model.

RESULTS

The articles that made up the RSL were published between 2010 and 2024, when analyzing the sample, it is noted that the 42 studies were published in 24 different journals. Where the journal Sustainability with an impact factor of 3.9 concentrates the majority, with seven publications, closely followed by the Journal of Cleaner Production with an impact factor of 11.1 and 6 publications.

The data were extracted based on the literature review and its concepts presented, some topics were selected to answer the proposed research question, and the following matrix was created in chart 3.

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Chart 3 - *Data extraction matrix*

Topic	Description
Goals	Focused on identifying the real objective of the study and how much it could contribute to the answer of the research question
Method	It was sought to know which methods are used to develop research in the area to support the method that would be used
Barriers to eco-innovation	The information present in the studies that discussed the difficulties faced by companies for the development and adoption of eco-innovations was extracted
Drivers for eco-innovation	By reading the articles, information regarding the issues that somehow encouraged and boosted eco-innovations was separated
Conclusion	What was concluded from the study
Reference	APA citation of papers

Source: Prepared by the author (2024).

The first data extraction process was carried out based on the complete reading of the articles, which allowed, following the data matrix presented in Chart 3, to collect the necessary information to answer the RSL research question.

Table 4 - *Barriers to eco-innovations*

Barriers pointed out	Authors
Organizational capabilities	Cristiny et al., (2022), Triguero et al., (2022), Xavier et al., (2020), Aguilar-Fernández & Otegi-Olaso (2018), Amankwah-Amoah (2024), García-Granero et al., (2020), Baran (2021), Häggmark & Elofsson (2022)
Demand	Pourvaziri et al., (2022), Lopes et al., (2022), Ociepa-Kubicka & Pachura (2017), Kesidou & Demirel (2012), Anttonen et al., (2013), Urbaniec (2015)
Information	Abdullah et al., (2015), Triguero et al., (2022), Wilts et al., (2013), García-Granero et al., (2020), Saunila et al., (2018), Baran (2021)
Public Policies	Zhang & Yin (2023), Cristiny et al., (2022), Abdullah et al., (2015), Pourvaziri et al., (2022)
Financial Resources	Martínez-Martínez et al., (2023), Cristiny et al., (2022), Abdullah et al., (2015), Pourvaziri et al., (2022), Feng et al., (2024), Ociepa-Kubicka & Pachura (2017), Hazarika & Zhang (2019), Aghion et al., (2009), Aguilar-Fernández & Otegi-Olaso (2018), Saunila et al., (2018), Passaro et al., (2023), Häggmark & Elofsson (2022), Sperotto & Tartaruga (2021), Schäfer et al., (2024), Rodríguez-Rebés et al., (2024)
Human resources	Martínez-Martínez et al., (2023), Rodríguez-Rebés et al., (2021), Sperotto & Tartaruga (2021), Rodríguez-Rebés et al., (2024)

Source: Prepared by the author (2024).

In the same way that the barriers to eco-innovation were extracted from the articles, the same occurred with the drivers, which were grouped into topics: Relationships;

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Government incentives; Organizational direction; Demands and Financial Advantages, in addition to highlighting the authors who discuss each of them, which can be seen in Chart 5.

Table 5 - *Drivers of eco-innovations*

Drivers pointed out	Authors
Relationships	Martínez-Martínez et al., (2023), Cristiny et al., (2022), Triguero et al., (2022), Fernandes et al., (2022), Rodríguez-Rebés et al., (2021), Rodríguez-Rebés et al., (2024)
Government Incentives	Zhang & Yin (2023), Cristiny et al., (2022), Triguero et al., (2022), Fernandes et al., (2022), Román et al., (2021), Hazarika & Zhang (2019), Barforoush et al., (2021), Rodríguez-Rebés et al., (2021), Amankwah-Amoah (2024), Kesidou & Demirel (2012), Baran (2021), Qi et al., (2010), Hojnik & Ruzzier (2016), Anttonen et al., (2013), Hojnik & Ruzzier (2016)
Organizational direction	Zhang & Yin (2023), Cristiny et al., (2022), Fernandes et al., (2022), Román et al., (2021) Xavier et al., (2020), Luqmani et al., (2017), Aghion et al. (2009), García-Granero et al. (2020), Qi et al., (2010), Rodríguez-Rebés et al., (2024), Urbaniec (2015), Peters et al., (2024)
Demands	Cristiny et al., (2022), Fernandes et al., (2022), Román et al., (2021), Barforoush et al., (2021), Rodríguez-Rebés et al., (2021), Amankwah-Amoah (2024), García-Granero et al., (2020), Kesidou & Demirel (2012), Saunila et al., (2018), Passaro et al., (2023), Urbaniec (2015)
Financial advantages	Aguilar-Fernández & Otegi-Olaso (2018), Barforoush et al., (2021), Fang & Lv (2023), Saunila et al., (2018), Baran (2021), Häggmark & Elofsson (2022), Hojnik & Ruzzier (2016), Sperotto & Tartaruga (2021), Anttonen et al., (2013)

Source: Prepared by the author (2024).

The articles that made up the Complementary Literature Review (RCL) were published between 2016 and 2024, with a predominance for the year 2022, with three articles. The data collected sought to identify the way in which the *roadmaps* were built over time, their positive points and their limitations, aiming to help the construction of the proposed model.

When analyzing the sample, it is noted that the 10 selected studies were published in eight different journals. Where the journal Sustainability concentrates the majority, with three publications, indicating its importance in the segment, being highlighted in the two literature reviews, it is also noted that in the RCL the presence of journals such as Business Strategy and the Environment and the Journal of Business Logistics stand out with impact factors of 12.5 and 11.2, respectively.

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The data were extracted following the RSL pattern through a table created in Excel, some topics were selected to answer the question proposed for this sample, and the following matrix was then created, shown in chart 6.

Chart 6 - *Data extraction matrix*

Topic	Description
Goals	Focused on identifying the actual purpose of the study
Method	It was sought to know which methods are used to develop the *proposed* roadmaps
Problems solved	The information present in the studies that discussed the problems that were solved with the *proposed* roadmaps was extracted
Article limitations	When reading the articles, the information regarding the limitations that the authors themselves pointed out in their research was separated
Conclusion	What was concluded from the study
Reference	APA citation of papers

Source: Prepared by the author (2024).

The data extraction process was carried out based on the complete reading of the articles, which allowed, following the data matrix presented in Chart 6, to collect the necessary information to complement the RSL and allow the proposition of the model, then the selected models will be detailed.

After describing the main characteristics of the methods proposed in the articles, the specificities of each one were left aside because they are other contexts that are not part of the objective of the RCL. The most relevant questions were then selected so that they can incorporate the research proposal, positive factors and the limitations pointed out by the authors.

As positive factors, we can highlight that the presence of a graphic model that clearly incorporates the objectives and directions of the proposal was a relevant factor, as cited by Cenk & Okudan (2022) and Polas et al. (2022).

Another factor pointed out in the research is the simplicity of the proposed method, since its common presentation is in graphic mode, simplicity allows the model to be well understood, which facilitates its acceptance as well as its application by interested parties, whether they are companies or government sectors, as expressed in the work of Polas et al. (2022).

Limiting factors were selected in the articles, which allowed us to understand the challenges to be overcome by the present research. Among them is the regionality of the

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sample, for Cenk & Okudan (2022) and Polas et al. (2022), with a sample selected based on only one region, the model may present difficulties in adhering to different contexts, different cultures, and in different sectors.

The complexity of the proposal was cited by Street (2016), demonstrating that the more complex the *roadmap* presented, the greater the difficulty of implementing it, to overcome this difficulty in his research, a parallel group was created to assist in the implementation of the *roadmap*.

Another limiting factor pointed out by the authors lies in very generic structures that end up not taking into account the specificities of the sectors or locations Remi et al. (2020), causing the result of the research to end up becoming insufficient, Villegas et al. (2022) suggest that for this purpose, other studies should be carried out to complement the research, which may point out, for example, other factors to include in the *roadmap*.

As a last limiting and no less important factor, Hsu et al. (2024) present difficulties in evaluating the *roadmaps* generated, either due to lack of practical application in case studies, as they point out, or because the proposal is very recent and has not given time for the development of more research in the sector, as in the case of Industry 5.0.

MODEL PRESENTATION

The construction of the model is summarized in Table 1, which presents the premises reached through the literature review and that were used in the proposition of the model:

Table 1 - *Assumptions for the construction of the roadmap*

Origins	Resulting notes for the construction of the model
Roadmap	Overview of the project, including the timeline, stages to be followed, points of evaluations, resources needed, and *stakeholders*, and is flexible.
Systematic Review of the Literature	Barriers: Organizational Capabilities, Demand, Information, Financial Resources, and Human Resources.
	Drivers: Relationships, Organizational Direction and Demands.
Revision Complementary to Literature	Positive points: Logical organization of the data, presence of a graphic model, simplicity of the proposed method, sectoral coverage.
	Limitations: Very generic structures, difficulties in evaluation, restrictions of the sample evaluated.

Source: Prepared by the author (2024).

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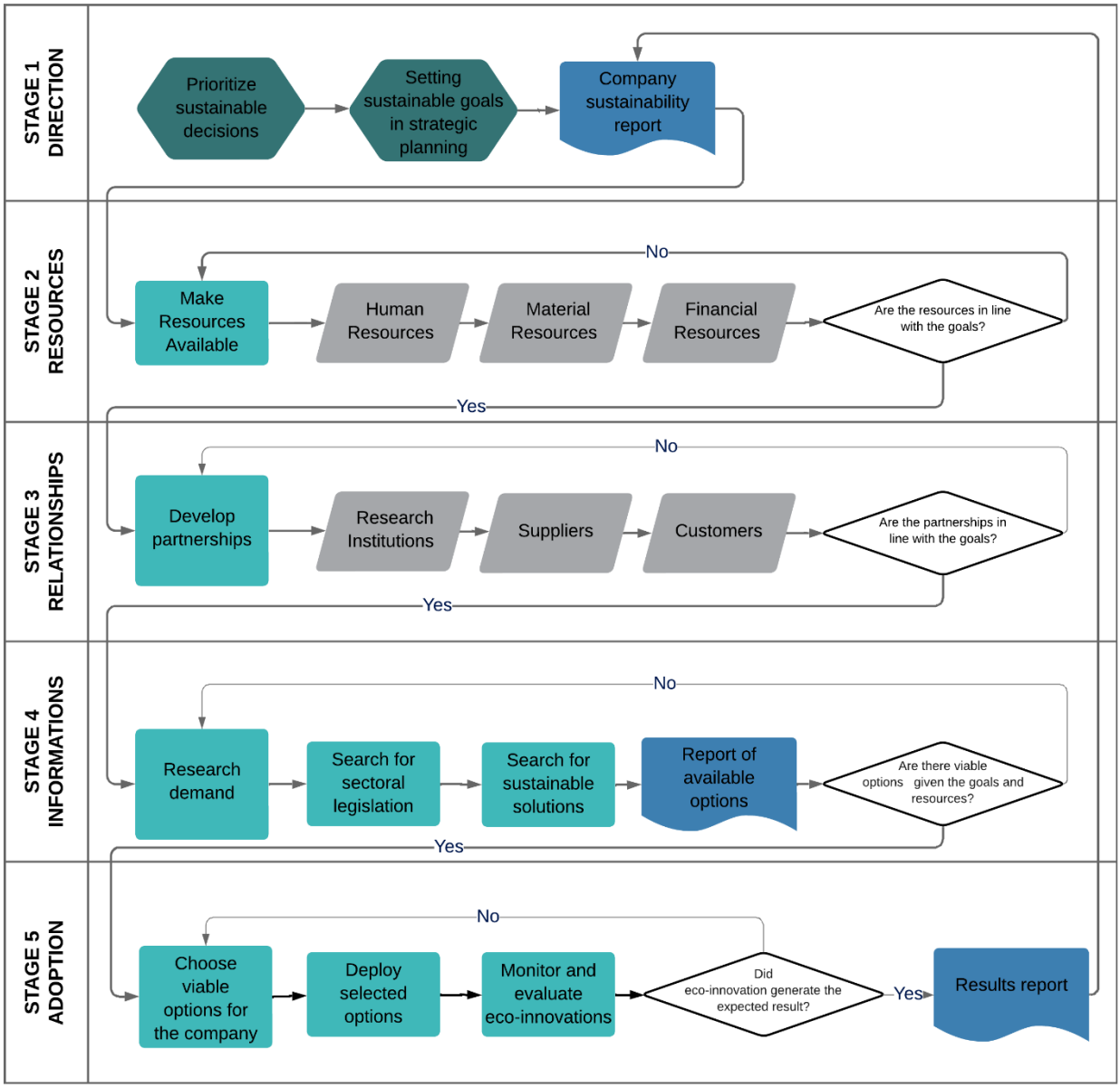
Figure 2 - *Proposed model*



Source: Prepared by the author (2024).

The model proposal was built with a graphical demonstration, presenting stages of development and evaluation points following the premises of the *Phaal roadmap* (2004). This proposal has five stages, following the way of construction of the models presented by authors found during the RCL such as: Cenk & Okudan (2022), Reim et al. (2020), Ghobakhloo et al. (2021), Villegas et al. (2022), Hsu et al. (2024) and Richey Jr et al. (2023). According to these authors, the presentation of the *roadmap* in stages allows for a better implementation flow, better manageability, greater clarity in information and ease of control of the time dedicated to each stage.

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The logical organization of the data collected in both the RSL and the RCL was divided into five stages that include the results obtained throughout the two stages of bibliographic research, stage 1 – Direction, stage 2 – Resources, stage 3 – Relationships, stage 4 – Information and stage 5 – Adoption.

Stage 1 was developed based on the arguments of Román et al. 2021 and Urbaniec (2015). For these authors, the desire to innovate in a sustainable way, when incorporated into the company's guidelines in its strategic planning, tends to motivate the organization in general in the search for new sustainable solutions. Thus, the first step of stage 1 is the inclusion of the sustainable development goals (SDGs) in the company's strategic planning.

For García-Granero et al., 2020 and Qi et al., 2010, a strong corporate culture in relation to the environment and managerial concern, based on the personal values and beliefs of the company's leaders about the importance of environmental protection, are relevant factors for the organization's members to be encouraged to develop new sustainable ideas, in addition to, facilitate the incorporation of new sustainable procedures into their routines. Based on these premises, it was proposed that the second step of stage 1 be the prioritization of sustainable decisions.

With the first two steps of stage 1 completed, a report is then produced with the company's SDGs, this document allows the manager to obtain enough data so that he can then plan stage 2 of the *roadmap*.

Stage 2 occurs when, in possession of the SDGs, the company makes available the necessary resources to achieve the stated objectives, Triguero et al. 2022, state that the company's transition to more sustainable practices, especially with regard to the reconfiguration of products and processes to incorporate eco innovations, requires resources so that they can be realized. Amankwah-Amoah (2024) and García-Granero et al. (2020) point to the need for strategic planning of human resources to direct the proper management of the process, as well as the company's material resources, whether space or equipment, for example, in addition to financial resources to pay for the research, purchase and implementation of eco-innovations in the company. Based on this bibliographic finding, stage 2 was constructed, so that the company pays attention to the availability and evaluation of the necessary resources. The objective is to find out if the resources made available have the capacity to meet the SDGs. With a positive conclusion,

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the company moves on to stage 3, with a negative conclusion, the company returns to stage 2 to provide the necessary resources for the adoption of eco-innovations.

In stage 3, with the necessary resources available, the company begins to develop its relationships, a priori in three different areas presented by the proposal: research institutions, suppliers and customers. Fernandes et al. (2022) expose that the relationship with research institutions such as universities has the power to foster the development of eco-innovations by sharing resources. For Cristiny et al. (2022), the relationship between companies, from the early stages of product or service development, is recognized as a driver of eco-innovations. For Martínez-Martínez et al. (2023), active engagement with customers and attention to their expectations is a strategy for fostering eco-innovations, since knowing the demand facilitates the process.

After the establishment of the partnerships, the *roadmap* proposes another moment of reflection for managers, in which the partnerships developed must be evaluated as to their ability to contribute to the SDGs, if the answer is positive, the company moves to stage 4 if the answer is negative, the company resumes the development of partnerships.

In stage 4 is when, after the establishment of partnerships, information is collected, Abdullah et al. (2015) and Baran (2021) point out that the lack of information on the benefits of using eco innovations contributes to their low adoption, since the literature points to the difficulty in accessing this information. In addition, the lack of knowledge and understanding about the possibilities of eco-innovations also hinders their adoption (Wilts et al., 2013). Stage 4 was therefore proposed, so that the company, through its partnerships, seeks from customers the real demand for its projects, from the government the real legal needs for the adoption of sustainable practices and the possible benefits generated by this adoption in the sector, and from its suppliers and educational institutions the possibilities of eco-innovative products or processes that may be adopted, thus generating a report with these possibilities for the evaluation of managers.

If the solutions reached in the survey are feasible and in line with the company's SDGs, it moves on to the fifth and final stage. If the solutions, for any reason, do not meet the SDGs or it is not possible to adopt them, the company returns to the research step.

In stage 5, the last stage of the proposal, the company based on the possibilities report chooses, acquires and implements the selected eco-innovation. After this process, the eco-innovation is monitored and evaluated to find out whether or not it is meeting the company's SDGs, if it does not, the company returns to stage 1 choosing another eco-

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innovation proposal, if it does, a report is generated containing the results of the adoption of eco-innovation, its positive points and possible limitations, a report that returns to feed the company's SDGs.

FINAL CONSIDERATIONS

The low number of publications that deal directly with the civil construction sector is a counterintuitive finding if the impact of the sector is taken into account. Scientific research discusses in many articles and reviews a diversity of barriers and drivers, which were thus grouped and presented in the RSL, to later be incorporated into the proposed method.

With the RCL it is possible to understand how the literature built and presented solutions close to the research problem, having then been synthesized its positive and negative points that contributed as premises for the development of the method proposed in this article.

With the presentation and description of the proposed model based on the results of the RSL, RCL and the premises of the *roadmap* , it is understood that the research question of the work has been answered satisfactorily, having been delivered as an answer a method that encompasses the findings in the literature and capable of helping managers to better and more safely manage eco-innovations in their corporations.

LIMITATIONS OF RESEARCH AND FUTURE STUDIES

On the assumption that this study did not focus on gray literature, which in some way, can present complementary information with the possibility of contributing to the understanding of eco-innovations in civil construction. This limitation may inspire further research or further research.

The proposed method was developed in a theoretical way based on the bibliographic research that was carried out throughout this work, it is suggested for future research that the method can be tested and evaluated in the practical context of companies.

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ISSN: 2358-2472

REFERENCES

1. Abdul-Rashid, S. H., Sakundarini, N., Ghazilla, R. A. R., & Thurasamy, R. (2017). The impact of sustainable manufacturing practices on sustainability performance: Empirical evidence from Malaysia. International Journal of Operations & Production Management, 37(2), 182–204. https://doi.org/10.1108/IJOPM-04-2015-0223

2. Afum, E., Osei-Ahenkan, V. Y., Agyabeng-Mensah, Y., Owusu, J. A., Kusi, L. Y., & Ankomah, J. (2020). Green manufacturing practices and sustainable performance among Ghanaian manufacturing SMEs: The explanatory link of green supply chain integration. Management of Environmental Quality: An International Journal, 31(6), 1457–1475. https://doi.org/10.1108/MEQ-01-2020-0019

3. Aibar-Guzmán, B., & Frías-Aceituno, J. (2021). Is it necessary to centralize power in the CEO to ensure environmental innovation? Administrative Sciences, 11(1), Article 27. https://doi.org/10.3390/admsci11010027

4. Albort-Morant, G., Henseler, J., Leal-Millán, A., & Cepeda-Carrión, G. (2017). Mapping the field: A bibliometric analysis of green innovation. Sustainability, 9(6), Article 1011. https://doi.org/10.3390/su9061011

5. Amankwah-Amoah, J., Abdalla, S., Mogaji, E., Elbanna, A., & Dwivedi, Y. K. (2024). The impending disruption of creative industries by generative AI: Opportunities, challenges, and research agenda. International Journal of Information Management, 79, Article 102759. https://doi.org/10.1016/j.ijinfomgt.2024.102759

6. Barbieri, J. C., & Simantob, M. (2007). Organizações inovadoras sustentáveis: Uma reflexão sobre o futuro das organizações. Atlas.

7. Barbieri, J. C., Vasconcelos, I. F. G., Andreassi, T., & Vasconcelos, F. C. (2010). Inovação e sustentabilidade: Novos modelos e proposições. Revista de Administração de Empresas, 50(2), 146–154. https://doi.org/10.1590/S0034-75902010000200002

8. Bribián, I. Z., Capilla, A. V., & Usón, A. A. (2011). Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. Building and Environment, 46(5), 1133–1140. https://doi.org/10.1016/j.buildenv.2010.12.002

9. Budayan, C., & Okudan, O. (2022). Roadmap for the implementation of total quality management (TQM) in ISO 9001-certified construction companies: Evidence from Turkey. Ain Shams Engineering Journal, 13(6), Article 101788. https://doi.org/10.1016/j.asej.2022.101788

10. Cai, W., & Li, G. (2018). The drivers of eco-innovation and its impact on performance: Evidence from China. Journal of Cleaner Production, 176, 110–118. https://doi.org/10.1016/j.jclepro.2017.12.109

Revista ARACÊ
ISSN: 2358-2472

11. Cai, W. G., & Zhou, X. L. (2014). On the drivers of eco-innovation: Empirical evidence from China. Journal of Cleaner Production, 79, 239–248. https://doi.org/10.1016/j.jclepro.2014.05.035

12. Câmara Brasileira da Indústria da Construção. (2022). Construção civil desempenho 2021 e cenário 2022. https://cbic.org.br/wp-content/uploads/2021/12/construcao-civil-desempenho-2021-e-cenarios-2022.pdf

13. Cerchione, R., & Esposito, E. (2016). A systematic review of supply chain knowledge management research: State of the art and research opportunities. International Journal of Production Economics, 182, 276–292. https://doi.org/10.1016/j.ijpe.2016.09.006

14. Chardine-Baumann, E., & Botta-Genoulaz, V. (2014). A framework for sustainable performance assessment of supply chain management practices. Computers & Industrial Engineering, 76, 138–147. https://doi.org/10.1016/j.cie.2014.07.029

15. Chang, R. D., Zuo, J., Soebarto, V., Zhao, Z. Y., Zillante, G., & Gan, X. L. (2016). Sustainability transition of the Chinese construction industry: Practices and behaviors of the leading construction firms. Journal of Management in Engineering, 32(4), Article 05016009. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000434

16. Christensen, C. M. (1997). The innovator's dilemma. Harvard Business School Press.

17. Clemens, B. (2006). Economic incentives and small firms: Does it pay to be green? Journal of Business Research, 59(4), 492–500. https://doi.org/10.1016/j.jbusres.2005.08.006

18. Cohen, C. (2003). Padrões de consumo e energia: Efeitos sobre o meio ambiente e o desenvolvimento. Elsevier.

19. Del Río, P., Carrillo-Hermosilla, J., Könnölä, T., & Bleda, M. (2016). Resources, capabilities and competences for eco-innovation. Technological and Economic Development of Economy, 22(2), 274–292. https://doi.org/10.3846/20294913.2015.1070301

20. Diaz, J. (2014). Embedded LCA information in BIM models. In S. O. Ekolu, M. Dundu, & X. Gao (Eds.), Construction materials and structures: Proceedings of the First International Conference on Construction Materials and Structures (p. 1548). IOS Press.

21. Drucker, P. F. (1987). Inovação e espírito empreendedor: Prática e princípios (2nd ed.). Pioneira.

22. Dugonski, F. C. V., & Tumelero, C. (2022). Barriers and facilitators of technological eco-innovations: A multilevel analysis in a Brazilian cosmetics company. Innovation & Management Review, 19(3), 237–251. https://doi.org/10.1108/INMR-01-2021-0003

Revista ARACÊ
ISSN: 2358-2472

23. Durdyev, S., Mohamed, S., Lay, M. L., & Ismail, S. (2017). Key factors affecting construction safety performance in developing countries: Evidence from Cambodia. Construction Economics and Building, 17(4), 48–65. https://doi.org/10.5130/AJCEB.v17i4.5596

24. Dybvig, P. H., & Spatt, C. S. (1983). Adoption externalities as public goods. Journal of Public Economics, 20(2), 231–247. https://doi.org/10.1016/0047-2727(83)90012-9

25. Ferreira, A. R., & Theófilo, C. R. (2006). Contabilidade da construção civil: Estudo sobre as formas de mensuração e reconhecimento de resultados. In Anais do Congresso Brasileiro de Custos. [Publisher not specified].

26. Fussler, C., & James, P. (1996). A breakthrough discipline for innovation and sustainability. Pitman Publishing.

27. García-Granero, E. M., Piedra-Muñoz, L., & Galdeano-Gómez, E. (2020). Measuring eco-innovation dimensions: The role of environmental corporate culture and commercial orientation. Research Policy, 49(8), Article 104028. https://doi.org/10.1016/j.respol.2020.104028

28. García-Sánchez, I., Gallego-Álvarez, I., & Zafra-Gómez, J. L. (2021). Do independent, female and specialist directors promote eco-innovation and eco-design in agri-food firms? Business Strategy and the Environment, 30(2), 1136–1152. https://doi.org/10.1002/bse.2676

29. Garcia, J. C. R. (2001). Transmissão de tecnologia: Análise de conceito. DataGramaZero, 2(2), Article e021008.

30. Garrone, P., Grilli, L., & Mrkajic, B. (2018). The role of institutional pressures in the introduction of energy-efficiency innovations. Business Strategy and the Environment, 27(8), 1245–1257. https://doi.org/10.1002/bse.2072

31. Global Alliance for Buildings and Construction. (2023). Global status report for buildings and construction 2023. United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/45095/global_status_report_buildings_construction_2023.pdf

32. Hermosilla, J., del Río, P., & Könnölä, T. (2010). Diversity of eco-innovations: Reflections from selected case studies. Journal of Cleaner Production, 18(10–11), 1073–1083. https://doi.org/10.1016/j.jclepro.2010.02.014

33. Hizarci-Payne, A. K., İpek, İ., & Kurt Gümüş, G. (2021). How environmental innovation influences firm performance: A meta-analytic review. Business Strategy and the Environment, 30(2), 1174–1190. https://doi.org/10.1002/bse.2678

34. Hojnik, J., & Ruzzier, M. (2016). The driving forces of process eco-innovation and its impact on performance: Insights from Slovenia. Journal of Cleaner Production, 133, 812–825. https://doi.org/10.1016/j.jclepro.2016.06.002

Revista ARACÊ
ISSN: 2358-2472

35. Hsu, C.-H., Li, Z.-H., Zhuo, H.-J., & Zhang, T.-Y. (2024). Enabling Industry 5.0-driven circular economy transformation: A strategic roadmap. Sustainability, 16(22), Article 9954. https://doi.org/10.3390/su16229954

36. International Energy Agency. (2020). Atlas of energy. http://energyatlas.iea.org

37. Intergovernmental Panel on Climate Change. (2023). Synthesis report of the IPCC sixth assessment report (AR6). IPCC.

38. Jakhar, S. K. (2017). Stakeholder engagement and environmental practice adoption: The mediating role of process management practices. Sustainable Development, 25(2), 92–110. https://doi.org/10.1002/sd.1644

39. Jiang, Y., Guo, Y., Bashir, M. F., & Shahbaz, M. (2024). Do renewable energy, environmental regulations and green innovation matter for China's zero carbon transition: Evidence from green total factor productivity. Journal of Environmental Management, 352, Article 120030. https://doi.org/10.1016/j.jenvman.2024.120030

40. Kemp, R., & Pearson, P. (2007). Final report MEI project about measuring eco-innovation. UNU-MERIT.

41. Keppel, G., Mokany, K., Wardell-Johnson, G. W., Watson, J. E. M., & Williams, K. J. (2024). Managing climate-change refugia to prevent extinctions. Trends in Ecology & Evolution, 39(9), 800–808. https://doi.org/10.1016/j.tree.2024.05.002

42. Kesidou, E., & Demirel, P. (2012). On the drivers of eco-innovations: Empirical evidence from the UK. Research Policy, 41(5), 862–870. https://doi.org/10.1016/j.respol.2012.01.005

43. Klewitz, J., & Hansen, E. G. (2014). Sustainability-oriented innovation of SMEs: A systematic review. Journal of Cleaner Production, 65, 57–75. https://doi.org/10.1016/j.jclepro.2013.07.017

44. Kralj, D. (2008). Dialectal system approach supporting environmental innovation for sustainable development. Kybernetes, 37(9/10), 1542–1560. https://doi.org/10.1108/03684920810907850

45. Larsson, N. (2023). The international initiative for a sustainable built environment. International Initiative for a Sustainable Built Environment. http://www.iisbe.org/sbmethod

46. Lee, W. L., & Burnett, J. (2008). Benchmarking energy use assessment of HK-BEAM, BREEAM, and LEED. Building and Environment, 43(11), 1882–1891. https://doi.org/10.1016/j.buildenv.2007.11.007

47. Leising, E., Quist, J., & Bocken, N. (2018). Circular economy in the building sector: Three cases and a collaboration tool. Journal of Cleaner Production, 176, 976–989. https://doi.org/10.1016/j.jclepro.2017.12.010

Revista ARACÊ
ISSN: 2358-2472

48. Li, Y. (2014). Environmental innovation practices and performance: Moderating effect of resource commitment. Journal of Cleaner Production, 66, 450–458. https://doi.org/10.1016/j.jclepro.2013.11.044

49. Liao, Z. (2018). Corporate culture, environmental innovation and financial performance. Business Strategy and the Environment, 27(8), 1368–1375. https://doi.org/10.1002/bse.2186

50. Liu, Z., Geng, R., Tse, Y. K. M., & Han, S. (2023). Mapping the relationship between social media usage and organizational performance: A meta-analysis. Technological Forecasting and Social Change, 187, Article 122253. https://doi.org/10.1016/j.techfore.2022.122253

51. López Pérez, G., García Sánchez, I. M., & Zafra Gómez, J. L. (2024). A systematic literature review and bibliometric analysis of eco-innovation on financial performance: Identifying barriers and drivers. Business Strategy and the Environment, 33(2), 1321–1340. https://doi.org/10.1002/bse.3552

52. Machuca-Villegas, L., Gasca-Hurtado, G. P., Morillo Puente, S., & Restrepo Tamayo, L. M. (2022). Perceptions of the human and social factors that influence the productivity of software development teams in Colombia: A statistical analysis. Journal of Systems and Software, 192, Article 111408. https://doi.org/10.1016/j.jss.2022.111408

53. Marín-Vinuesa, L., Scarpellini, S., Portillo-Tarragona, P., & Moneva, J. (2020). The impact of eco-innovation on performance through the measurement of financial resources and green patents. Organization & Environment, 33(2), 285–310. https://doi.org/10.1177/1086026618819103

54. Martins, M. G., & Barros, M. M. S. (2005). A formação de parcerias como alternativa para impulsionar a inovação na produção de edifícios. Boletim Técnico 391, Escola Politécnica da USP.

55. Miozzo, M., & Dewick, P. (2004). Building competitive advantage: Innovation and corporate governance in European construction. Research Policy, 33(8), 1153–1166. https://doi.org/10.1016/j.respol.2004.05.002

56. Monteiro Filha, D. C., Costa, A. C. R., & Rocha, E. R. P. (2010). Perspectivas e desafios para inovar na construção civil. BNDES Setorial, 31, 141–164.

57. Nielsen, K. R. (2020). Policymakers' views on sustainable end-user innovation: Implications for sustainable innovation. Journal of Cleaner Production, 254, Article 120030. https://doi.org/10.1016/j.jclepro.2020.120030

58. Organisation for Economic Co-operation and Development. (2002). Frascati manual: Proposed standard practice for surveys on research and experimental development. OECD Publishing.

Revista ARACÊ
ISSN: 2358-2472

59. Organisation for Economic Co-operation and Development. (2005). Oslo manual: Diretrizes para coleta e interpretação de dados sobre inovação (3rd ed.). ARTI/FINEP.

60. Organisation for Economic Co-operation and Development, & Eurostat. (2018). Oslo manual 2018: Guidelines for collecting, reporting and using data on innovation (4th ed.). OECD Publishing.

61. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, Article n71. https://doi.org/10.1136/bmj.n71

62. Pan, Y., Zhang, D., Yang, P., Poon, L. L. M., & Wang, Q. (2020). Viral load of SARS-CoV-2 in clinical samples. The Lancet Infectious Diseases, 20(4), 411–412. https://doi.org/10.1016/S1473-3099(20)30113-4

63. Pires, V. R. S. (2021). Roadmap para implantação e gestão de inovações em empresas de construção civil de pequeno e médio porte [Master's dissertation, Centro Estadual de Educação Tecnológica Paula Souza]. Repositório CEETEPS.

64. Porter, M. E., & van der Linde, C. (1995). Green and competitive: Ending the stalemate. Harvard Business Review, 73(5), 120–134.

65. Potrich, L., Cortimiglia, M. N., & de Medeiros, J. F. (2019). A systematic literature review on firm-level proactive environmental management. Journal of Environmental Management, 243, 273–286. https://doi.org/10.1016/j.jenvman.2019.04.110

66. Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. Harvard Business Review, 68(3), 79–91.

67. Perl-Vorbach, E., Rauter, R., & Baumgartner, R. J. (2014). Open innovation in the context of sustainable innovation: Findings based on a literature review. In 9th International Symposium on Sustainable Leadership (pp. 1–15). [Publisher not specified].

68. Pourvaziri, M., Mahmoudkelayeh, S., Kamranfar, S., Fathollahi-Fard, A. M., Gheibi, M., & Kumar, A. (2024). Barriers to green procurement of the Iranian construction industry: An interpretive structural modeling approach. International Journal of Environmental Science and Technology. Advance online publication. https://doi.org/10.1007/s13762-024-05715-6

69. Rennings, K. (1998). Towards a theory and policy of eco-innovation: Neoclassical and (co-)evolutionary perspectives [Unpublished manuscript].

Revista ARACÊ
ISSN: 2358-2472

70. Rennings, K. (2000). Redefining innovation—Eco-innovation research and the contribution from ecological economics. Ecological Economics, 32(2), 319–332. https://doi.org/10.1016/S0921-8009(99)00112-3

71. Sachs, J. D., Lafortune, G., & Fuller, G. (2024). The SDGs and the UN Summit of the Future: Sustainable Development Report 2024. SDSN, Dublin University Press. https://doi.org/10.25546/108572

72. Schumpeter, J. A. (1957). The theory of economic development. Harvard University Press.

73. Silva, F. G. D., Hartman, A., & Reise, D. R. (2006). Avaliação do nível de inovação tecnológica: Desenvolvimento e teste de uma metodologia. In Anais do Encontro Nacional de Engenharia de Produção. [Publisher not specified].

74. Silva, J. J., & Cirani, C. B. S. (2017). Capacidade de inovação: Uma revisão sistemática da literatura. In VI Simpósio Internacional de Gestão de Projetos, Inovação e Sustentabilidade (pp. 1–17). https://singep.org.br/6singep/resultado/291.pdf

75. Singh, M. P., & Chakraborty, A. (2021). Eco-innovation and sustainability performance: An empirical study on Indian manufacturing SMEs. World Review of Entrepreneurship, Management and Sustainable Development, 17(4), 497–512. https://doi.org/10.1504/WREMSD.2021.116666

76. Toledo, R., Abreu, A. F., & Jungles, A. E. (2000). A difusão de inovações tecnológicas na indústria da construção civil. In ENTAC 2000: Anais (Vol. 8). [Publisher not specified].

77. Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British Journal of Management, 14(3), 207–222. https://doi.org/10.1111/1467-8551.00375

78. Turzo, T., Marzi, G., Favino, C., & Terzani, S. (2022). Non-financial reporting research and practice: Lessons from the last decade. Journal of Cleaner Production, 345, Article 131154. https://doi.org/10.1016/j.jclepro.2022.131154

79. Usón, A. A., Capilla, A. V., Bribián, I. Z., Scarpellini, S., & Sastresa, E. L. (2011). Energy efficiency in transport and mobility from an eco-efficiency viewpoint. Energy, 36(4), 1916–1923. https://doi.org/10.1016/j.energy.2010.05.002

80. Valdez-Juarez, L. E., & Castillo-Vergara, M. (2021). Technological capabilities, open innovation, and eco-innovation: Dynamic capabilities to increase corporate performance of SMEs. Journal of Open Innovation: Technology, Market, and Complexity, 7(1), Article 8. https://doi.org/10.3390/joitmc7010008

81. Valero, A., Valero, A., & Mudd, G. M. (2009). Exergy: A useful indicator for the sustainability of mineral resources and mining. In SIDMI Conference (pp. 6–9). [Publisher not specified].

Revista ARACÊ
ISSN: 2358-2472

82. Veile, J. W., Kiel, D., Müller, J. M., & Voigt, K.-I. (2020). Lessons learned from Industry 4.0 implementation in the German manufacturing industry. Journal of Manufacturing Technology Management, 31(5), 977–997. https://doi.org/10.1108/JMTM-08-2018-0270

83. Vence, X., & Pereira, Á. (2019). Eco-innovation and circular business models as drivers for a circular economy. Contaduría y Administración, 64(1), Article 1806. https://doi.org/10.22201/fca.24488410e.2019.1806

84. Vergna, J. R. G. (2007). Formação e gerência de redes de empresas de construção civil: Sistematização de um modelo de atores e recursos para obras de edificações [Master's dissertation, Escola de Engenharia de São Carlos, Universidade de São Paulo]. Repositório USP.

85. Wilts, H., Dehoust, G., Jepsen, D., & Knappe, F. (2013). Eco-innovations for waste prevention—Best practices, drivers, and barriers. Science of the Total Environment, 461–462, 823–829. https://doi.org/10.1016/j.scitotenv.2013.05.096

86. Zaidi, S. A. H., Wei, Z., Gedikli, A., Zafar, M. W., Hou, F., & Iftikhar, Y. (2019). The impact of globalization, natural resources abundance, and human capital on eco-innovation: Evidence from G-20 countries. Resources Policy, 64, Article 101504. https://doi.org/10.1016/j.resourpol.2019.101504

87. Zhang, J., & Yin, K. (2023). Application of gradient boosting model to forecast corporate green innovation performance. Frontiers in Environmental Science, 11, Article 1252271. https://doi.org/10.3389/fenvs.2023.1252271