

Review Article

Global Practices in ISO 14001 Implementation Across the Construction Industry

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Abstract - The construction sector significantly contributes to global environmental pollution due to CO₂ emissions, solid waste generation, and the massive consumption of natural resources. This impact has raised awareness of the importance of sustainable practices in organizations, including the implementation of environmental management systems such as ISO 14001. ISO 14001 provides a systematic framework for improving environmental management, reducing negative impacts, and optimizing resource use. However, the adoption and effectiveness of this standard vary considerably across different countries and sectors. For instance, China has made significant progress due to strong governmental and organizational commitment, whereas in Latin America, implementation faces challenges due to factors like lack of governmental support and insufficient infrastructure. This study offers a comparative analysis of ISO 14001 implementation in the construction industry in Latin America, specifically in Brazil, Chile, Venezuela, Ecuador, and Peru. It compares it with experiences from countries like Saudi Arabia, Denmark, China, Portugal, and Spain. Through reviews, interviews, and surveys, the study identifies best practices and proposes new strategies to improve the standard's adoption, aiming for a balance between economic development and environmental conservation. Despite its widespread adoption, the results of ISO 14001 implementation vary significantly across regions. This study aims to provide a deeper understanding of how local conditions affect the standard's effectiveness, offering recommendations to improve its adoption in Latin America and other developing regions.

Keywords - ISO 14001, Construction, Management systems, Environmental management, Project management.

1. Introduction

The construction sector is globally recognized as one of the most significant contributors to environmental degradation. The industry is responsible for large-scale CO₂ emissions, substantial generation of solid waste, and extensive consumption of natural resources, all of which have led to a progressive deterioration of the environment. These impacts have not gone unnoticed, as they have sparked a growing awareness within social, corporate, and governmental spheres about the urgent need for sustainable practices. In response to these challenges, various measures have been implemented by organizations worldwide, aiming to mitigate the harmful effects of industrial activities on the environment. Among these measures, the adoption of environmental management systems, particularly the ISO 14001 standard, has gained prominence. ISO 14001 establishes a structured framework of procedures, methods, and techniques designed to help organizations achieve high standards in environmental preservation and resource efficiency. However, despite the widespread adoption of ISO 14001, the effectiveness of its implementation varies significantly across different regions and sectors. The diversity in practices, strategies, and

experiences among construction companies around the world indicates that there is no one-size-fits-all approach to environmental management. This variability underscores the need for a comparative analysis of global practices, which can highlight best practices and offer valuable insights for regions such as Peru, where the potential for enhancing ISO 14001 implementation remains significant. The research gap addressed by this study lies in the limited understanding of how local contexts—cultural, regulatory, and organizational—affect the success of ISO 14001 implementation in the construction industry. While existing research has extensively documented the benefits of ISO 14001, particularly in terms of environmental performance and sustainability, there is a lack of comprehensive studies that compare the experiences of different countries and provide actionable recommendations tailored to specific regional contexts. This study aims to fill this gap by conducting a comparative analysis of ISO 14001 implementation across construction companies in Latin America—specifically in Brazil, Chile, Venezuela, Ecuador, and Peru—and juxtaposing these experiences with those from global counterparts in Saudi Arabia, Denmark, China, Portugal, and



Spain. Through a qualitative approach involving reviews, interviews, and surveys, this research seeks to identify best practices and propose new strategies that can be adopted by Peruvian construction companies, ultimately contributing to a sustainable balance between economic development and environmental conservation. This study offers a fresh perspective by focusing on the intersection of global best practices and local adaptations in the implementation of ISO 14001. By analyzing and comparing different approaches across various countries, the research aims to provide a deeper understanding of how this standard can be more effectively tailored to meet the unique challenges and opportunities present in diverse settings. The findings of this study are intended to not only enrich the academic discourse but also serve as a practical resource for policymakers, industry leaders, and environmental managers who are committed to enhancing environmental performance in the construction sector.

2. Materials and Methods

2.1. Approach, Scope, and Design

The approach developed in this research is qualitative because the research will be based on data collection methods that are neither standardized nor predetermined in detail, depending on the researcher's perspectives and point of view. The scope is descriptive given that the phenomenon is being studied; however, it is convenient to describe the entire existing theoretical framework in order to organize it and describe the practices implemented.

2.2. Case Studies in Countries Outside of Latin America

The researcher carries out the first relevant research emphasizing the acceptance of the ISO 14001 standard and its application and certification benefits, which have been applied in different countries around the world, in order to contribute to sustainability and pollution prevention [1]. This research process consisted of five stages: review of journal articles, content evaluation, content validation related to the research question, and data extraction [2]. Subsequently, an article was published in the United Arab Emirates, whose methodology consisted of conducting interviews to learn about environmental experiences in construction companies in that country; likewise, the use of questionnaires was added to collect information from companies that are ISO 14001 certified and those that were not certified [3]. Something similar happened in a study carried out in Denmark, in which mixed information was collected; first twenty interviews were conducted in order to analyze Danish companies on how they manage and develop the environmental management system based on the ISO 14001 standard; then, a survey was shared with responses from 277 Danish companies certified to ISO 14001 [4]. Another relevant research originates in Indonesia of a quantitative type, where through surveys, information was collected from three construction experts, who provided information on preferences for green buildings and then applied criteria comparison techniques to classify the most

accurate and objective results [5]. In the same way, an analysis of a study carried out in the United Kingdom, with a deductive research approach, is carried out, which consists of three phases through which the opinions of experts in the sector were obtained. These were the review of the existing literature as evidence, the collection of data, and finally, the analysis of the data using statistics to determine the benefits generated by the implementation of ISO 14001 [2]. Likewise, in Portugal, a study was carried out through surveys of the different companies that apply the ISO 14001:2015 standard, highlighting the increase in competitiveness, the commitment of the management, the management with the company's plans and the commitment to communication with those involved [6]. Likewise, research carried out in Spain was based on the use of surveys to companies, specifying the possible questions to problems represented by the insertion of the ISO 14001 standard. For the selection of companies, the number of employees and their production activities were taken into account [7]. Also, another case in Spain was analyzed on the contrast between symbolic environmental behavior and the implementation of ISO 14001, in which a binary logistic regression is used for the analysis of a universal demonstration of 1961 plants with approximately, which employ 50 workers in each of them [8]. On the other hand, in a study carried out in China, the SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) was used so that participants could discuss it. Information could be collected based on four aspects: the participation of those involved, internal development, sustainability, and resource management in companies [9].

2.3. Case Studies in Latin America

In Venezuela, a study analyzes the current situation of its construction companies in terms of environmental management through a series of surveys. This research is quantitative and non-experimental in design, based on a population and sample that seeks to explain the environmental problems generated by these companies [10]. Likewise, the research carried out in Brazil was explanatory, based on the collection of data through interviews and questionnaires to personnel in charge of 35 works on waste management [11]. Similarly, another study conducted in Brazil used surveys that were systematically conducted to collect information from 32 civil construction companies in order to recognize environmental particularities [12]. On the other hand, in Ecuador, research was formulated based on the evolution of the ISO 14001 standard and its implementation, establishing the benefits offered by the standard due to the generation of certifications in the country of Ecuador [13]. In Chile, methodologies were carried out through comparative inspections of international sustainability certifications of construction materials. These certifications, called BREEAM and LEED, are European and global standard certifications, respectively [14]. On the other hand, in Guatemala, a qualitative study was carried out based on the management and control system by the entity of the Ministry of

Environment and Natural Resources due to the increase in negative impact on the sustainable development of the environment and natural resources, generated by construction [15].

2.4. Case Studies in Peru

On the other hand, in Peru, the impact of environmental business policies on solid waste management in the construction sector in the city of Lima was analyzed. This study corresponds to a statistical analysis with a quantitative approach that is also based on surveys [16]. A qualitative study carried out in the province of Huánuco worked with a non-probabilistic sample of cases, which were used for the identification and characterization of construction and demolition waste in the town of Huacrachuco [17].

In Arequipa, the qualitative case study method was used, as well as the descriptive research on the construction site of a hospital (Gonzales, 2021) [18]. In another case in Arequipa, the methodology used was quantitative for the characterization and assessment of environmental aspects, identifying the environmental risks in a cement company and the risk priority index in order to minimize environmental impacts for adequate decision-making in times of disaster [19]. Likewise, a case study of the ISO 14001 standard and its impact on the construction of civil works in the BDP company was carried out quantitatively from surveys of 36 items for a population sample of 92 employees of the same company. Sampling was randomly selected using random probability sampling.

The sectors of items of the questionnaire are Diagnosis, planning, implementation, design, execution and delivery, in which the questions are answered with a YES or NO in three types of aspects (clarity, pertinence and relevance [20]. Likewise, in Independencia, a study established 3 important points to using water properly, such as using correct techniques, maintaining environmental principles in those involved and defining verification mechanisms, which is of great benefit to this Industrial institution [21]. On the other hand, the research work carried out in the department of Trujillo uses quantitative methodology through techniques and instruments to ensure the quality of the research. Subsequently, the Ishikawa diagram will be made with the causes found to determine the environmental and economic impacts of the implementation of the ISO 14001:2015 environment [22]. On the other hand, the methodology used in Cañete, with a quantitative, correlational approach, applied the survey technique and two instruments, one to measure project management with the ISO 14001 standard and the other to measure the environmental quality variable [23]. Likewise, research carried out in Cuzco, with a qualitative and inductive approach, was carried out in 2 stages; the first was a diagnosis of the current situation in the aspects of quality and the environment, and the second was the design of improvement strategies [24].

3. Results

3.1. Implementation in Construction Companies Outside Latin America

Regarding the study in Portugal on the ISO 14001 standard, he mentions that the acceptance of this international standard is based on generating better environmental performance, with this referring to systematic management, making an important contribution to sustainability. Through the prevention of pollution, in addition to complying with applicable laws [1]. About the case study in Indonesia, he mentions that the GSCM Green Supply Chain Management provides benefits to the environment; for its implementation, it will require an organization of activities and procedures so that the company can have a responsible link with the environment. It also states that the TOPSIS method is used to classify alternatives in green practices [5]. In the United Arab Emirates, some studies have stated that the implementation of ISO 14001 is difficult for private companies; however, this was discredited after research concluded that implementing such a standard generates direct benefits, helping to promote environmental sustainability practices, for the companies surveyed [3].

In Denmark, it was described that there are 2 primary systems for environmental management systems: the EU Environmental Audit and Management Scheme (EMAS) and the ISO 14001 standard aimed at environmental management. In this way, the ISO 14001 standard emphasizes that companies must prove that environmental objectives are measurable if required, communicated and followed as appropriate; in addition, four requirements were identified to achieve sustainable objectives in companies, these are: external factors, subjective factors, managerial factors and the identification of stakeholders. These are the ones that influence the implementation of environmental objectives. Therefore, a nationwide survey was conducted to account for and validate current practices and future potential with respect to environmental management systems in Danish ISO 14001-certified companies, where responses were obtained from 277 of them [4].

China began to develop as a power in its development as a country in recent decades, incurring high inputs, high consumptions and therefore high emissions in the environment, which is why China is one of the countries that is in the crosshairs against others one of the greatest climate changes to play which has been of attention for the application of environmental protection measures. Companies that evaluate ISO 14001 performance do so with a focus on environmental performance as well as sustainability in the economic, environmental, and governmental spheres [9]. In Portugal, voluntary certification has been increasing over the years with the aim of complying with corrective measures and actions with organizations in the development of environmental sustainability. One of the most useful concepts that respondents consider about ISO 14001:2015 is the

assessment of risks and opportunities, the mapping of the business environment and the life cycle point of view [6]. In this regard, ISO 14001 is an approved universal method that regulates the installation of an environmental management procedure. It is based on achieving harmony between the conservation of production and the shortening of the effects on the ecosystem. In addition, the positive consequences of the implementation of the standard contribute to continuous improvement in environmental management and to growing the company's image. For this reason, in Spain, in the internal management of companies or organizations, the agreed ISO 14001 standard decrees techniques are used to inspect the effects that they have on the environment [7]. In another similar case, symbolic adoption means that companies use the ISO 14001 standard to legalize their environmental performance through the support of other institutions that endorse them, but without them committing to environmental sustainability, what is wanted with the present work is to analyze whether symbolic environmental behavior influences the adoption of ISO 14001. The incorporation of the standard helps in international trade and opens doors to partnerships with foreigners. In addition, it is considered expensive, but research states that companies express that it is worth investing in this standard since there is pressure from the labor market and customers [8].

3.2. Implementation in Construction Companies in Latin America

In the case of construction companies in the state of Mérida, of the thirteen managers of construction companies, only one has a properly structured environmental management system in his company. Specifically, there is no written record of the goals and responsibilities set for staff in terms of environmental protection. On the other hand, twelve of them indicate that they have some method for the disposal of surplus products and materials; the rest do not. Apart from that, for order and cleanliness during the construction process, all managers keep it present. However, several security elements were observed to be absent (Vergara, 2014) [10]. In Ecuador, the implementation of the ISO 14001 standard made it possible to identify environmental aspects, as well as the applicable legislation, in order to then formulate and assume a commitment to environmental policy. This will achieve the planned objectives and targets through the prevention of pollution. It is here where, in 2019, 200 certifications were generated in different economic sectors, the largest being in the construction sector with 29 certifications [13]. In Brazil, construction companies contribute to urban growth. They are also a highly polluting industry due to their different activities, such as soil deterioration, noise pollution, pollution of natural resources and, above all, the generation of waste. The ISO 14001 standard supports the organization and execution of an environmental management procedure, as it makes it possible to estimate and inspect the environmental impacts of its actions, production or services in order to achieve economic and environmental objectives [12]. Civil construction waste

management is waste treatment activities that, by controlling and managing it, allows ISO 14001 to be effective in the construction company due to the mitigation of environmental impacts [11]. In another study carried out in Chile, the Sustainable Building Certification (CES) is applied to minimize the environmental impacts generated by humanity, balancing the economic, environmental and sustainable aspects for the preservation of natural resources; likewise, the verification of the materials used in constructions is accentuated to verify in which process greater emphasis should be placed, whether from design to construction [14]. In Guatemala, the government and construction companies have been implementing initiatives to achieve sustainable social and economic development, a development for the benefit of the community. However, this was met with little acceptance by construction companies. For this reason, an analysis of environmental assessment and development was used, in which the commitment of the construction companies to the implementation of the ISO 14001 standard is analyzed, which is one of the requirements for its operation so that there is a balance with the development of economic and social sustainability [25].

3.3. Implementation in Peruvian Construction Companies

Already in Peru, in the province of Huacrachuco - Huánuco, no study has been carried out on the design of sanitary landfills; however, the concern for public health has generated the necessary interest in the final disposal of construction waste since these are accumulated on the slopes of the hills affecting the environment and giving a bad appearance to the landscape environment. It also puts the health of the population at risk. Therefore, for waste management, it is very important to know the environmental impacts of waste generation in relation to the production and consumption activities that are carried out [17]. In the case of Arequipa, with the advancement of technology, construction projects have increased, which has a greater impact on the environment. However, through environmental management systems focused on sustainable development, a balance between nature and human intervention can be achieved [18]. On the other hand, in Arequipa, the proper selection of construction materials is also taken into account; it is important to take into account the criteria of environmental management in civil construction, the reasonable use of energy, and reduce toxic materials in the yield, ecological material uses, use of the resources of the area and shortening of costs of transportation of materials [19]. In the case of Lima, it is proposed that construction companies should take an important role in the development of their activities and correct management of solid waste from construction sites, specifically through recycling and reuse, with the aim of contributing to environmental decontamination. Likewise, the environmental social responsibility expressed in its policies would be decisive for the correct management of solid waste from the works. Finally, the use of tools such as the Lean Construction philosophy, application of PMI concepts,

certification of professionals dedicated to the execution of projects and the use of BIM support the efficiency of solid waste management [16]. Another case of implementation of the ISO 14001:2015 standard in Lima develops the application of the standard, allowing the evaluation of the relationship between study variables: ISO 14001:2015 standard and the construction of civil works in a given time [20]. On the other hand, the international standard ISO 14001:2015 supported the Trujillo company Consorcio GY D2 with a framework that favors the environment and responds to versatile environmental situations, taking into account socioeconomic balance. Also, to reduce the environmental impact, the reduction of waste and emissions is resorted to by making use of efficient energies. Therefore, environmental objectives are in line with the environmental policies that are planned [22]. On the other hand, the ISO 14001 standard was widely disseminated to the districts and population centers of Cañete through their social organizations for application in the socioeconomic activities of the province, allowing the need for environmental policies to be identified [23].

4. Implementation

4.1. In Companies Outside of Latin America

In Portugal, the ISO 14001 standard is more widely adopted internationally, contributing to better environmental performance, efficiency, and profitability, as well as improving the quality of customer service and allowing their satisfaction [1]. In the case study in Indonesia, the results were achieved through the mixture of PWS and TOPSIS methods, which made it possible to classify options that would be applied in the development of the framework. Therefore, its analysis shows higher criteria for organizational performance compared to environmental and economic performance [5]. Regarding the results of the study in the United Arab Emirates, it is presented that the practices of segregating and controlling toxic substances were the most used, and the least used was the use of recyclable materials. In the category of water-related practices, sewage capture and treatment due to construction was the most commonly used and building on-site water recovery/filtration systems was the least practiced. Finally, in the air pollution reduction category, practices of preventing on-site burned materials were the most widely performed, while using chlorine-free air conditioning gases was the least [3]. In addition, in the case of Denmark, the results showed that a large part of the companies stated that they present an environmental management system due to customer demand of 60%. Also, 82% of companies agree that presenting certification improves the organizational image. According to the survey, 84% of companies responded that management is the one that defines environmental objectives, showing that processes are continuously included for employees and strategic personnel to set new environmental objectives, to later be reviewed and qualified by senior management. In addition, 45% of respondents considered it difficult to define new environmental goals, and 16% found it easy. In the interviews, it was verified that active companies

focus their environmental objectives related to energy, water, waste and fuel use [4]. In the case of the United Kingdom, the sample was very small since the survey consisted of 145 statements that had to be rated by the participants in the first stage. In contrast, in the second, they had to make corrections to these answers, of which only one participant made modifications. Closing the survey only in 2 rounds [26]. China has also become one of the countries with the highest certification in its entirety, surpassing the European Union in recent years. At the same time, the US and Germany maintained constant certification figures between 1999-2016. According to the number of certificates per capita, it could be highlighted that China has a low position in comparison.

Likewise, the highest certifications in China were given in the provinces of Guangdong, Jiangsu and Zhejiang, in the construction sectors presenting certified companies (22%), which is followed by the production of electronic equipment (10%), sale of appliances (10%), metal production (8%), technological services (7%) and machinery and equipment (6.5%) [9]. In the case of Portugal, as a result of the research, it was contemplated that 75% of the respondents did not make the transformation to the 2015 version, and 97% of the companies have at least the intention of proceeding with such a change. Approximately 77% of those involved with the move to ISO 14001:2015 made some modifications [6]. In this regard, after the analysis of 95 collaborating companies in Spain, it was found that 4% have not generated any benefit from the implementation of the standard. Meanwhile, 96% emphasized the positive results: optimizing current resources and allowing progress in the management of the waste produced; likewise, the implementation of the standard allows economic progress to be achieved by saving on the management of resources [7].

4.2. In construction companies in Latin America

In Ecuador, through the implementation of the standard it has generated positive changes for the economic sector, which allows it to obtain a comprehensive and active approach to the environmental aspect. In addition, there has been an increase in interest from the construction sector in obtaining an ISO 14001 certificate [13]. Another country that has generated an increase in certifications is Chile, which has allowed it to originate good project and environmental management, being a participant in the reduction of the carbon footprint [14]. In Brazil, some shortcomings in waste management were identified. Out of 32 companies, only 13 companies aimed for ISO 14001 certification [10]. In Guatemala, in order to obtain authorization in the construction sector, it is necessary to carry out an environmental impact study so that other countries can adopt solid waste management as an example.

4.3. In Peruvian Construction Companies

The results obtained in Huánuco with respect to a study on solid waste management highlight that only 70% of all solid waste corresponds to the construction sector [17].

Table 1. Implementation results in Lima, Peru

		V2 - Construction of civil works				
		Evaluation	Deficient	Regular	Efficient	Total
V-1 Implementation ISO	Deficient		0 (0.00%)	0.00%	0 (0.00%)	0.00%
	Regular		11 (14.86%)	39 (52.70%)	17 (22.97%)	90.53%
	Efficient		0 (0.00%)	7 (9.47%)	0 (0.00%)	9.47%
Total			14.86%	62.17%	22.97%	100.00%

In Arequipa, an environmental management system was implemented, which allowed it to obtain an 84% reduction in negative impacts on the environment [19]. On the other hand, the results of the survey carried out in Lima to employees of the company BDP Build D-Proyect S.A.C. regarding the construction of civil works with the implementation of the ISO 14001:2015 Standard show a higher frequency of acceptance at the regular level of the dependent variable, which represents a value of 62.17% as shown in Table 1. Likewise, in Lima, according to the results, the consumption of water resources in 2006 was 100,000 m³/year; with the application of awareness, management and technology measures, it was possible to reduce it by 20% to 21% in 2007 and 2008, respectively. In addition, in response to the survey carried out to users on the degree of awareness of the use of water, 58% consider that it should be used reasonably, and 18% assume that its consumption should be restricted; this of the 240 respondents, which 76% are in favor of water care [21]. In Trujillo, the implementation of an environmental management system based on the ISO14001 standard led to good levels of savings in the company Consorcio G and D2, a decrease in fines and performance, allowing greater supervision in environmental management and measuring economic benefits [22]. On the other hand, the results support that there is a significant relationship of $Rho = 0.725$ between project management oriented to ISO 14001 and environmental quality in restaurants in the district of San Vicente de Cañete, which also shows that the activity of establishments should be oriented towards environmental responsibility [23]. The research for the construction sector of Cusco proposes policy criteria for the implementation, appraisal and verification of the system, taking into account the other regulations in force [24].

4.4. Practical Implications and Recommendations

The findings of this research emphasize the paramount significance of rigorous implementation of the ISO 14001 environmental management system within the construction sector. It was noted that organizations with robustly established systems not only adhere to environmental regulations but also significantly improve their environmental performance, realizing cost efficiencies through the strategic optimization of resource utilization and the minimization of waste. For construction companies, it is essential to invest in ongoing training programs for employees on sustainable practices and environmental management. This ensures the proper implementation and maintenance of the ISO 14001 system. Additionally, establishing mechanisms for the regular

evaluation of the environmental management system is crucial to identify opportunities for continuous improvement and to adapt to new regulations or environmental challenges. Regulatory bodies are advised to develop and disseminate comprehensive guides and case studies on successful ISO 14001 implementation, with a particular focus on small and medium-sized construction companies. Furthermore, offering incentives, such as tax reductions or access to preferential financing, to companies that demonstrate a strong commitment to environmental stewardship and sustainability is highly recommended. Academic and research institutions need to encourage applied research in collaboration with industry, focusing on the exploration of new technologies and practices that can be integrated into the ISO 14001 environmental management system. Additionally, the development of specialized training programs in environmental management and sustainability aimed at construction professionals is crucial to enhancing their expertise in designing and implementing sustainable practices.

4.5. Limitations

This study, although exhaustive in its scope and analysis, faces inherent limitations in its methodological design and geographical scope. First, the qualitative nature of the research, while allowing for an in-depth understanding of ISO 14001 implementation practices, limits the possibility of generalizing the findings to all construction companies. Second, the selection of countries, while diverse, could be expanded to include more regions that are implementing ISO 14001 under different contexts, such as regulatory and cultural issues. Third, there are various academic works on the implementation of ISO in companies and organizations [27]; however, there is little information comparing implementation results across specific regions as this study does.

4.6. Future Research

To overcome the limitation in generalizing the results, future research could employ quantitative methodologies to assess the prevalence of ISO 14001 implementation practices identified in this study on a broader scale. Such an approach would allow for the collection and analysis of large-scale data, providing more statistically significant results that could be generalized across different contexts and industries. By incorporating surveys, structured interviews, and empirical data collection methods, future studies could quantify the extent of ISO 14001 adoption and its impact on environmental performance across a more diverse set of construction companies.

Additionally, future research could benefit from including a more diverse set of countries, particularly those from regions underrepresented in the current literature on the implementation of environmental management systems in the construction industry. Expanding the geographic scope of research to include countries from Africa, Southeast Asia, and other emerging markets could offer valuable insights into the challenges and successes of ISO 14001 implementation in varying regulatory, cultural, and economic environments. Moreover, longitudinal studies that track the long-term effects of ISO 14001 adoption on environmental and economic performance over several years would provide a deeper understanding of the standard's sustained impact. Another promising area for future research could involve comparative analyses between ISO 14001 and other environmental management frameworks, such as EMAS or sector-specific certifications, to evaluate their relative effectiveness in different industrial contexts. This could also include investigating the interplay between ISO 14001 and Corporate Social Responsibility (CSR) initiatives and exploring how these frameworks complement each other in driving sustainability goals within the construction sector.

5. Discussion

The analysis presented in this study highlights the varied implementation of ISO 14001 across different regions and sectors, particularly focusing on construction companies in Latin America compared to their global counterparts. One key finding is the significant influence of governmental and organizational commitment on the effectiveness of ISO 14001 implementation, as seen in countries like China and Denmark. These countries have demonstrated substantial progress in environmental management due to robust support systems and well-structured regulatory frameworks. Conversely, the challenges faced in Latin America, such as limited governmental support and inadequate infrastructure, underline the need for tailored strategies to enhance ISO 14001 adoption in these regions.

Data collected through qualitative methods, including interviews, surveys, and case studies, reveals that while the adoption of ISO 14001 is widespread, the depth and impact of its implementation vary considerably. For instance, the study found that in Brazil and Ecuador, the construction sector's engagement with ISO 14001 has led to positive environmental outcomes, albeit at different levels of intensity and success. The contrast between these countries and others, such as Peru and Venezuela, where implementation is less effective, suggests that local contexts, including economic conditions and cultural factors, play a critical role in shaping the outcomes of ISO 14001 adoption. In comparison to state-of-the-art techniques reported in the literature, this study achieves better results by emphasizing the integration of local context into the ISO 14001 implementation process. Previous studies have often focused on the standard's generic application without sufficiently accounting for regional differences in

regulatory frameworks, economic conditions, and cultural practices. By conducting a comparative analysis that juxtaposes global best practices with local adaptations, this research provides a more nuanced understanding of how ISO 14001 can be effectively implemented in diverse settings. This tailored approach not only enhances the relevance and applicability of the findings but also contributes to more sustainable and impactful environmental management practices in the construction sector.

In addressing the limitations of this study, it is important to note that the qualitative nature of the research, while providing in-depth insights, may not fully capture the broader trends across the construction industry. Future research could benefit from a more quantitative approach, incorporating larger sample sizes and statistical analyses to validate findings and provide a more comprehensive understanding of ISO 14001's impact globally. Moreover, the study underscores the need for ongoing evaluation and adaptation of environmental management practices to ensure they remain effective in the face of evolving regulatory and environmental challenges. Fostering a culture of continuous improvement and learning, construction companies in Latin America can enhance their environmental stewardship and contribute to broader sustainability goals.

6. Conclusion

This study has critically evaluated the implementation of the ISO 14001 environmental management system in construction companies worldwide, revealing significant variations in its application and impact. The results show that in China, the adoption of ISO 14001 has been particularly successful, with 22% of certifications concentrated in the construction sector, highlighting the global relevance of the standard and environmental commitment in different contexts. In Latin America, specifically in Peru, it was found that 62.17% of the evaluated construction companies exhibit a regular implementation of the standard, while 22.97% rated it as efficient.

Additionally, a 20% reduction in water consumption was observed in companies that applied technological and management measures, demonstrating the effectiveness of the environmental practices promoted by ISO 14001. Furthermore, in Trujillo, Peru, the implementation of the ISO 14001 system resulted in significant savings for the company Consorcio G y D2, along with a reduction in environmental fines. Previous studies also identified a significant correlation ($Rho = 0.725$) between ISO 14001-oriented project management and environmental quality in establishments in the district of San Vicente de Cañete. These quantitative results not only confirm the environmental and economic benefits derived from the implementation of ISO 14001 but also underscore the need for stronger regulatory support and implementation strategies tailored to local contexts to maximize its effectiveness.

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