DIPLOMA THESIS

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2024

Hungarian University of Agriculture and Life Sciences

Szent István Campus

Stipendium Hungricum

Engineering Management master's training education

Identifying the barriers to green product in Iran: Interpretive structural modeling approach

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Gödöllő, Hungary

2024

INSTITUTE OF TECHNOLOGY
ENGINEERING MANAGEMENT MASTER
Project management specialisation

DIPLOMA THESIS

worksheet

Mohammad Javad Delshad (DFS5R3)

for

Title of the diploma thesis:

Identifying the barriers to green product in Iran: Interpretive structural modeling approach

Task reference:

- Study the connected literature review.
- Introduce the utilization of Interpretive Structural Modeling and MICMAC methodology.
- Identify the critical hurdles including limited government aid and lacking standard procedures.
- Check the results and give suggestions.

Contributing department: Engineering Management

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Deadline of thesis submission: 2024. April 22.

Gödöllő, 2023. November. 15.

I approve

(head of deparment) (specialist coordinator)

Received

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Introduction

Introduction

In today's global environment, the lack of resources on the one hand and environmental changes on the other hand are considered as one of the basic challenges for mankind. These two challenges are also closely related to each other and have wide-ranging effects on human behavior and life. With the increase in global population and economic growth, the need for resources such as water, food, energy, and minerals has increased dramatically. This increase inevitably leads to tension and pressure on natural resources, which may lead to depopulation, a decrease in the quality of life, and even demographic and social conflicts. Climate change, air and water pollution, loss of biodiversity, and reduction of natural resources are among the negative effects of environmental changes. These effects can directly affect human health, quality of life, and sustainable development. To deal with these challenges, measures such as optimal use of resources, development of sustainable technologies, preservation and protection of the environment, and promotion of sustainable life patterns are of great importance. Also, international cooperation and global commitments are essential to solve these issues and create a stable environment for human life in the future[1].

The reduction of industrial activities emerges as a pivotal strategy for nations committed to environmental preservation and mitigation of ecological degradation. This approach necessitates the optimization of natural resource utilization, encompassing water, energy, and raw materials, thereby diminishing environmental impact through decreased consumption. Integration of clean technologies and mitigation of air, water, and soil pollution are integral components in the preservation of biodiversity and the conservation of natural resources. Moreover, this approach holds promise in fostering sustainable development and catalyzing regional and global economic growth, concurrently enhancing societal welfare and ensuring the preservation of resources for future generations[2].

Achieving this objective mandates that companies devise and implement innovative production processes characterized by minimal environmental repercussions. Presently, a growing number of firms are cognizant of their responsibilities in product development, service provision, and health-related endeavors, with the imperative of mitigating environmental risks throughout production emerging as a fundamental requisite. This evolving ethos underscores heightened corporate attention to environmental considerations and their ramifications during product design and production processes. Consequently, companies endeavor to integrate clean technologies and renewable materials into their product development endeavors to curtail adverse environmental impacts. Such conscientious and sustainable practices in product design and production not only position companies as proactive stewards of the environment but also confer upon them a competitive advantage.

On the contrary, regulatory mandates established by governmental and non-governmental entities, coupled with international standards, alongside customer demands for environmental adherence, exert a significant impact on organizational behavior and performance. These mandates may encompass legal stipulations, regulatory frameworks, ethical standards, and customer expectations for environmental safeguarding. Such imperatives and obligations have impelled organizations to enhance their environmental and economic prowess. In adhering to these directives and securing environmental endorsements, organizations may undertake measures such as deploying clean technologies, streamlining production processes, curtailing natural resource consumption, implementing recycling initiatives, and mitigating pollution. These initiatives, besides preserving the environment, engender cost efficiencies and augment organizational productivity. Overall, the focus on environmental issues as a societal imperative, coupled with meeting customer demands, not only fosters environmental preservation but also enhances organizational performance and profitability.

The ramifications of operational endeavors, notably production and manufacturing, exert a profound and noteworthy influence on the environment due to their extensive and diversified nature. These activities not only necessitate substantial resource utilization but also have the potential to engender pollutants, leading to air and water contamination, biodiversity loss, and environmental degradation. For instance, the operational processes typically demand significant energy consumption, primarily derived from fossil fuels, thereby escalating greenhouse gas emissions and contributing to global warming. Moreover, the employment of chemical substances and products in manufacturing procedures can exacerbate water and soil pollution, resulting in the deterioration of water and soil resource quality. However, avenues exist for mitigating these deleterious impacts, including the adoption of clean and efficient technologies, enhancements in production processes, material recycling initiatives, utilization of renewable energy sources, and enforcement of rigorous environmental standards and regulations. These interventions hold promise for curbing resource consumption, ameliorating pollutant emissions, and safeguarding the environment, thereby culminating in enhanced environmental and economic performance for organizational entities.

Henceforth, the corporate social responsibility (CSR) paradigm embodies the voluntary engagement of enterprises in sustainable development, constituting an indispensable requisite for its realization. This responsibility entails adherence to legal mandates alongside ethical and societal obligations regarding corporate activities and their environmental and societal ramifications. Firms are obligated to operate with commitment and accountability towards their impacts on both the environment and society. Consequently, environmental conservation has emerged as a paramount concern within contemporary human society, prompting the establishment of a novel production paradigm termed "green production." This paradigm underscores the adoption of clean technologies, judicious resource allocation, preservation of biodiversity, and societal value creation, serving as principal avenues for organizations to pursue sustainable and conscientious development[3].

Problem Statement

Despite the multifaceted social, economic, legal, and environmental obligations that impact corporate executives, fostering environmental sustainability through green production practices faces notable challenges. Empirical investigations unveil a plethora of barriers impeding companies' transition towards green and sustainable production processes, thwarting their commitment to environmental stewardship within the production paradigm. Scholarly inquiry suggests that the realization of green and sustainable production is contingent upon coordinated efforts between governmental bodies and industries, strategic policy interventions, and the mitigation of impediments hindering the adoption of eco-friendly practices. Diverse obstacles, such as financial constraints, necessitating organizational cultural transformations, limited access to sustainable technologies, and apprehensions regarding financial ramifications, obstruct the seamless adoption of green production initiatives. Nevertheless, collaborative frameworks and synergies between governmental entities and industry stakeholders offer promising avenues to identify and navigate these barriers, steering enterprises towards environmentally responsible and sustainable production methodologies. Strategic interventions aimed at alleviating these barriers, including financial incentives, capacity-building initiatives, research and development support for sustainable technologies, and the formulation of conducive regulatory frameworks, hold the potential to facilitate the successful adoption of green and sustainable production practices by enterprises.

Scholarly inquiries underscore a myriad of obstacles confronting companies in their pursuit of green and sustainable production methodologies. These impediments span across legal, economic, environmental, and social domains, posing formidable challenges to companies' endeavors. Given the complexity of these barriers, a thorough and obligatory examination from diverse perspectives becomes imperative to elucidate pathways for overcoming these challenges and enhancing production processes within Iranian manufacturing enterprises. This study endeavors to conduct an in-depth analysis of the barriers hindering green production practices in Iranian manufacturing enterprises and proffer solutions for enhancement.

Research Importance

Within the Iranian manufacturing landscape, impediments to the adoption of green and sustainable production practices hold significant implications. Notably, inefficient legal mandates pose hurdles, occasionally ensnaring company executives in legal complexities. Furthermore, a dearth of skilled professionals proficient in green production methodologies may undermine the quality and efficacy of production processes. The lack of unequivocal commitment from senior management to green and sustainable production further compounds the challenge by potentially sidelining associated obligations and responsibilities. Moreover, subdued consumer demand for environmentally friendly products can precipitate market challenges for manufacturing enterprises, ultimately undermining their economic viability. In summary, addressing the barriers to green production within Iranian manufacturing enterprises necessitates a comprehensive and obligatory examination from a broad spectrum of social, economic, and environmental perspectives, aiming to devise apt strategies for promoting sustainable production practices.

Research Questions

Primary Category: Barriers to Green and Sustainable Production

1. What are the legal impediments hindering the adoption of green and sustainable production practices within the manufacturing firms of Iran?

2. How can social perspectives assist in identifying the barriers to green production within the manufacturing sector?

3. What economic factors pose challenges to the implementation of green and sustainable production methods in Iranian manufacturing enterprises?

4. How can environmental considerations aid in discerning the obstacles obstructing green production initiatives?

Secondary Category: Strategies for Enhancement

1. What strategies can be employed to enhance legal frameworks and facilitate the adoption of green and sustainable production practices?

2. How can the alignment with social needs contribute to the promotion of green and sustainable production methodologies?

3. What measures can be implemented to improve the economic landscape and support the integration of green production principles within Iranian manufacturing entities?

4. In what ways can the integration of new technologies foster advancements in green and sustainable production practices within Iranian manufacturing firms?

Research Objectives

1. Legal Impediments to Green and Sustainable Production in the Iranian Manufacturing Sector: A Comprehensive Analysis

2. Social Barriers to Green Production: Identifying and Addressing Challenges in the Iranian Context

3. Economic Constraints and Their Impact on the Quality of Environmentally Friendly Products in Iran's Manufacturing Industry

4. Environmental Challenges to Green and Sustainable Production: An In-depth Examination of Key Factors

5. Enhancing Legal Frameworks for Green and Sustainable Production: Recommendations for Reform and Improvement

6. Addressing Social Needs and Preferences in Green Production: Strategies for Effective Engagement

7. Promoting Economic Viability for Green and Sustainable Production in Iran: Policy Interventions and Practical Measures

8. Harnessing Emerging Technologies for Healthier and More Sustainable Production Practices in the Iranian Manufacturing Sector

Research Methodology

Utilizing the interpretive structural modeling approach, our research methodology adopts a reflexive stance towards discerning and interpreting the conceptual and patterned intricacies within the data, thus facilitating a nuanced comprehension of social and organizational dynamics. This approach integrates two foundational conceptual frameworks: the Structural Model and the Interpretive Model, to explicate the interrelations among diverse variables. By analyzing both qualitative and quantitative data, we aim to unveil the latent concepts and patterns, subsequently scrutinizing their relationships through the structural model.

Research Procedure: The research initiates the comprehensive gathering of qualitative and quantitative data pertinent to the domain of green and sustainable production within Iranian manufacturing entities. Following data collection, a meticulous analysis of content ensues, wherein emergent patterns and concepts are interpreted to unveil insights into the obstacles and remedies associated with green and sustainable production.

Conceptual Analysis: This phase entails a rigorous examination of the data's conceptual landscape, aimed at delineating a spectrum of impediments and resolutions about green and sustainable production. Employing methodologies such as content analysis for textual data and factor analysis for numerical data, we delve deep into the interpretative process to elucidate underlying themes.

Structural Modeling: Leveraging structural models, we undertake an in-depth exploration of the interrelationships among variables. Utilizing methodologies like structural equation models (SEM) and multiple regression models, we seek to elucidate the causal pathways between variables, thus contributing to a comprehensive understanding of the phenomenon under study.

Interpretation and Conclusion: Drawing upon the insights gleaned from data analysis and structural modeling, we engage in a process of interpretation to derive meaningful conclusions. These conclusions not only deepen our understanding of the obstacles and solutions related to green and sustainable production within Iranian manufacturing enterprises but also offer actionable recommendations aimed at enhancing the current scenario.

Literature Review

Introduction

This study identifies challenges that prevent industries from successfully implementing Green Production. A comprehensive literature review was done to identify these impediments. This section reviews the literature on impediments to Green Production techniques in manufacturing processes. Conducting a literature review is an important element of academic study. The current literature was evaluated to identify hurdles to Green Production in manufacturing processes.

There is extensive research on the challenges of both green and lean manufacturing. However, there is a scarcity of studies addressing impediments to Green Production. To find relevant research papers, search terms like "Green Production" and "Green Production Barriers" were used in various publishers' electronic databases. The electronic databases included Elsevier (sciencedirect.com), Emerald (emeraldinsight.com), Taylor & Francis (tandfonline.com), IEEE (ieeexplore.iee.org), Springer (springerlink.com), Wiley (onlinelibrary.wiley.com), and Inderscience Publishers (inderscience.com). Additionally, Google Scholar (scholar.google.com) was used. The literature review focused on papers that were most relevant to the topic under consideration.

Green Products

The existing literature recognizes that Green Production entails achieving a balance between profitability, efficiency, customer satisfaction, quality, and responsiveness to environmental priorities and initiatives (Garza-Reyes, 2015; Mittal et al., 2016). While some studies propose that lean principles drive Green Production, others argue that Green Production drives lean, and there are differing opinions on which should be implemented first, with some advocating for simultaneous adoption of both (Inman and Green, 2018). Additionally, the literature indicates that Green Production and lean share similar capabilities. Moreover, implementing lean strategies can reduce the marginal costs associated with Green Production by either lowering implementation costs or providing additional inputs for significant environmental benefits, thereby improving environmental practices (Hajmohammad et al., 2013).

The concurrent adoption of these approaches enables organizations to enhance both their financial and environmental performance (Gaikwad and Sunnapwar, 2020). However, the literature suggests that implementing Green Production activities is challenging due to various barriers (Kumar et al., 2016). Despite this, only a limited number of studies in the existing literature have examined the barriers to Green Production (Cherrafi et al., 2017; Sindhwani et al., 2019; Kumar et al., 2016). There is a notable gap in the literature regarding the comprehensive identification and analysis of barriers that hinder the implementation of Green Production. Furthermore, there is a need for further research to elucidate the complex relationships among these barriers and assess the extent of influence that one barrier may have on another.

In addressing this gap, an initial list of fifty-seven barriers has been compiled based on a thorough review of the literature, as presented in **Table 2-1**. Additionally, Graza-Reyes (2015) has highlighted the need for additional research to simplify the intricate relationships among different barriers to Green Production and analyze the degree of influence that one barrier exerts on another. Thus, further investigation is warranted to deepen our understanding of the impediments to Green Production and develop strategies to overcome them effectively.

Identification of barriers from the existing literature

Environmental Awareness Deficiency

Despite the increasing awareness of environmental concerns among decision-makers in manufacturing operations, industrialists, scientists, and consumers globally, studies indicate that mere environmental knowledge may not suffice to drive positive environmental behavior[4]. The urgency of addressing environmental issues stems from the dire consequences of leaving them unresolved. Failure to address these challenges may render the Earth uninhabitable for future generations. Consequently, the lack of environmental knowledge emerges as a substantial barrier to the effective implementation of green production practices.

Zsóka et al. (2013) examined the impact of environmental education on the environmental knowledge, attitudes, and behaviors of university and high school students. It emphasizes the importance of integrating sustainability issues into education to achieve a focused and explicit impact. Through a comparative questionnaire survey analysis, the research finds a strong correlation between the intensity of environmental education and students' environmental knowledge. This correlation is attributed to both the content of environmental education and the intrinsic motivation of committed students, particularly at the university level. The study highlights the role of environmental education in shaping attitudes towards sustainable consumption and lifestyle changes, particularly by addressing consumerism[5].

In a broad context, consumer knowledge enables understanding of product attributes, facilitating evaluation based on quality and benefits. Environmental knowledge is closely linked to attitudes and pro-environmental behavior. It plays a pivotal role in shaping attitudes and fostering a sense of social responsibility, encouraging environmentally-friendly consumption. Environmental knowledge encompasses consumers' perceived understanding of the environment, including awareness of environmentally friendly and harmful behaviors and products. It also encompasses recognition of green product identification such as eco-labels and symbols, classified as subjective knowledge[6]. Subjective knowledge has demonstrated a significant association with willingness to pay higher prices for organic products[7], intention to recycle and reduce energy consumption[8], and engagement in pro-environmental behaviors[9].

Consumers with higher subjective knowledge exhibit greater confidence in performing pro-environmental behaviors, whereas those with lower knowledge display lower self-confidence[10]. Consequently, consumers may hesitate to act without sufficient knowledge. For instance, understanding eco-labels influences purchase decisions, with knowledgeable consumers more likely to opt for green products[11, 12].

Insufficient Management

Insufficient commitment from top management stands as a prominent obstacle to the successful implementation of green practices[13]. Competent leadership is essential for the adoption of green production practices, with top management's resolve playing a pivotal role. Sustained motivation of employees is imperative for the adoption of new practices in manufacturing operations. The effective implementation of green production initiatives in manufacturing industries hinges upon the steadfast commitment demonstrated by top management[14]. Active involvement of top management is specifically required for the successful implementation of green production practices[15]. Li et al. (2019) underscored the importance of top management in continually monitoring and evaluating how the institutional environment fosters the significance of green production within a company. Moreover, they emphasized the need for top management to assess how internal organizational factors either facilitate or impede the adoption of green practices and to respond accordingly[16].

Resistance/fear of change

Certain management practices often reflect acceptance of the karma doctrine, which includes principles such as duty, loyalty to others, compliance, and the willingness to fulfill one's responsibilities even if it causes personal discomfort[17]. Resistance to change manifests as a reluctance of a system to deviate from its current behavior, despite attempts to induce change through various means[18, 19]. Employees within organizations exhibit resistance to changes in their daily work routines, often feeling uneasy due to the unpredictability of outcomes[19]. The persistence of values that hinder change contributes to this resistance. Managing resistance to change effectively is crucial in any change process, as it can determine the success or failure of the endeavor[20].

Financial constraints

The adoption of green production practices often necessitates an initial investment, posing a significant risk for business leaders. Insufficient financial resources can create obstacles in implementing new environmental policies, particularly for organizations prioritizing profit-making[19]. Numerous studies have identified a lack of financial resources as a prominent barrier to the implementation of green production initiatives. This barrier is particularly pronounced for small companies, where limited financial resources may impede the adoption of environmentally friendly practices[21]. The challenge of securing adequate funding for green initiatives underscores the importance of addressing financial constraints to facilitate the transition toward sustainable production methods.

Increasingly, small and medium-sized enterprises (SMEs) worldwide are aspiring towards sustainable business practices, which promise profitability, resilience, and positive social and environmental impacts. To achieve this, many SMEs are turning to green thinking' as a popular strategy to enhance production efficiency and reduce waste. Candera et al (2019) studied the co-evolution of green thinking and examined how these practices can facilitate successful transitions to sustainable business practices, particularly focusing on manufacturing SMEs in Queensland, Australia. Through in-depth interviews with CEOs and senior managers involved in sustainability and lean manufacturing, the study identifies four key enablers and six key barriers to sustainable business practice. Drawing on institutional theory, the study highlights the influence of normative, coercive, and mimetic drivers in shaping SMEs' environmental, social, and economic decision-making processes and legitimizing the transition to sustainable business practices. In response to these findings, the study proposed a 'Model of strategic enablers of sustainable business practice' to guide SMEs in leveraging lean and green strategies to achieve sustainable business outcomes intentionally. The model emphasized the importance of adopting lean and green thinking to accelerate SMEs' contributions to the circular economy at the firm level. Furthermore, the study suggested that agencies and professional bodies can play a crucial role in supporting SMEs during this transition by offering targeted interventions that address the identified enablers and barriers. By embracing lean and green practices, SMEs can effectively navigate towards sustainable business practices, thus making significant strides towards a more circular and sustainable economy[22].

Manufacturing performance is critical for organizational success, necessitating the adoption of sustainability measures due to reliance on non-renewable resources and waste generation. Bhanot et al (2017) proposed a comprehensive sustainability framework for the manufacturing sector, aiming to enhance enablers and address barriers. Structural equation modeling validated enablers and barriers statistically, based on responses from both groups. The study seeked to bridge gaps in opinions between researchers and industry professionals to facilitate effective sustainability implementation in manufacturing[23].

Green products require high degrees of innovation and investment. This increases the costs of production development and consequently makes them more expensive than available replacements. The price factor makes the customer reluctant to purchase. In addition, the fairness of the price of green products increases the consumer's perceived value and purchase intention[24]. For example, the Chinese pay attention to environmental quality and thus, are inclined to pay more for green products. Even if the studies indicate that the consumers in the newly-emerged markets are willing to pay higher prices for green products, it turned out otherwise[25].

It can be inferred from the above-mentioned that the green products’ price affects the purchase intention of consumers. Overall, the perceived price is one of the main criteria for purchasing green products, and the price of such products is more effective on consumers’ intention to purchase. A constant decrease in the price of products is a vital factor in gaining a higher percentage of customers. Also, the cost price of green products is an obstacle to directing producers towards investment in green products line and changing them into green businesses[26].

As a result of the increase in green products consumerism, the use of such products is significantly increased. This is especially true for the developed countries. In addition, the emergence of consumerism indicates that some consumers are willing to pay the premium price. However, generally, the lower incomes of customers in developing countries make them prioritize their higher hierarchical needs over green products[27]. Price is a critical factor for green products. Green products usually have higher prices than conventional products. Mostly, they have higher primary and output costs, however, their long-run costs are lower. Most consumers are willing to pay higher prices only if they perceive the added value of the product. Green products should be intended for environmental safety by maintaining the balance between the customer's expenses and the satisfaction of paying more[28].

Lack of Employee Training

Proper training and knowledge are essential for the successful implementation of green product practices, both for managers and employees. Training plays a crucial role in equipping organizations with the skills and knowledge necessary for adopting green product practices[29]. It is increasingly urgent for industries to invest in training to enhance resource efficiency and environmental sustainability. Continuous training programs are vital for employees in manufacturing industries to effectively implement green product approaches[30]. Professionals in manufacturing industries require training to embrace green systems and ensure the sustainable growth of these initiatives[31]. Given the complexity of policies and practices, some employees may lack awareness of green values.

Therefore, implementing various education and training programs is essential to enhance employees' understanding of environmental principles and green policies[32].

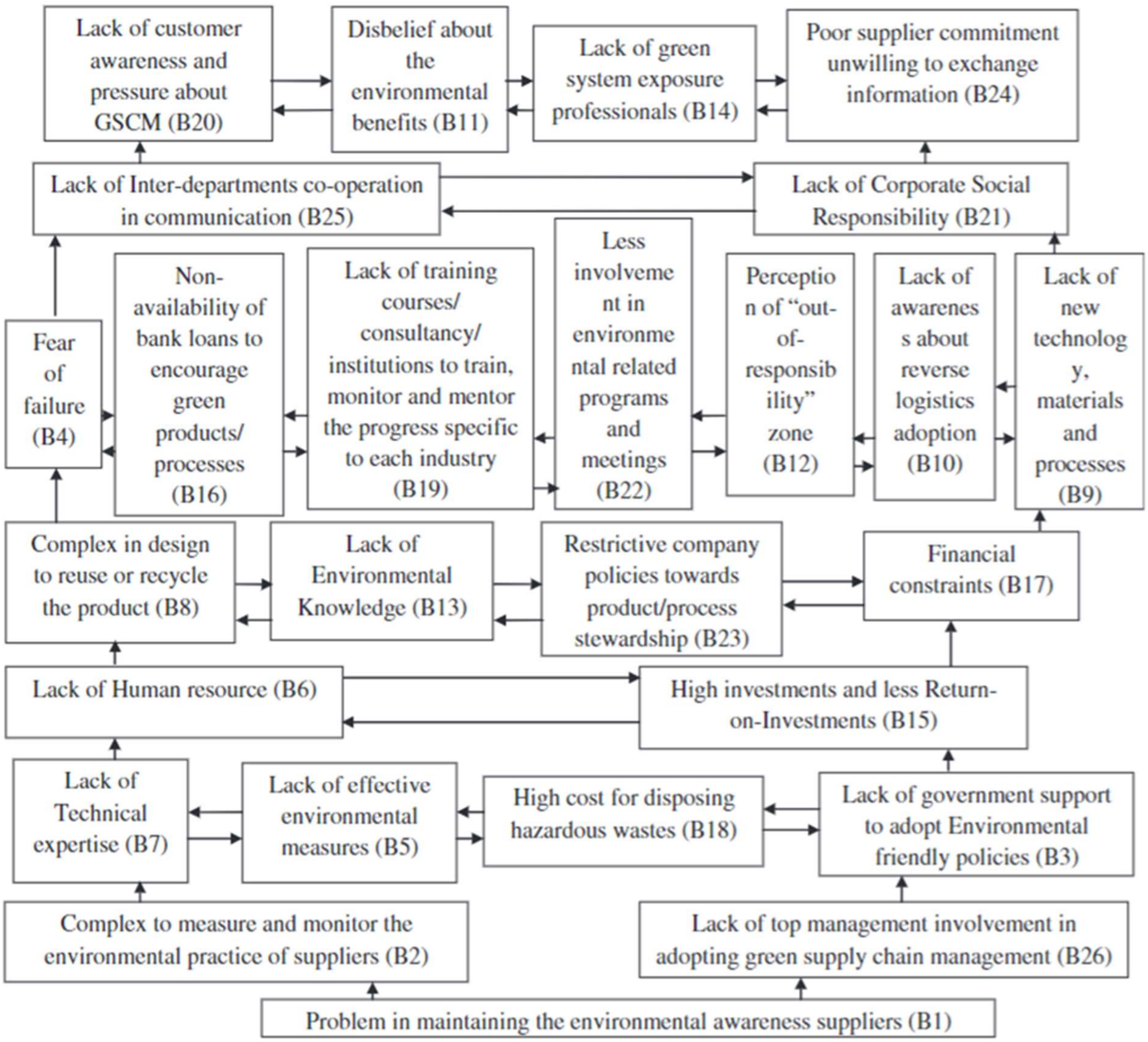

Figure 2- 1 The mid-level position of lack of the training in the ISM model of Ref.[31]

Insufficient Government Support

Governmental backing is pivotal for facilitating the seamless operation of businesses, especially in cultivating an environment conducive to sustainable practices within manufacturing sectors. Manufacturing industries must abide by environmental regulations to ensure compliance with the laws governing their operations. However, the regulatory landscape can be significantly influenced by political dynamics, potentially leading to disruptions in sustainability initiatives. Abrupt political changes in a region can pose challenges to the effective implementation of green product strategies[31].

To address this issue, there is a pressing need for governments to provide robust support through various means. For instance, policymakers can implement supportive policies and regulations that incentivize and facilitate the adoption of eco-friendly technologies and practices. Subsidies, tax incentives, and grants can be instrumental in encouraging businesses to invest in sustainable solutions and upgrade outdated technologies[33].

Furthermore, government initiatives can extend beyond regulatory measures to encompass educational and awareness-building programs. By promoting knowledge dissemination and training initiatives focused on sustainable practices, governments can empower businesses to embrace green product strategies more effectively. Investing in educational campaigns and providing resources for training programs can equip manufacturing industries with the necessary skills and knowledge to navigate the transition toward sustainability[21]. Ultimately, by bolstering government support through a combination of regulatory frameworks, financial incentives, and educational initiatives, manufacturing industries can be better positioned to integrate green product practices into their operations, fostering a more sustainable future.

Technological constraints

The dynamic nature of manufacturing industries often demands technological advancements to enhance operations. However, integrating new technologies requires careful planning, maintenance, and a skilled workforce to oversee implementation. Technological upgrades, such as those in computer-aided manufacturing, computer-aided design, and robotics, necessitate proficient manpower for efficient management[19]. This barrier stems from the reliance on outdated industrial technology and the scarcity of skilled labor[21]. Overcoming technological constraints requires a strategic approach to ensure smooth transitions and maximize the benefits of technological innovation.

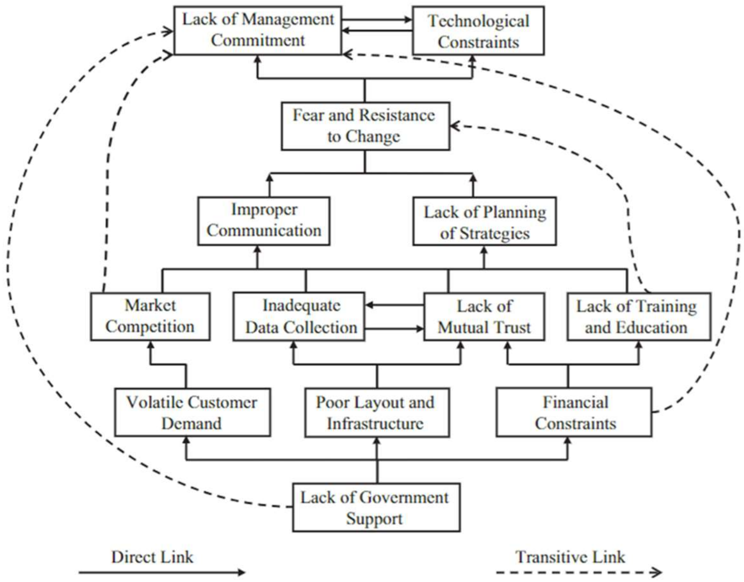

Figure 2- 2 The role of the technological constaraints at the top of the barriers positions [19]

Lack of Communication

Effective communication skills are essential in fostering a conducive work environment. Clear communication not only conveys messages accurately but also resolves issues encountered during the implementation of initiatives like Green Lean. Conversely, a lack of effective communication undermines the confidence of workers in manufacturing industries. Employees need to be adequately informed about the changes associated with Green Lean practices being introduced[34]. Successful adoption of Green Lean principles relies on efficient communication, team management, and coordination across different levels[35]. Hence, the absence of good communication hampers the effective utilization of Green Lean practices within organizations.

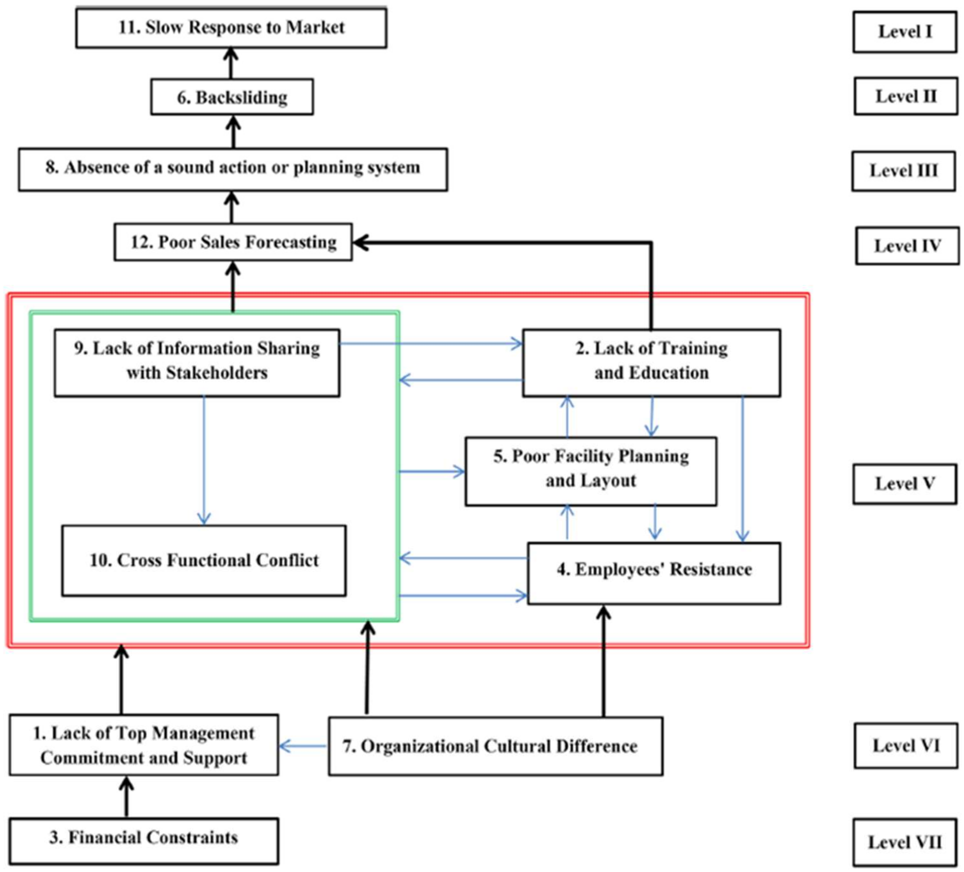

Figure 2- 3 The position of lack of communication in the ISM model of ref. [34]

Supplier issues

Effective implementation of Green Lean practices requires collaborative efforts involving all members of the supply chain to enhance competitiveness[36]. However, suppliers may exhibit reluctance to embrace Green Lean initiatives due to entrenched traditional beliefs[37]. Manufacturing industries can incentivize suppliers by offering rewards and benefits for adhering to stringent environmental regulations and supporting Green Lean strategies[38]. Suppliers play a vital role as cohesive elements within organizations, crucial for survival and growth in today's competitive landscape. Nonetheless, studies indicate that suppliers have not always been actively engaged in Lean implementation efforts[15]. Addressing this barrier requires fostering stronger partnerships and collaboration with suppliers to align their goals with the organization's sustainability objectives.

It is believed that awareness is created before the availability of a product. A study has approved that the level of awareness of Green Products (GPs) is above their availability. According to Yadav and Pathak (2017), availability paves the way for consumers to buy green products. The availability of GPs makes consumers pay more attention to the value presented by environmental safety[39]. Also, it is reported that the weakness in the availability of GPs in the market makes consumers ignore such choices[27]. Similarly, it has been reported that the unavailability of GPs in the market causes unpopularity and thus lack of demand for such products. Factors such as availability cannot be excluded from the factors influencing consumers to purchase green products[40]. Therefore, availability affects the choice of green products or non-green rivals. Clearly, unavailability means no purchase. A portion of consumers who are environmentally responsible have difficulties finding green products when shopping[41].

The low availability of green products is an important obstacle. If green products cannot be physically accessed when shopping, advantages such as performance and safety are reduced. Thus, it is a big obstacle to the acceptance of green products[42]. In addition, the low availability of the product requires the consumers to refer to specialized stores to buy eco-friendly products. Even when such products are available in some stores, the inadequate and unattractive point-of-purchase presentation and display make the consumers spend more time buying such products. Therefore, consumers consider green purchases to be time-consuming and require extra effort[43].

Lack of Standard Practices

The lack of international environmental certificates (e.g., ISO 14001) creates difficulties for various industries regarding international recognition. As a result, they will not be able to penetrate the global market and increase their market share. The lack of standard practices for producing green products is another potential obstacle to green activities in the supply chain of businesses. If manufacturing industries want to keep up with international standards, they should achieve the sustainability certificate (ISO 14001). Without this certificate, the producers will not implement green product manufacturing methods correctly. The industries that intend to implement such methods should know standard procedures for green activities. Since contemporary industries do not do green activities with a standard procedure, there is a knowledge gap in the implementation of standard procedures for the production of green products[44].

Also, there are not enough standards to define the sustainability of a firm or a product, because different sectors are faced with different challenges. For example, paper and plastic sectors compete in the same market[45]. Creation of a common standard is difficult as the European Union found through multiple initiatives at the firm and product levels. Lobbying by trade associations for their interests leads to more complexity of the standardization procedures and prolongation of the rules established by it. Standardization plays a very important role in sustainable development efforts, which is due to its significant effects on the design of products and processes[46]. Standards can define the acceptable levels of energy consumption, waste management methods, and other environmental protection measures. Green products standard helps consumers with a better understanding of the increasing number of green and eco-friendly products in the market. Their standards provide a comprehensive view of the life cycle of each product as well as a degree of 'greenness' explained with a simple symbol and a report[47]. Green labels or standards are voluntary or mandatory plans that demonstrate the environmental features or functions of a product or a service. They can cover aspects such as energy efficiency, water consumption, carbon footprint, waste management, biodiversity, or social responsibility. Some of the green labels and standards include the EU Ecolabel, the Energy Star, the Forest Stewardship Council (FSC), and the Fairtrade certification.

Table 2- 1 A list of important barriers toward green production

Entry	Item
1	Environmental Awareness Deficiency
2	Insufficient Management
3	Resistance/fear of change
4	Financial constraints
5	Lack of Employee Training
6	Insufficient Government Support
7	Technological constraints
8	Lack of Communication
9	Supplier issues
10	Lack of Standard Practices

Case Study

Green Standard

Green Standard for green production in Iran encompasses a comprehensive set of guidelines and regulations aimed at promoting environmentally sustainable practices within industries. The expansion of industrial activities has significantly contributed to environmental degradation, posing threats to the planet's ecosystems. Whether intentional or inadvertent, human actions have led to the degradation of the environment, affecting both human and non-human life forms. To ensure the longevity of the environment, it is imperative to transition towards sustainable practices that minimize harm to the ecosystem.

The Green Standard outlines a series of requirements and recommendations tailored to industries to foster environmentally friendly production methods and products. By eliminating harmful practices and adopting sustainable alternatives, industries can mitigate their environmental impact and contribute positively to ecosystem preservation. Compliance with the Green Standard not only benefits human society by improving living conditions but also supports the well-being of other species sharing the planet.

Industries adhering to the Green Standard are recognized for employing practices that prioritize environmental preservation. In light of increasing concerns such as air pollution, climate change, and resource depletion, the demand for green industries has grown substantially. Financial institutions, both domestic and international, are increasingly reluctant to provide support to industries that contribute to environmental pollution.

The Green Standard evaluates various parameters to ensure compliance and certification for green production:

- Absence of the industrial unit from the list of environmental polluters.

- Confirmation of pollutant reduction processes by relevant authorities.

- Implementation of efficient waste recycling management.

- Adoption of clean energy sources over fossil fuels.

- Acquisition of ISO 14000 and ISO 18000 certifications.

- Development of green spaces within industrial premises.

- Optimization of energy consumption throughout the production process.

- Enhancement of environmental knowledge and awareness among management and employees.

- Minimization of negative environmental impacts and waste generation.

Verification of compliance with these criteria is overseen by the Environmental Protection Organization of the respective province where the industrial unit is located. Upon meeting all requirements, industrial units receive certification as compliant with the Green Standard. Certification under the Green Standard is valid for one year, subject to annual reassessment for continued compliance. This ensures ongoing commitment to green production practices and reinforces the transition towards environmentally sustainable industries in Iran.

Regulations

The support of lawmakers for the environment has not been able to provide the necessary and deserving protection for this environment as it should. It should be noted that legislative support for the environment is not evaluated positively from two perspectives. Firstly, due to the lack of coherence and fragmentation of environmental laws. It should be explained that criminal support for the environment in general, and criminal support for the environment in particular, has been scattered across various laws, which has posed numerous problems both in terms of accessibility for law recipients and judicial issues (such as the obsolescence of laws). Therefore, it is clear that the environment, as one of the technical and specialized subjects, requires the formulation of a unified and cohesive set of regulations because transparency in legislation is one of the consequences of the fundamental principles of crime and punishment[48].

The existence of dispersion in environmental laws can be well illustrated with an example. One of the earliest laws that the legislator enacted to protect forest trees is the Law on Conservation and Exploitation of Forests and Rangelands, passed in 1967. In this law, behaviors such as cutting down forest trees have been criminalized. Subsequently, in the year 1992, the legislature passed the Law on Conservation and Protection of Natural Resources and Forest Reserves, which prohibited the cutting of forest trees and provided for penalties for offenders. With this action, it seemed that the second law had repealed the first law. However, in an astonishing move, the Council of Ministers increased the monetary fines stipulated in the first law in its resolution of 2003.[48]

The second flaw in the legislated punitive policy for environmental protection is the negligible level of penalties considered for urban environmental protection. In this regard, the deterrent aim of the penalties will not be adequately fulfilled; however, this does not mean that the legislator should increase their severity mindset and initiate the increase of penalties beyond the standards of criminalization. Instead, it means that in adopting punitive policies, careful consideration should be given, and within the framework of punitive measures, other tools should be used to support urban environmental protection.

Article 29 of the Law on Air Pollution Prevention states: "Owners and officials of polluting factories and workshops who act contrary to the provisions of Articles 14, 16, and 17 of this law shall, for the first time, be subject to a fine ranging from five hundred thousand rials to one million rials, and in case of repetition, they shall be sentenced to imprisonment from two to six months and a fine ranging from seven hundred thousand rials to two million rials." Article 14 of the aforementioned law prohibits the establishment and operation of new factories and workshops that do not comply with the criteria and standards of Article 12, as well as the operation of factories, workshops, and power plants that cause excessive air pollution.[48]

Failure to comply with regulations, remediation of pollution, or cessation of activities contributing to air pollution within the production sector is addressed in Article 29 of the law outlining measures to prevent air pollution. It states: "Owners and managers of polluting factories and workshops, upon first offense of contravening Articles 14, 16, and 17 of this law, shall face fines ranging from five hundred thousand to one million rials. In case of recurrence, they shall be subject to imprisonment for a period of two to six months, along with fines ranging from seven hundred thousand to two million rials."

Article 14 of the aforementioned law prohibits the operation of new factories and workshops that fail to comply with the regulations outlined in Article 12[48], as well as the operation of existing factories, workshops, and power plants causing pollution beyond permissible limits. If factories or workshops cause air pollution, the environmental organization issues a warning and sets a deadline for remediation or cessation of activities until pollution is resolved.[48]

The enforcement of non-compliance with this provision is detailed in Article 29, which refers to Article 16. According to Article 16: "If owners and officials of polluting factories, workshops, and power plants fail to take action to address pollution or prevent the operation of relevant facilities within the specified deadline, upon request from the environmental organization and the directive of the relevant judicial authority, immediate action will be taken by law enforcement officers to halt the operation of polluting factories."[48]

The note accompanying this article further stipulates: "If owners and officials of polluting factories, workshops, and power plants persist in operating after being notified by the Environmental Protection Organization, or attempt to reopen and resume activities following closure without permission or a valid court order, they will face penalties outlined in this law and related regulations for non-compliance with legal and judicial orders."[48]

Article 17 of the law pertains to the implementation of prohibitions and penalties for their violation. It states: "In emergencies or adverse weather conditions, the head of the Environmental Protection Organization may request immediate cessation of activities from factories and workshops posing imminent danger, with a prompt warning. In case of refusal, suspension of activities will be enforced by order of the local court until the hazard is resolved. Obstruction of inspection and refusal to cooperate with officials from the Environmental Protection Organization are addressed in Article 30 of the law. It outlines penalties ranging from fines of five hundred thousand to five million rials, and imprisonment for one to three months, depending on the severity and recurrence of the offense."[48]

Institutionalization of Green Government in Iran

Efforts to institutionalize green and sustainable government organizations necessitate systematic and structural changes within societies and governmental structures. The pivotal role of government organizations and policymakers in addressing environmental challenges and climate change underscores the importance of governments as key political players in crafting green management guidelines and initiatives. Their unique legitimacy in resource allocation distinguishes them from other actors[49].

Green government represents a contemporary form of governance, although its definition remains nuanced. Broadly, it embodies a government that upholds fundamental rights and freedoms, evaluates its efficiency based on its ability to protect human rights, and promotes environmental awareness and governance on national and global scales.

Green government is an enhanced iteration of good governance within democratic societies. It fosters environmentally conscious citizens, upholds the rule of law, combats corruption, and distinguishes between civil, environmental, and political rights. Debates among environmentalists, green management associations, and political theorists often revolve around whether a green government is inherently powerful. Such a government should effectively address national and global environmental challenges, safeguard natural and human resources, maintain legitimacy amidst cultural diversity, and lead efforts to resolve global environmental issues. Amidst the critical circumstances of the Covid-19 pandemic, there is a growing expectation for governments to spearhead structural green changes. This includes greater involvement of green government in economic planning, income redistribution, and wealth creation to foster growth, especially in societies reliant on energy and oil. Such transformations require targeted planning and adherence to implementation deadlines, leveraging governments' regulatory powers to address global environmental concerns[50].

Methodology

Introduction

The methodology section of this study contains the systematic approach employed to identify and analyze the barriers to green product adoption in Iran, utilizing the Interpretive Structural Modeling (ISM) approach. This section outlines the rationale behind the chosen methodology, elucidates the key steps involved, and underscores the significance of employing ISM in understanding the complexities of green product adoption within the Iranian context.

Understanding the barriers to green product adoption in Iran necessitates a robust and systematic methodology that can capture the multifaceted nature of sustainability challenges while providing actionable insights for policymakers, businesses, and stakeholders. In light of this imperative, the ISM approach emerges as a fitting methodological framework due to its ability to elucidate the interrelationships among various factors influencing complex systems. ISM offers a structured and rigorous methodology for analyzing the causal relationships among different variables, thereby facilitating a comprehensive understanding of the barriers to green product adoption. By employing ISM, this study seeks to uncover the underlying dynamics driving the reluctance or impediments encountered in the adoption of environmentally sustainable products within the Iranian market.

The methodology employed in this study comprises several key steps, each designed to systematically elucidate the barriers to green product adoption in Iran:

Literature Review: The methodology begins with an extensive review of existing literature on green product adoption, sustainability barriers, and related studies conducted in Iran. This step lays the groundwork for understanding the prevailing discourse surrounding sustainability challenges and provides a theoretical foundation for subsequent analysis.

Expert Consultation: Engaging with experts in the field of environmental sustainability, green product development, and market dynamics in Iran forms a pivotal aspect of this methodology. Through semi-structured interviews or focus group discussions, insights from these experts enrich the understanding of the specific challenges and opportunities related to green product adoption.

Identification of Barriers: Building upon insights gleaned from the literature review and expert consultation, this step involves compiling a comprehensive list of potential barriers to green product adoption in Iran. These barriers are categorized into thematic areas and prioritized based on their perceived significance and impact.

Structural Modeling: The final step in the methodology entails the application of Interpretive Structural Modeling (ISM) to develop a hierarchical structure of the identified barriers. This structural model elucidates the causal relationships among different barriers, thereby providing a holistic understanding of the complexities involved in green product adoption.

The adoption of ISM in this study holds several implications and advantages. Firstly, ISM enables the identification of both direct and indirect relationships among barriers, shedding light on the underlying systemic factors influencing green product adoption. Additionally, ISM facilitates the visualization of complex interdependencies, allowing stakeholders to discern patterns and leverage leverage points for intervention. Moreover, the hierarchical structure generated through ISM offers a structured framework for policy formulation and strategic decision-making, thereby enhancing the efficacy of interventions aimed at promoting sustainability in Iran.

Research method

The study commenced with an exhaustive review of existing literature on barriers to green production. This literature review aimed to identify and synthesize previous research findings regarding obstacles encountered in the implementation of green production practices across various industries. 10 consultation sessions were organized with experts specializing in environmental management, sustainable manufacturing, and green production practices. These experts were selected based on their extensive experience in the field, with a criterion of having more than 5 years of professional experience. The consultation sessions employed brainstorming and focused group methods to elicit expert opinions on the most influential barriers to green production.

During the consultation sessions, experts engaged in discussions to identify and prioritize the critical barriers to green production. The facilitator guided the discussions to ensure comprehensive coverage of all relevant factors. The experts were then asked to rank the identified barriers in order of their perceived significance. Through the analysis of expert responses and discussions during the consultation sessions, a list of key barriers to green production was identified. These barriers represented the most critical challenges reported by professionals in the field.

To examine the interrelationships among the identified barriers to green production, Interpretive Structural Modeling (ISM) methodology was applied. ISM is a systematic approach that helps visualize the hierarchical structure and interdependencies among variables. Using ISM, the relationships among the identified barriers were analyzed to understand their mutual influences and dependencies[51].

Furthermore, a Matrix Impact Cross-Reference Multiplication Applied to a Classification (MICMAC) analysis was conducted to categorize the barriers based on their driving and dependence power. This analysis helped classify the barriers such as autonomous, dependent, linkage, and independent. Understanding these categories provided insights into the role of each barrier in influencing the overall implementation of green production practices.

A graphical representation of the methodology was created to illustrate the process of barrier identification, interrelationship analysis, and categorization using ISM and MICMAC analysis. This graphical representation served as a visual aid to understand the methodology and its application in the study (Figure 3-1).

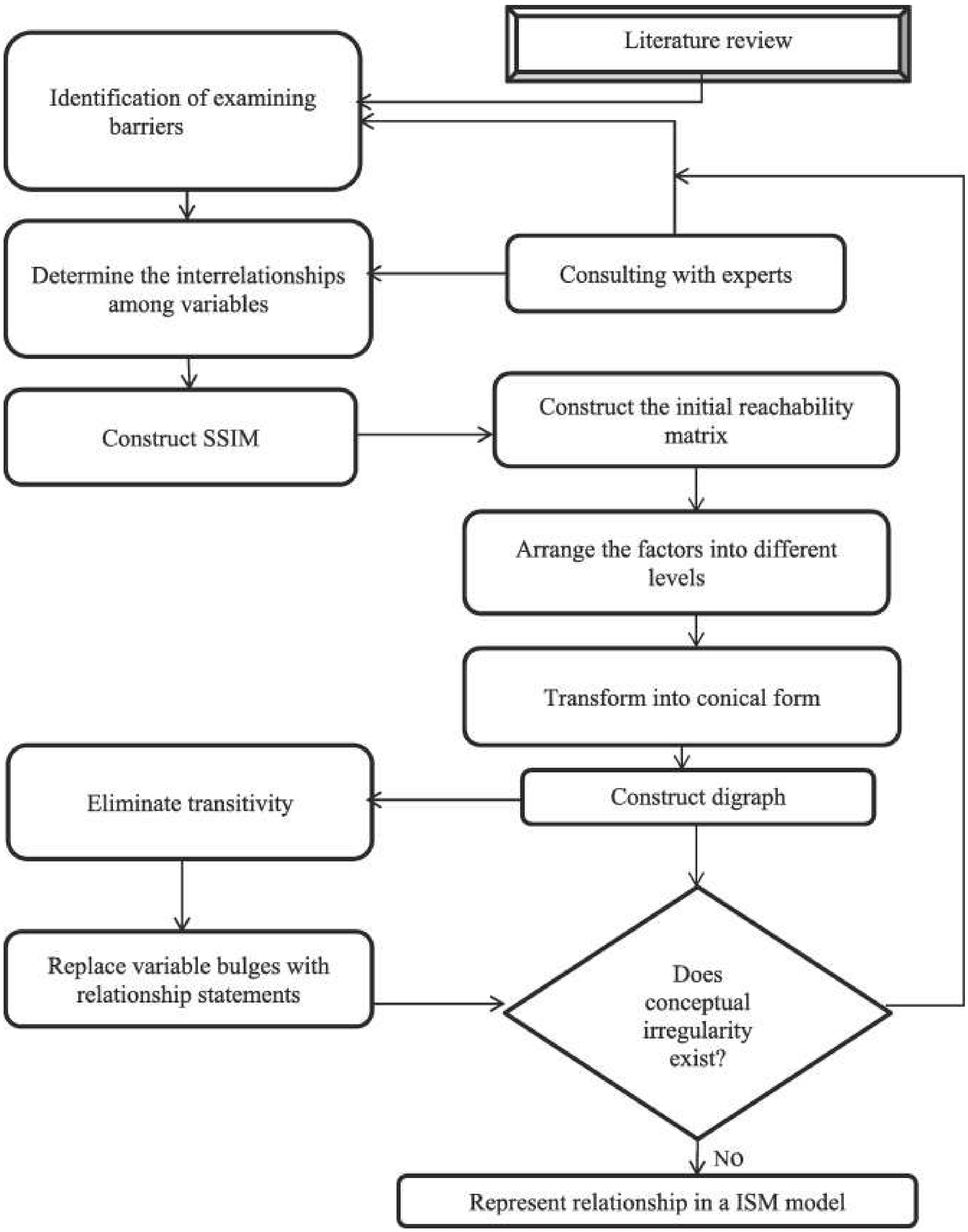

Figure 3- 1 ISM based methodology

Interpretive Structural Modeling (ISM)

Interpretive Structural Modeling (ISM) is a technique designed to provide decision-makers with a clear understanding of the relationships among various factors[52]. By converting ambiguous and vague models into well-defined structures, ISM facilitates the organization of diverse and interconnected elements into a cohesive model. It is particularly useful for elucidating the interactions among multiple factors that contribute to complex problems, offering a more accurate representation than considering each factor in isolation. However, the complexity of ISM arises from the multitude of factors and their inherent connections, making it challenging to construct the model clearly. As a result, a systematic approach is required to classify the structure within the model[53].

In applying ISM, concepts from graph theory are utilized to delineate the interrelationships among variables, providing a method to manage the complexity of these variables. This approach helps impose order on the intricate web of factors, making it easier to comprehend the system's structure. Given that manufacturing systems encompass numerous interconnected factors related to physical elements and decision-making processes, clarifying these interrelationships is essential for effective management. ISM serves to organize these interrelated factors into a systematic model, aiding in decision-making and problem-solving[54].

The development of an ISM involves an eight-step procedure[55]:

Step 1: Identification of green production barriers through literature review and expert consultation, utilizing organizational methods such as brainstorming and focus groups to establish connections among variables.

Step 2: Establishment of interrelationships among variables identified in Step 1, with input from manufacturing professionals and academia to discern the nature of these connections.

Step 3: Development of a Structural Self-Interaction Matrix (SSIM) to indicate pairwise relationships among variables, considering contextual connections and expert consensus.

The four symbols denoting the direction of relationships between two factors (b and b) were:

(a)V indicated the influence of factor a on factor b

(b)A indicated the influence of factor b on factor a

(c)X indicated the mutual influence of factors a and b

(d)O indicated no influence

Based on the contextual relationship, SSIM was developed. It was finalized by obtaining consensus from a group of experts.

Step 4: Creation of an initial reachability matrix based on the SSIM, converting directional relationships between variables into binary values using predefined rules.

The subsequent steps of the ISM methodology involve further analysis and refinement of the reachability matrix to derive a final model depicting the hierarchical structure and interdependencies among variables (Table 3-1).

Table 3- 1 Rules for conversion

SSIM	**(*a*, *b*) entry**	**(b, *a*) entry**
V	1	0
A	0	1
X	1	1
O	0	0

Step 5: From the final reachability matrix, the reachability and antecedent sets were derived. The intersections of these sets were then determined for all factors, allowing for the identification of factor levels within the ISM hierarchy. Factors sharing the same reachability and intersection occupied the highest level within the hierarchy. Once top-

level factors were identified, they were excluded from further consideration, and the procedure was repeated until the level of each factor was determined. The resulting levels were used to develop the digraph and ISM model.

Step 6: In this step, the conical matrix was developed by summing the factors of the same level across columns and rows of the final reachability matrix. Driving power, represented by the summation of 1's in the rows, and dependence power, represented by the summation of 1's in the columns, were then ranked in descending order based on row and column sums, respectively.

Step 7: An initial digraph with transitive links was created from the conical matrix, providing a visual representation of the elements and their interdependencies. To establish the final digraph, indirect links were eliminated, and factors were positioned according to their determined level.

Step 8: Transforming the nodes of the factors into statements, the digraph was converted into an ISM model.

MICMAC Analysis

MICMAC, which stands for cross-impact matrix multiplication applied for classification, aims to determine the dependence and driving powers of factors within the system. This analysis identifies key factors categorized as either independent or linkage factors based on their driving and dependence powers.

Linkage factors:

These factors exhibit strong driving and dependence powers, impacting other factors and generating feedback effects. As a result, they are considered unstable.

Autonomous factors:

Weak in both driving and dependence powers, autonomous factors have limited links to the system, albeit with relatively strong connections.

Dependent factors

With weak driving power but strong dependence power, these factors rely heavily on other elements within the system.

Independent factors

Strong in driving power but weak in dependence power, independent factors exert significant influence on the system while being less affected by external factors.

Research sample

The research sample consisted of 35 experts from production companies in Iran facing challenges in implementing green production practices. These experts were carefully selected based on their extensive experience and knowledge in the field of production, particularly in relation to green production initiatives. Below are brief profiles of the selected companies represented by the experts:

1. Zarshenas Manufacturing Company

Zarshenas Manufacturing Company is a leading manufacturer in the automotive industry, specializing in the production of eco-friendly vehicle components.

2. Niloufar Production Company

Niloufar Production Company is renowned for its expertise in textile manufacturing, offering a wide range of eco-friendly fabric solutions.

3. Sabzan Industrial Company

Sabzan Industrial Company specializes in the production of agricultural machinery and equipment with a strong emphasis on sustainability.

4. Zeytoon Manufacturing Company

Zeytoon Manufacturing Company is a leading producer of household appliances, prioritizing eco-friendly design and production methods.

5. Bargostan Industrial Company

Bargostan Industrial Company specializes in the manufacturing of packaging materials, focusing on sustainable solutions to minimize waste and pollution.

6. Genobiotic Technology Company

Genobiotic Technology Company specializes in developing green solutions for renewable energy generation, including solar panels, wind turbines, and hydroelectric systems.

7.Novin Manufacturing Company

Novin Manufacturing Company is dedicated to producing eco-friendly cleaning products and detergents using natural ingredients and biodegradable formulas.

8. Cibl Industrial Company

Cibl Industrial Company specializes in manufacturing eco-friendly building materials, such as recycled wood products, low-emission insulation, and sustainable flooring options.

9. Pardazan Technology Company

Pardazan Technology Company develops innovative software solutions for environmental monitoring and management, including air quality monitoring systems, water resource management software, and waste tracking platforms. By leveraging technology, the company helps organizations optimize resource usage and minimize environmental impact.

10. Azinsakht Manufacturing Company

Azinsakht Manufacturing Company specializes in the production of eco-friendly furniture and home decor using sustainable materials and ethical production practices.

11. Sabzsazan Industrial Company

Sabzsazan Industrial Company is a manufacturer of eco-friendly packaging machinery and equipment, including recyclable packaging machines, biodegradable film wrappers, and compostable packaging materials.

12. Sabznegar Technology Company

Sabznegar Technology Company specializes in developing green transportation solutions, including electric vehicles, hybrid engines, and fuel-efficient technologies.

13. Sanatpardaz Manufacturing Company

Sanatpardaz Manufacturing Company focuses on producing organic and natural food products, including healthy snacks, organic beverages, and plant-based foods.

14. Derkhshan Industrial Company

Derakhshan Industrial Company specializes in manufacturing eco-friendly paints and coatings for architectural and industrial applications.

15. Amoozeh Technology Company

Amoozeh Technology Company develops innovative educational tools and resources for promoting environmental awareness and sustainability literacy.

16. Sabz Technical and Engineering Company

Sabz Technical and Engineering Company is a pioneer in the development and implementation of green technology solutions.

17. Eco Manufacturing Company

Eco Manufacturing Company is dedicated to producing environmentally friendly household products, ranging from biodegradable packaging materials to compostable tableware.

18. Davankar Industrial Company

Davankar Industrial Company specializes in the manufacturing of water-saving technologies and sustainable irrigation systems for agriculture.

19. Baranzar Manufacturing Company

Baranzar Manufacturing Company is a leading producer of eco-friendly textiles and clothing, using organic cotton and recycled materials in its manufacturing processes.

20. Atipardaz Industrial Company

Atipardaz Industrial Company specializes in the production of sustainable packaging solutions for food and beverage industries.

21. Parsian Manufacturing Company

Parsian Manufacturing Company is a leading manufacturer of organic fertilizers and soil amendments for agricultural use.

22. Sabzaine Technology Company

Sabzaine Technology Company specializes in the development of green building materials and sustainable construction technologies.

23. Metis Industrial Company

Metis Industrial Company is a manufacturer of eco-friendly packaging solutions for pharmaceutical and healthcare industries.

24. Gostarsazan Manufacturing Company

Gostarsazan Manufacturing Company specializes in the production of sustainable agricultural equipment and machinery, such as solar-powered irrigation systems and energy-efficient farming tools.

25. Pakan Industrial Company

Pakan Industrial Company is a manufacturer of eco-friendly household appliances and electronics, focusing on energy efficiency and resource conservation. *Pishva Manufacturing Company*

Pishva Manufacturing Company specializes in producing eco-friendly household appliances, such as energy-efficient refrigerators, washing machines, and air conditioners.

27. Aabad Industrial Company

Aabad Industrial Company focuses on manufacturing sustainable agricultural equipment and machinery, including organic fertilizer spreaders, drip irrigation systems, and solar-powered agricultural tools.

28. Nikoopishgam Technology Company

Nikoopishgam Technology Company develops cutting-edge green technologies for waste management and recycling, including advanced sorting systems, composting equipment, and waste-to-energy solutions.

29. Karafarin Manufacturing Company

Karafarin Manufacturing Company specializes in producing eco-friendly clothing and textiles made from organic and sustainable materials, such as organic cotton, bamboo fiber, and recycled fabrics.

30. Memaran Industrial Company

Memaran Industrial Company focuses on manufacturing green infrastructure products for sustainable urban development, including permeable paving systems, green roofs, and rainwater harvesting solutions.

31. Pardish Technology Company

Pardis Technology Company develops eco-friendly water purification and treatment technologies, including filtration systems, desalination plants, and wastewater recycling solutions.

32. Andishehpardaz Manufacturing Company

Andishehpardaz Manufacturing Company specializes in producing sustainable packaging materials and solutions, including biodegradable plastics, compostable packaging, and eco-friendly packaging designs.

33. Sadramehr Industrial Company

Sadramehr Industrial Company focuses on manufacturing green agricultural technologies and equipment for hydroponic and aquaponic farming, including nutrient solutions, grow lights, and automated farming systems.

34. Ideapardazan Technology Company

Ideapardazan Technology Company develops eco-friendly energy solutions for residential and commercial buildings, including solar panels, energy-efficient lighting, and smart energy management systems.

35. *Sharidsazeh Manufacturing Company*

Sharifsazeh Manufacturing Company specializes in producing sustainable construction materials and green building solutions, including recycled aggregates, eco-friendly insulation, and energy-efficient windows.

Questioanare

This section outlines the development and structure of the questionnaire utilized to identify barriers to green product adoption in Iranian companies. The questionnaire includes demographic informations, perceptions of green product adoption, and a detailed assessment of barriers we found from litreture review. The design of the questionnaire aims to gather insights from 35 experts in relevant fields to provide a comprehensive understanding of the challenges hindering the widespread acceptance of sustainable practices in Iran's market landscape (Appendix 1).

Validity and reliability of the items

In general, the validity and reliability of the items have been confirmed in previous questionnaires, but so far these items have not been used in a single questionnaire in Persian language. Therefore, experts were asked to read the questionnaire and express their opinions. Examining and evaluating each test or questionnaire in terms of content validity is especially important in different types of practical articles. Because this type of validity is a factor that confirms how successful the questionnaire has been in covering the objectives of the test.

Content validity is a factor that shows the extent to which the questions selected in each test have been able to correctly evaluate and measure the main characteristic of the researcher in the society. Here, the method of evaluating content validity and calculating CVI and CVR is used. Content validity ratio or CVR is a method of measuring the validity of a questionnaire. In this method, each of the questions are classified based on the three-part Likert spectrum:

- The item is necessary
- The item is useful but not necessary or no comment
- The item is not necessary

To calculate this reliability ratio, they use the following formula:

$$CVR = \frac{Ne - \frac{N}{2}}{\frac{n}{2}}$$

N is the total number of experts and N_e is the number of necessary answers. Based on the number of 35 experts in the research, the minimum acceptable CRV is 0.31.

Content validity index or CVI is also used to measure the validity of the questionnaire. For the calculation of CVI, the degree of relevance of each item is specified with the following four-part spectrum:

1. The item is unrelated or completely disagreement (score 1)
2. The need for fundamental revision or disagreement (score 2)
3. Related but need to review or agreement (Score 4)
4. Completely related or completely agreement (score 5)

The number of options 3 and 4 should be divided by the total number of answers and if the result is less than 0.7, the item is rejected. If it is between 0.7 and 0.79, it should be revised, and if it is greater than 0.79, it is acceptable.

According to Table 3-2, all items of the questionnaire have acceptable validity.

Table 3- 2 CVR and CVI of the related barriers extracted from litreture review

Item	Responses					Total Responses	CVI	CVR
	Compeletely agreement	Agreement	No idea	Disagreement	Compeletly dis agreement			
Insufficient Management	35					35	1	1
Resistance/fear of change	34	1				35	1	1
Environmental Awareness Deficiency	32	3				35	1	1
Insufficient Government Support	33	1	1			35	0.971428	0.942857
Lack of Standard Practices	31	3	1			35	0.971428	0.942857
Lack of Communication	34		1			35	0.971428	0.942857

Financial constraints	33	2				35	1	1
Lack of Employee Training	34	1				35	1	1
Technological constraints	33	2				35	1	1
Supplier issues	33	1	1			35	0.971428	0.942857

Cronbach's alpha measures a questionnaire's reliability by analyzing its internal consistency. This method assesses the internal consistency of measurement tools, such as questionnaires or tests, that evaluate several qualities. Typically, measurement tools are considered reliable if their alpha coefficient is greater than 0.7. The capability coefficient ranges from 0 (no connection) to +1 (full connection). The dependability coefficient reveals how accurately the measuring device captures the subject's steady or variable/temporary properties. This method assesses the internal consistency of measurement tools, such as questionnaires or tests, that evaluate several qualities. These tools allow you many numerical answers to each question.

To compute Cronbach's alpha coefficient, first calculate the variance of each sub-set of questions in the questionnaire, as well as the total variance. He estimated the alpha coefficient with the following formula:

$$r_\alpha = (\frac{k}{k-1})(1 - \frac{\sum {s_j}^2}{{s_x}^2})$$

in which:

The k symbol is the number of questions or items in the questionnaire or test

The symbol S2 is the variance of the k-test

And sigma S2 is the total variance of the test

We used Cronbach's alpha to assess reliability. The alpha value of all multi-question constructs reported from all experts below is above the 0.715 point. Therefore, these structures have good reliability.

Reliability Statistics

Cronbach's Alpha	N of Items
.715	10

Results and discussion

Expert Panel Demographics and Backgrounds

In the assessment of proposed barriers related to sustainability in the Iranian green products, a panel of 35 experts was selected. The selection process was based on four main criteria to ensure the panel's expertise and diversity. These criteria included:

Sufficient Knowledge and Understanding of Sustainability: All experts were chosen for their deep understanding of sustainability principles relevant to the green industries. This criterion ensured that the panel could accurately evaluate the proposed barriers from an environmental, social, and economic perspective.

Work and Academic Experience: Each expert brought a wealth of practical work experience and academic background in fields such as civil engineering, architecture, environmental science, and sustainable development. Their combined expertise offered a comprehensive view of the challenges and opportunities in the construction sector.

Participation and Involvement in the Procurement Process: The panel included experts who were actively involved in the procurement process, ensuring a nuanced understanding of how proposed barriers might impact procurement practices in the green industries.

Knowledge of Related Rules and Regulations: Experts were selected based on their familiarity with the regulatory landscape specific to Iran's green industries. This criterion ensured that the panel could assess the proposed barriers within the context of the country's legal frameworks.

The demographic features of the selected experts are summarized in Table 1-4. This table provides a breakdown of gender, age, educational background, years of experience, career level, and affiliation for each expert. These demographic features can help provide insights into the diversity and expertise of the panel.

Table 4- 1 Demographic features of the experts panel

Epert	Gender	Age	Educational Background	Years of Experience	Career Level
1	Female	38	Environmental Science (MSc)	10	Senior
2	Male	45	Civil Engineering (BEng)	15	Senior
3	Male	52	Sustainable Development (PhD)	5	Senior
4	Female	40	Construction Management (BSc)	8	Senior
5	Male	42	Architecture (M.Arch)	12	Senior
6	Female	30	Environmental Engineering (BEng)	3	Junior
7	Male	55	Construction Law (LLB)	20	Senior
8	Female	34	Sustainability Studies (BA)	6	Mid-Level
9	Male	48	Civil Engineering (PhD)	25	Senior
10	Male	37	Urban Planning (MSc)	7	Mid-Level
11	Female	33	Environmental Science (BSc)	4	Mid-Level
12	Male	39	Civil Engineering (MEng)	10	Mid-Level
13	Female	41	Sustainable Architecture (MArch)	8	Mid-Level
14	Male	50	Environmental Policy (PhD)	12	Senior
15	Female	36	Construction Economics (BSc)	6	Mid-Level
16	Male	47	Civil Engineering (BEng)	18	Senior
17	Female	35	Architecture (B.Arch)	5	Mid-Level
18	Male	43	Environmental Engineering (MEng)	9	Senior
19	Female	44	Construction Management (BSc)	14	Senior
20	Male	38	Sustainable Development (MSc)	7	Senior
21	Female	53	Civil Engineering (PhD)	22	Senior
22	Male	40	Urban Planning (MUP)	10	Senior
23	Female	46	Architecture (M.Arch)	15	Senior
24	Male	34	Environmental Science (BSc)	8	Mid-Level
25	Female	42	Civil Engineering (BEng)	12	Senior
26	Male	49	Construction Management (MSc)	16	Senior
27	Female	31	Sustainability Studies (BA)	5	Junior
28	Male	36	Urban Planning (MUP)	8	Mid-Level
29	Male	51	Construction Law (LLM)	10	Senior
30	Female	37	Sustainable Architecture (MArch)	6	Mid-Level

31	Male	45	Environmental Engineering (BEng)	13	Senior
32	Female	33	Civil Engineering (BSc)	9	Mid-Level
33	Male	39	Sustainability Policy (PhD)	7	Mid-Level
34	Female	41	Architecture (B.Arch)	11	Mid-Level
35	Male	38	Environmental Science (MSc)	10	Senior

Figure 4-1 illustrates the distribution of male and female experts of the study on identifying barriers to green product adoption in Iran. The data highlights the gender diversity among the participants with 45.7% female and 54.2% male.

Figure 4-2 illustrates age distribution of experts as a diverse range of experiences and perspectives. Among the 35 experts surveyed, the ages span from 30 to 55 years old, with varying levels of experience and career stages represented. This diversity in age suggests a rich different insights, with younger experts potentially offering fresh perspectives and innovative ideas, while more seasoned professionals bring extensive experience and knowledge to the table. The distribution also indicates a relatively balanced representation across different age groups, with experts evenly distributed throughout the range. This balance ensures that the study benefits from a broad spectrum of viewpoints, encompassing both the perspectives of seasoned industry veterans and the energy of emerging professionals.

The educational level distribution of experts participating in the study on identifying barriers to green product adoption in Iran reveals a diverse and well-educated participant pool (Figure 4-3). Across the 35 experts surveyed, a range of educational backgrounds is evident, spanning undergraduate degrees to postgraduate qualifications, including both master's and doctoral degrees. The educational backgrounds of the experts encompass a variety of disciplines relevant to sustainability and environmental management, such as environmental science, civil engineering, architecture, sustainable development, and construction management, among others. This diversity in educational backgrounds highlights the multidisciplinary nature of the study, drawing upon insights from experts with expertise in different fields relevant to green product adoption.

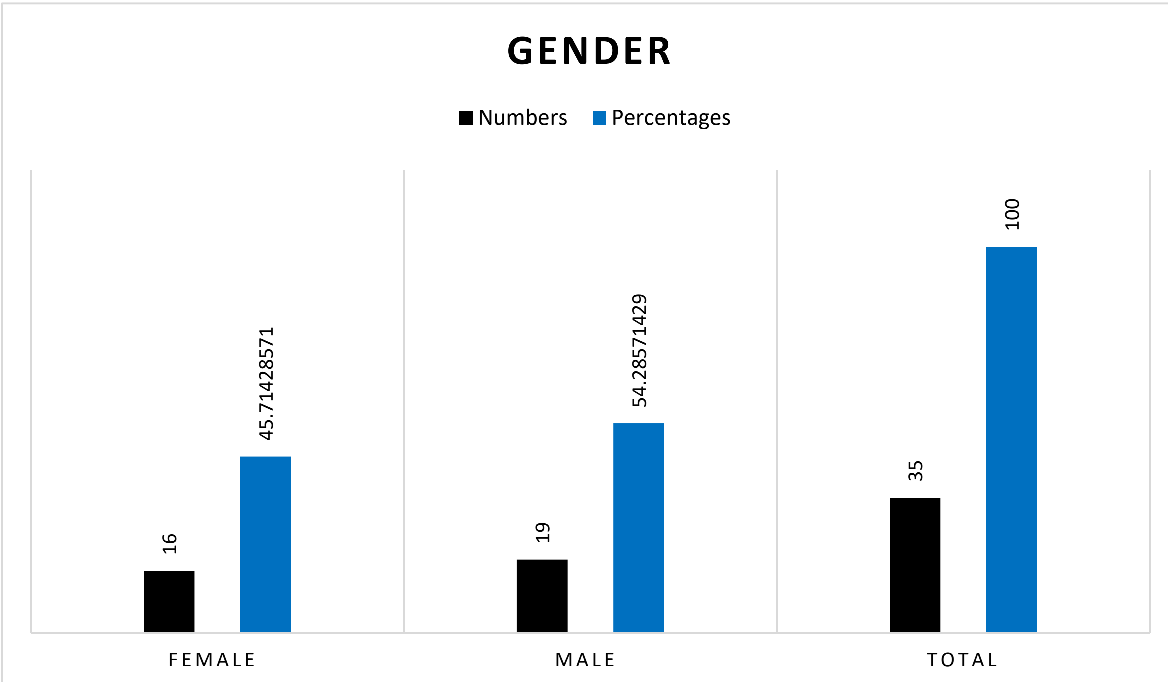

Figure 4- 1 Gender Distribution of Experts

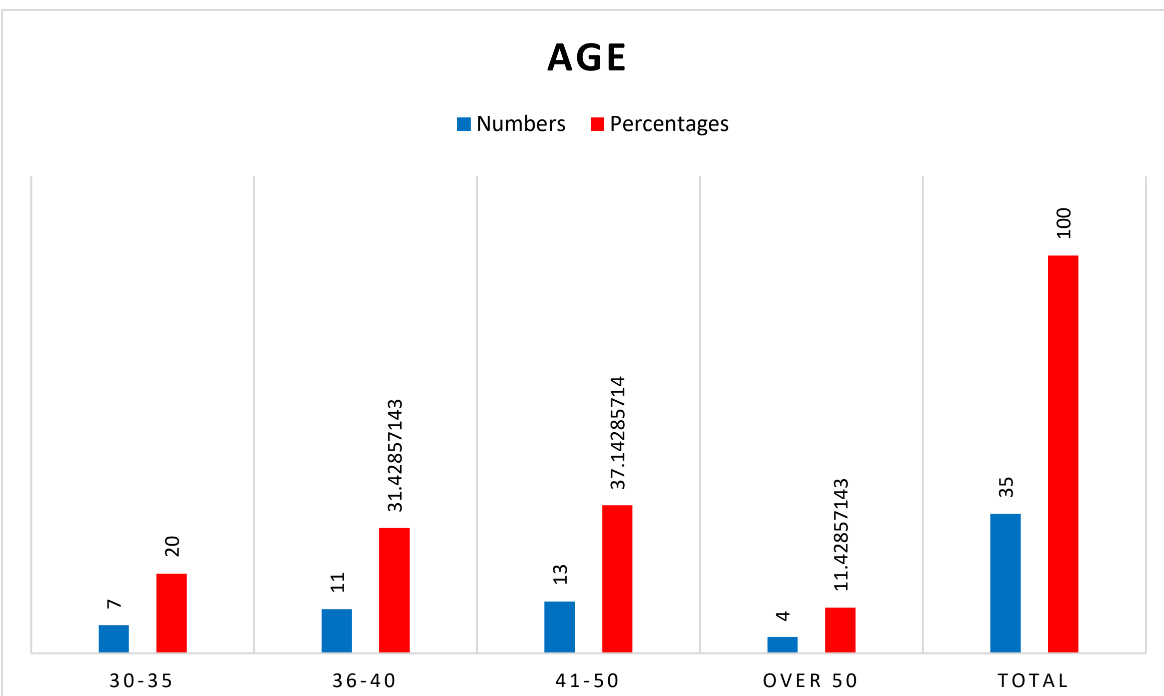

Figure 4- 2 Age Distribution of Experts

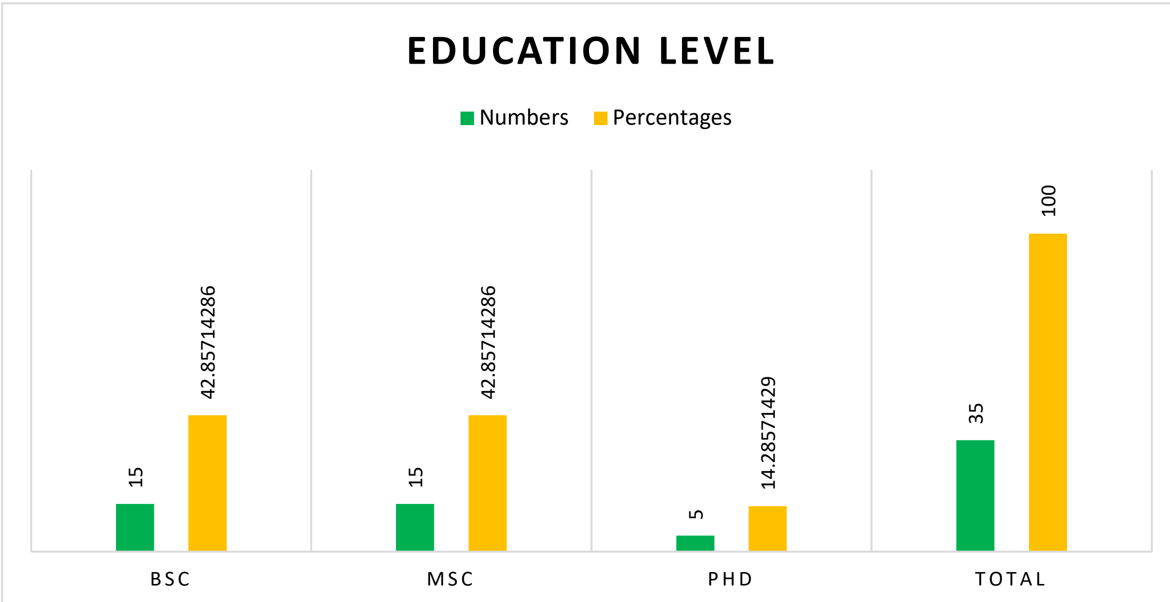

Figure 4- 3 Educational level Distribution of Experts

Figure 4-4 shows the diversity in work experience as a mix of seasoned professionals with extensive industry tenure and younger experts who may bring fresh perspectives and innovative thinking to the research. Experts with significant years of experience, ranging from 10 to 25 years, likely possess deep insights into industry trends, regulatory frameworks, and practical challenges related to sustainability initiatives. Conversely, experts with fewer years of experience, ranging from 3 to 7 years, may offer a different vantage point, bringing a keen understanding of emerging trends, technologies, and consumer preferences in the field of sustainability.

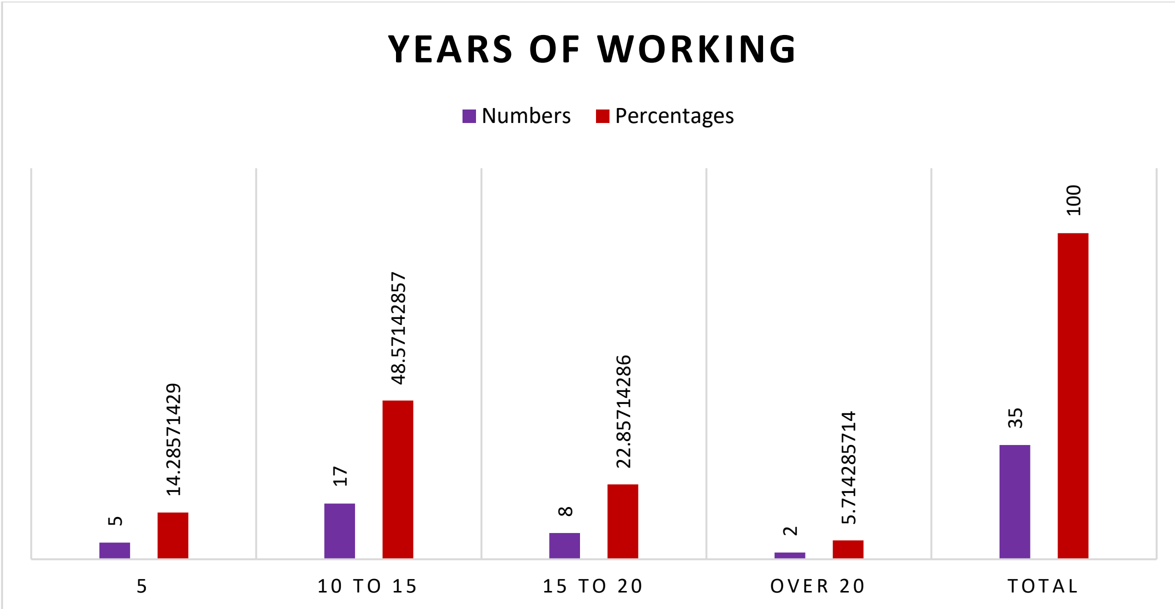

Figure 4- 4 Work experience Distribution of Experts

Figure 4-5 reflects a diverse mix of career stages, with experts occupying roles at various levels of seniority within their respective fields. Senior-level professionals, comprising a significant portion of the participant pool, bring extensive experience and expertise to the research endeavor. Mid-level professionals, representing another substantial segment of the expert panel, contribute a blend of experience and energy to the study. Junior-level experts, while fewer in number, offer fresh perspectives and enthusiasm for addressing sustainability issues. Despite having less experience, these individuals bring a wealth of knowledge and a willingness to learn, contributing diverse viewpoints and novel ideas to the research discourse.

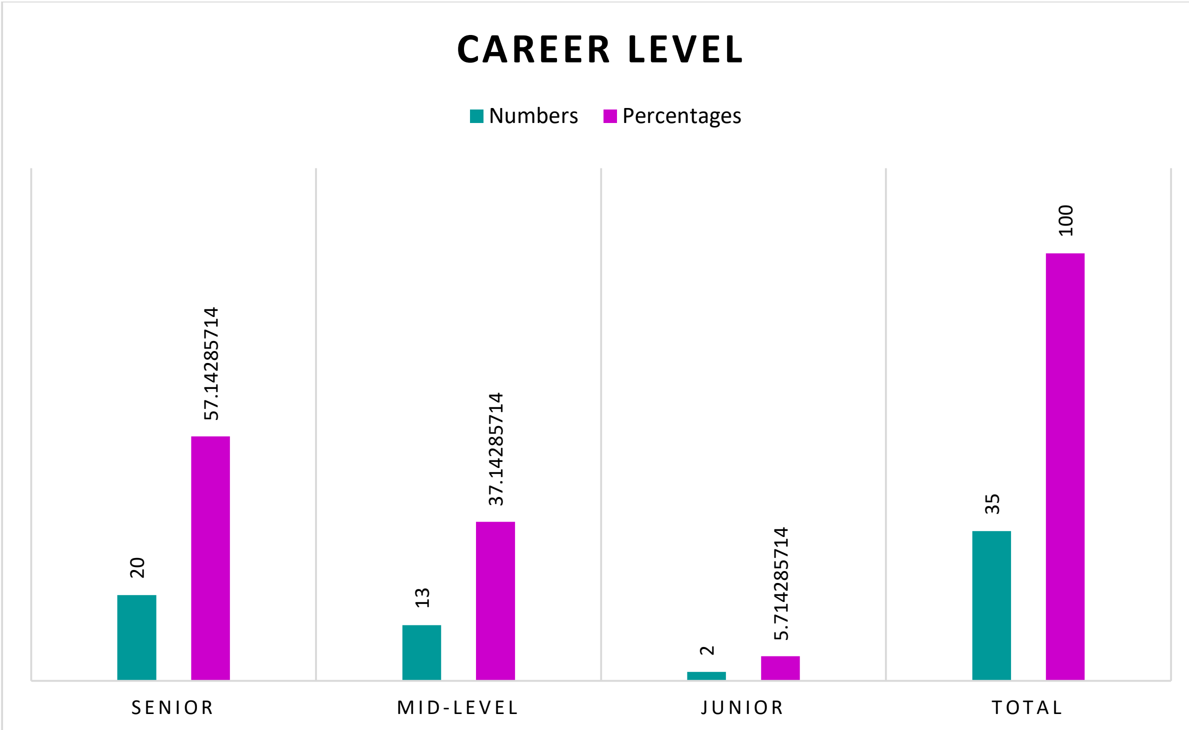

Figure 4- 5 Career Level Distribution of Experts

Expert Feedbacks

Table 4-2 shows the selection feedback of experts about the barriers I found from the literature review. Based on expert opinions, 10 barriers were selected. The experts were asked to rank those in order of importance. Using a Pareto chart, 10 barriers from the initial 10 were selected. The Pareto chart is shown in Figure 4-6 and the corresponding data is given in the table.

Table 4- 2 Experts' feedback on green production barriers

Experts	**Barriers**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Expert-1	●	●	●	●	●	●	●	●	●	●
Expert-2	●	●	●	●	●	●	●	●	●	●
Expert-3	●	●	●	●	●	●		●	●	●

Expert-4	●	●	●	●	●	●		●	●	●
Expert-5	●	●	●	●	●	●		●	●	●
Expert-6	●	●	●	●	●	●		●		
Expert-7	●	●	●	●	●	●		●		●
Expert-8	●	●	●	●	●	●	●	●	●	●
Expert-9	●	●	●			●		●	●	
Expert-10	●	●	●	●	●	●	●	●	●	●
Expert-11	●	●	●	●	●	●	●		●	
Expert-12	●	●	●	●	●	●	●		●	
Expert-13	●	●	●						●	
Expert-14	●	●	●						●	
Expert-15	●	●	●	●	●	●	●	●		
Expert-16	●	●	●	●	●	●			●	●
Expert-17	●	●	●	●	●	●		●		●
Expert-18	●	●	●			●	●			●
Expert-19	●	●	●			●				●
Expert-20	●	●	●			●				●
Expert-21	●	●	●	●	●	●	●			●
Expert-22	●	●	●				●			●
Expert-23	●	●	●				●			●

Expert-24	●	●	●				●		●	●
Expert-25		●					●			●
Expert-26		●	●			●		●		●
Expert-27	●	●	●	●	●	●	●	●		●
Expert-28	●	●	●	●	●	●	●	●		●
Expert-29	●	●	●	●	●	●	●	●	●	●
Expert-30	●	●	●	●	●	●	●	●	●	●
Expert-31	●	●	●	●	●	●	●	●	●	●
Expert-32	●	●	●	●	●	●	●	●	●	●
Expert-33	●	●	●	●		●	●	●	●	●
Expert-34	●	●	●			●		●	●	●
Expert-35	●	●	●			●			●	●
Total	33	35	34	22	21	29	22	24	21	28

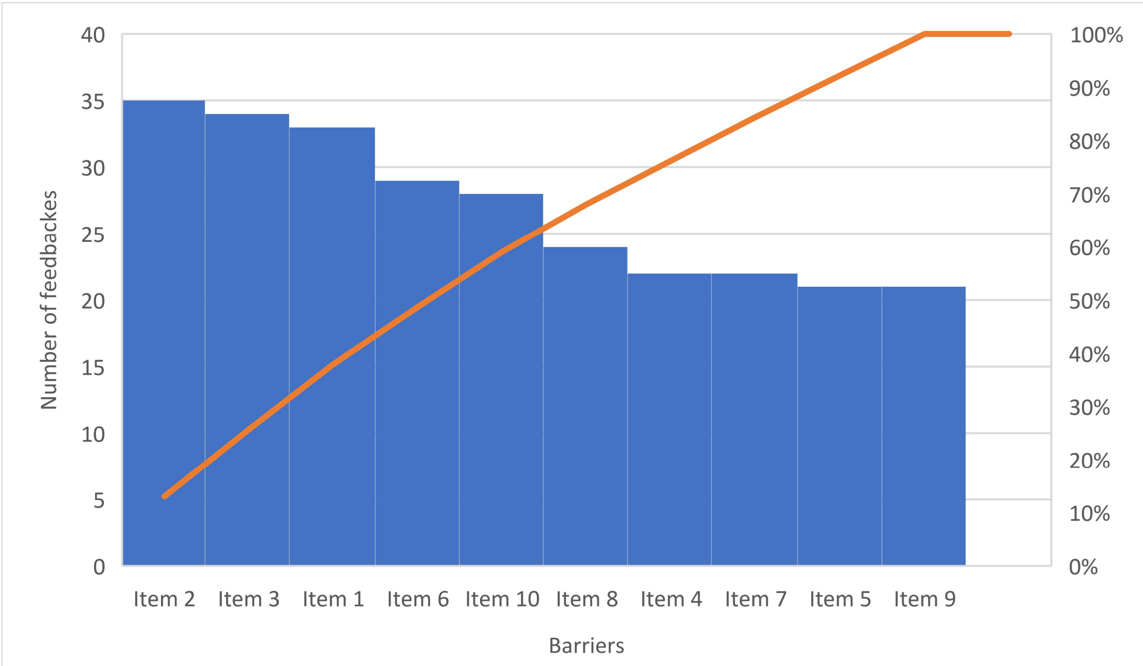

Figure 4- 6 Pareto Chart of selected items

Results on the importance of the barrier items

The respondents used a Likert scale to assign points from 1 to 5 to indicate the importance of each barrier, with 3 indicating a neutral response (Table 4-3).

The barriers were ranked then based on the obtained mean scores and standard deviations (Table 4-4). This table illustrates the ranking of barriers hindering the adoption of green products in Iran, based on the average scores provided by 35 experts. The barriers are ranked from highest to lowest average score, shedding light on the perceived significance of each obstacle in the context of promoting sustainable practices within the Iranian market.

Table 4- 3 Rating of Barrier Importance on Likert Scale

	Insufficient Management	Resistance/fear of change	Environmental Awareness Deficiency	Insufficient Government Support	Lack of Standard Practices	Lack of Communication	Financial constraints	Lack of Employee Training	Technological constraints	Supplier issues
Exper 1	5	5	5	5	5	5	5	5	5	5
Exper 2	5	5	5	5	5	5	5	5	5	5
Exper 3	5	5	5	5	5	5	5	5	5	5
Exper 4	5	5	5	5	5	5	5	5	5	5
Exper 5	5	5	5	5	5	5	5	5	5	5
Exper 6	5	5	5	5	5	5	5	5	5	5
Exper 7	5	5	5	5	5	5	5	5	5	5
Exper 8	5	5	5	5	5	5	5	5	5	5
Exper 9	5	5	5	5	4	5	5	5	5	5
Exper 10	5	5	5	5	5	5	5	5	5	5
Exper 11	5	5	5	5	5	5	5	5	5	5
Exper 12	5	5	5	5	5	5	5	5	4	5
Exper 13	5	5	5	5	5	5	5	5	5	5
Exper 14	5	5	5	5	5	5	5	5	5	5
Exper 15	5	5	5	5	5	5	5	5	5	5
Exper 16	5	5	5	5	5	5	5	5	5	5
Exper 17	5	5	5	5	5	5	5	5	5	5
Exper 18	5	5	5	5	5	5	5	5	5	5
Exper 19	5	5	4	5	5	3	5	5	5	5
Exper 20	5	5	5	5	5	5	5	5	5	5
Exper 21	5	5	5	5	5	5	5	5	5	5
Exper 22	5	5	5	5	5	5	5	5	5	5
Exper 23	5	5	5	5	5	5	5	5	5	5
Exper 24	5	5	5	5	5	5	4	5	5	5
Exper 25	5	4	4	4	4	5	4	4	4	4
Exper 26	5	5	5	5	5	5	5	5	5	3
Exper 27	5	5	5	5	4	5	5	5	5	5
Exper 28	5	5	5	5	5	5	5	5	5	5
Exper 29	5	5	5	5	5	5	5	5	5	5
Exper 30	5	5	5	5	5	5	5	5	5	5
Exper 31	5	5	5	5	5	5	5	5	5	5
Exper 32	5	5	5	3	5	5	5	5	5	5
Exper 33	5	5	5	5	5	5	5	5	5	5
Exper 34	5	5	5	5	5	5	5	5	5	5

Exper 35	5	5	5	5	3	5	5	5	5	5

Table 4- 4 Descriptive Statistics of the importance scores for each barrier

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
InsufficientManagement	35	5	5	5.00	.000	.000
ResistanceFearofchange	35	4	5	4.97	.169	.029
EnvironmentalAwarenessDeficiency	35	4	5	4.94	.236	.055
InsufficientGovernmentSupport	35	3	5	4.91	.373	.139
LackofStandardPractices	35	3	5	4.86	.430	.185
LackofCommunication	35	3	5	4.94	.338	.114
FinancialConstraints	35	4	5	4.94	.236	.055
LackofEmployeeTraining	35	4	5	4.97	.169	.029
TechnologicalConstraints	35	4	5	4.94	.236	.055
SupplierIssues	35	3	5	4.91	.373	.139
Valid N (listwise)	35					

Here are the items ranked from highest to lowest average score based on the scores provided by our experts:

1. Insufficient Management: Average score of 5
2. Insufficient Government Support: Average score of 5
3. Environmental Awareness Deficiency: Average score of 5
4. Lack of Employee Training: Average score of 5
5. Lack of Communication: Average score of 5
6. Resistance/fear of change: Average score of 5
7. Financial constraints: Average score of 4.97
8. Lack of Standard Practices: Average score of 4.94
9. Technological constraints: Average score of 4.89
10. Supplier issues: Average score of 4.89

ISM process

The first step in the Interpretive Structural Modeling (ISM) methodology involves the crucial task of defining the problem at hand along with its pertinent variables. In our specific case, these variables correspond to the ten identified barriers relevant to the adoption of green products. Following this initial phase, the focus shifts towards the development of the Structural Self Interaction Matrix (SSIM). This matrix serves as a foundational element, facilitating the representation of the intricate relationships among the variables. Each relationship is symbolized by one of four letters - V, A, X, and O - denoting various types of interactions, such as dominance, influence, and mutual exclusion. To ensure the accuracy and reliability of the constructed matrix, experts in the field were consulted. Through collaborative efforts and expert consensus, the intricate web of relationships among the variables was carefully delineated and documented within the SSIM framework. The culmination of this collaborative endeavor is summarized in Table 4-5, which presents a comprehensive overview of the implications and insights derived from the expert-driven consensus regarding the relationships among the identified variables.

In Table 4-5, symbols such as "V," "A," "X," and "O" are used to represent different types of relationships between variables. Specifically, "V" indicates that one variable depends on another, while "A" suggests the opposite scenario, where the second variable depends on the first. "X" signifies a bidirectional or mutual dependence between variables, and "O" denotes that there is no dependence between the variables. The variables themselves are identified and listed by numbers in Table 4-6. Once these relationships are established in the Structural Self Interaction Matrix (SSIM), the next step in the ISM methodology involves converting these symbolic representations into a binary format to create the Interpretive Relationship Matrix (IRM). This conversion process is guided by specific rules outlined in Chapter 3, section 3.2.1 of the ISM methodology.

Table 4-6 presents the outcomes of this conversion process, demonstrating the results of the IRM procedure. Here, the symbols "1" and "0" are used to indicate the presence or absence of a relationship between each pair of variables, respectively. This binary representation simplifies the interpretation of the relationships between variables and facilitates further analysis within the ISM framework.

In the ISM approach, the subsequent step involves supplementing the IRM to produce the final reachability matrix. This augmentation introduces transitivity, enhancing the matrix's accuracy by addressing bias and potential errors. The process follows a structured procedure to systematically incorporate transitivity rules.

For instance, if element (i) has an impact on element (b), and element (a) influences element (k), then element (i) also influences element (k) in the matrix. This establishes a hierarchical relationship between variables, reflecting their interconnectedness and influence within the system. The outcomes of this process are delineated in Table 4-7, where the "driving" column signifies each variable's position in the hierarchical structure of the ISM. Variables with higher driving power exert greater influence and significance on the identified problem. Conversely, the "dependence" column illustrates the extent of dependency of each variable within the system. Higher values in this column indicate a greater reliance on other variables for influence and impact.

Upon establishing the final reachability matrix, the ISM methodology proceeds to form reachability sets, antecedent sets, and intersection sets. The reachability set encompasses the barrier itself along with all other barriers influenced by it. Conversely, the antecedent set comprises the target variable and all barriers influencing it. The intersection set encompasses the shared barriers between the reachability and antecedent sets.

If a variable or variables exhibit identical contents in both the reachability and intersection sets, it indicates that these variables constitute the top level of the barriers' hierarchy. These variables are subsequently segregated from the sets, marking the initiation of the level partitioning process. This iterative procedure continues with other variables to discern additional hierarchical levels.

This process, termed as level partitioning, aims to delineate the hierarchical structure of barriers comprehensively. Table 4-8 to 4-12 serve as the representation of the identified hierarchical levels for the implementation of green products within the Iranian construction industry.

Table 4- 5 Expert-Derived Structural Self Interaction Matrix (SSIM) Showing Relationships Among Identified Barriers

	B1) Insufficient Management	B2) Resistance/fear of change	B3) Environmental Awareness Deficiency	B4) Insufficient Government Support	B5) Lack of Communication	B6) Lack of Employee Training	B7) Financial constraints	B8) Lack of Standard Practices	B9) Technological constraints	B10) Supplier issues
A1) Insufficient Management		V	V	A	X	V	X	X	X	V
A2) Resistance/fear of change			X	A	X	A	A	A	A	X
A3) Environmental Awareness Deficiency				A	X	X	O	A	A	X
A4) Insufficient Government Support					V	V	V	X	V	V
A5) Lack of Communication						A	X	O	A	V
A6) Lack of Employee Training							A	A	X	O
A7) Financial constraints								A	A	X
A8) Lack of Standard Practices									V	V
A9) Technological constraints										A
A10) Supplier issues										

Table 4- 6 IBM results

	B1) Insufficient Management	B2) Resistance/fear of change	B3) Environmental Awareness Deficiency	B4) Insufficient Government Support	B5) Lack of Communication	B6) Lack of Employee Training	B7) Financial constraints	B8) Lack of Standard Practices	B9) Technological constraints	B10) Supplier issues
A1) Insufficient Management	1	1	1	0	1	1	1	1	1	1
A2) Resistance/fear of change	0	1	1	0	1	0	0	0	0	1
A3) Environmental Awareness Deficiency	0	0	1	0	1	1	0	0	0	1
A4) Insufficient Government Support	1	1	1	1	1	1	1	1	1	1
A5) Lack of Communication	1	1	1	0	1	0	1	0	0	1
A6) Lack of Employee Training	0	1	1	0	1	1	0	0	1	0
A7) Financial constraints	1	1	0	0	1	1	1	0	0	1
A8) Lack of Standard Practices	1	1	1	1	0	1	1	1	1	1
A9) Technological constraints	1	1	1	0	1	1	1	0	1	0
A10) Supplier issues	0	1	1	0	0	0	1	0	1	1

Table 4- 7 Reachability matrix

	Item B1	Item B2	Item B3	Item B4	Item B5	Item B6	Item B7	Item B8	Item B9	Item B10	**Driving Power**
A1) Insufficient Management	1	1	1	1*	1	1	1	1	1	1	10
A2) Resistance/fear of change	0	1	1	0	1	0	0	0	0	1	4
A3) Environmental Awareness Deficiency	1*	0	1	0	1	1	1*	0	1*	1	7
A4) Insufficient Government Support	1	1	1	1	1	1	1	1	1	1	10
A5) Lack of Communication	1	1	1	0	1	1*	1	1*	1*	1	9
A6) Lack of Employee Training	0	1	1	0	1	1	0	0	1	0	5
A7) Financial constraints	1	1	0	0	1	1	1	0	0	1	6
A8) Lack of Standard Practices	1	1	1	1	0	1	1	1	1	1	9
A9) Technological constraints	1	1	1	0	1	1	1	1*	1	1*	9
A10) Supplier issues	1*	1	1	0	1*	1*	1	0	1	1	8
Dependence Power	10	9	9	3	9	10	10	6	8	10	

Level 1 barriers in Table 4-8 exert significant influence and importance in the context of green product implementation within the Iranian construction industry.

1. Insufficient Management (A1): This barrier influences all other barriers listed in the table (barriers 1 to 10). It signifies that inadequate management practices have a widespread impact on various aspects of green product implementation. Insufficient Management is influenced by barriers 1, 3, 4, 5, 7, 8, 9, and 10. These are the barriers that contribute to or exacerbate inadequate management practices within the industry. The common barriers between the reachability and antecedent sets highlight the shared influencers and influenced variables for Insufficient Management. Classified as Level 1, indicating its position at the top of the hierarchy due to its extensive influence and significance.

2. Insufficient Government Support (A4): Similar to Insufficient Management, this barrier also influences all other barriers (barriers 1 to 10). Insufficient Government Support is influenced by barriers 1, 4, and 8. These are the factors contributing to the lack of adequate support from government entities for green product implementation. Represents the common barriers between the reachability and antecedent sets for Insufficient Government Support. Also classified as Level 1 due to its broad influence and importance within the hierarchy.

These Level 1 barriers serve as critical focal points for addressing challenges and driving improvements in green product implementation efforts within the Iranian construction industry. Understanding their extensive influence and interconnections can guide stakeholders in prioritizing interventions and allocating resources effectively to overcome these significant barriers.

Table 4- 8 Level partitioning (Level 1)

Items	Reachability	Antecedent	Intersect	Level
A1) Insufficient Management	1,2,3,4,5,6,7,8,9,10	1,3,4,5,7,8,9,10	1,3,4,5,7,8,9,10	Level 1
A2) Resistance/fear of change	2,3,5,10	1,2,4,5,6,7,8,9,10	2,5,10	
A3) Environmental Awareness Deficiency	1,3,5,6,7,9,10	1,2,3,4,5,6,8,9,10	1,3,5,6,9,10	
A4) Insufficient Government Support	1,2,3,4,5,6,7,8,9,10	1,4,8	1,4,8	Level 1
A5) Lack of Communication	1,2,3,5,6,7,8,9,10	1,2,3,4,5,6,7,9,10	1,2,3,5,6,7,9,10	
A6) Lack of Employee Training	2,3,5,6,9	1,3,4,5,6,7,8,9,10	3,5,6,9	
A7) Financial constraints	1,2,5,6,7,10	1,3,4,5,7,8,9,10	1,5,7,10	
A8) Lack of Standard Practices	1,2,3,4,6,7,8,9,10	1,4,5,8,9	1,4,8,9	
A9) Technological constraints	1,2,3,5,6,7,8,9,10	1,3,4,5,6,8,9,10	1,3,5,6,8,9,10	
A10) Supplier issues	1,2,3,5,6,7,9,10	1,2,3,4,5,7,8,9,10	1,2,3,5,7,9,10	

In Table 4-9, barriers 2, 3, 5, 6, 7, 8, 9, and 10 are influenced by Lack of Communication(A5). Lack of Communication is influenced by barriers 2, 3, 5, 6, 7, 9, and 10. Intersection Set represents the common barriers between the reachability and antecedent sets for Lack of Communication. This item was classified as Level 2, indicating its position in the hierarchy. Also, barriers 2, 3, 5, 6, 7, 8, 9, and 10 are influenced by Technological constraints. Technological constraints is influenced by barriers 3, 5, 6, 8, 9, and 10. Technological constraints was classified as Level 2, indicating its position in the hierarchy. These Level 2 barriers, Lack of Communication and Technological constraints, hold significance in influencing other barriers within the green product implementation framework in the Iranian construction industry. Understanding their roles and interconnections can guide targeted interventions and strategic initiatives aimed at addressing specific challenges and promoting sustainability practices effectively.

Table 4- 9 Level partitioning (Level 2)

Items	Reachability	Antecedent	Intersect	Level
A2) Resistance/fear of change	2,3,5,10	2,5,6,7,8,9,10	2,5,10	
A3) Environmental Awareness Deficiency	3,5,6,7,9,10	2,3,5,6,8,9,10	3,5,6,9,10	
A5) Lack of Communication	2,3,5,6,7,8,9,10	2,3,5,6,7,9,10	2,3,5,6,7,9,10	Leve2
A6) Lack of Employee Training	2,3,5,6,9	3,5,6,7,8,9,10	3,5,6,9	
A7) Financial constraints	2,5,6,7,10	3,5,7,8,9,10	5,7,10	
A8) Lack of Standard Practices	2,3,6,7,8,9,10	5,8,9	8,9	
A9) Technological constraints	2,3,5,6,7,8,9,10	3,5,6,8,9,10	3,5,6,8,9,10	Level2
A10) Supplier issues	2,3,5,6,7,9,10	2,3,5,7,8,9,10	2,3,5,7,9,10	

Lack of Standard Practices (A8) is identified as a Level 3 barrier (Table 4-10), indicating its position in the hierarchy of barriers influencing the implementation of green products in the Iranian construction industry. This barrier has a significant influence on several other barriers, including barriers 2, 3, 6, 7, and 10, as indicated by its reachability set. However, it is influenced by only one other barrier, which is barrier 8, as shown in its antecedent set. The intersection set reveals that barrier 8 is the common barrier between its reachability and antecedent sets. This categorization helps in understanding the specific role and influence of Lack of Standard Practices within the broader context of barriers to green product implementation.

Supplier issues (A10) is identified as a Level 4 barrier (Table 4-11), indicating its position as a relatively lower-level barrier in the hierarchy of barriers influencing the implementation of green products in the Iranian construction industry. This barrier influences several other barriers, including barriers 2, 3, 6, 7, and 10, as indicated by its reachability set. However, it is influenced by only three other barriers, which are barriers 2, 3, and 7, as shown in its antecedent set. The intersection set reveals that barriers 2, 3, and 7 are common barriers between its reachability and antecedent sets. Understanding the role and influence of Supplier issues within the broader context of barriers to green product implementation can aid in devising targeted strategies and interventions to address these barriers effectively.

Both Environmental Awareness Deficiency (A3) and Lack of Employee Training (A6) are identified as Level 5 barriers (Table 4-12), indicating their position as relatively mid-level barriers in the hierarchy. These barriers influence each other as well as several other barriers, indicating their significance in the context of green product implementation in the Iranian construction industry. Financial constraints (A7) is identified as a Level 6 barrier, indicating its position as a relatively mid-level barrier in the hierarchy. This barrier influences several other barriers and is influenced by a few other barriers, reflecting its importance in shaping the landscape of green product implementation challenges. Resistance/fear of change (A2) is identified as a Level 7 barrier, indicating its position as a relatively lower-level barrier in the hierarchy. This barrier influences several other barriers and is influenced by a few other barriers, suggesting its role in shaping the dynamics of green product implementation challenges, albeit at a slightly lower level compared to other barriers.

Table 4- 10 Level partitioning (Level 3)

Items	**Reachability**	**Antecedent**	**Intersect**	**Level**
A2) Resistance/fear of change	2,3,10	2,6,7,8,10	2,10	
A3) Environmental Awareness Deficiency	3,6,7,10	2,3,6,8,10	3,6,10	
A6) Lack of Employee Training	2,3,6	3,6,7,8,10	3,6	
A7) Financial constraints	2,6,7,10	3,7,8,10	7,10	
A8) Lack of Standard Practices	2,3,6,7,8,10	8	8	Level 3
A10) Supplier issues	2,3,6,7,10	2,3,7,8,10	2,3,7,10	

Table 4- 11 Level partitioning (Level 4)

Items	Reachability	Antecedent	Intersect	Level
A2) Resistance/fear of change	2,3,10	2,6,7,10	2,10	
A3) Environmental Awareness Deficiency	3,6,7,10	2,3,6,10	3,6,10	
A6) Lack of Employee Training	2,3,6	3,6,7,10	3,6	
A7) Financial constraints	2,6,7,10	3,7,10	7,10	
A10) Supplier issues	2,3,6,7,10	2,3,7,10	2,3,7,10	Level 4

Table 4- 12 Level partitioning (Level 5, 6, and 7)

Items	Reachability	Antecedent	Intersect	Level
A2) Resistance/fear of change	2,3	2,6,7	2	Level 7
A3) Environmental Awareness Deficiency	3,6,7	2,3,6	3,6	Level 5
A6) Lack of Employee Training	2,3,6	3,6,7	3,6	Level 5
A7) Financial constraints	2,6,7	3,7	7	Level 6

Discussion

In order to integrate green products in the Iranian construction industry, it is critical to understand the complex web of hurdles that impede growth. The Interpretive Structural Modeling (ISM) technique provides a systematic framework for delineating these barriers and understanding their hierarchical linkages. By assessing the levels of various obstacles, we can learn about their relative relevance, interdependence, and possible mitigation techniques (Figure 4-7).

At the top of the hierarchy are the Level 1 barriers, which represent the fundamental hurdles with the most significant driving and dependent forces. In our analysis, limitations such as insufficient management and government support are identified as Level 1 impediments. These barriers have a major impact on the system and are less prone to external effects. Their widespread influence emphasizes the importance of focused interventions and policy reforms at the organizational and governmental levels to create a favorable climate for green product deployment.

Moving down the chain, Level 2 obstacles reveal interconnected issues that are influenced by Level 1 barriers while also having their own effect on the system. At this stage, barriers such as a lack of communication and standard practices become apparent. These impediments represent significant gaps in coordination, knowledge distribution, and industry-wide adherence to established norms and standards. Addressing these difficulties requires coordinated efforts from all stakeholders, with a focus on effective communication channels and standardized processes.

Level 3 barriers are intermediate in the hierarchy, demonstrating reliance on Level 1 and Level 2 barriers while also impacting lower-level impediments. Financial restrictions arise significantly at this level, reflecting the financial complexities and resource limitations common in green product implementation efforts. Financial barriers must be overcome through innovative finance arrangements, incentive schemes, and effective resource allocation techniques that ease financial constraints and promote investment in sustainable activities.

As we progress through the hierarchy, Level 4 barriers indicate specific issues with a more localized impact. Supplier difficulties, for example, are identified as Level 4 barriers, underlining their importance as unique but major obstructions to green product deployment. To manage risks and increase supply chain resilience, it may be necessary to establish supplier partnerships, promote supply chain transparency, and incentivize sustainable sourcing practices.

Level 5 obstacles highlight sector-specific issues that necessitate customized solutions and industry-specific actions. At this level, environmental awareness deficiencies and a lack of employee training appear, emphasizing the significance of environmental education and workforce development programs. Improving environmental literacy among stakeholders and providing training programs to equip staff with the essential skills and information are critical for establishing a sustainable culture in the construction sector.

At Level 6, limitations such as financial limits remain operational impediments to advancement at multiple organizational levels. These obstacles demand focused interventions to improve financial procedures, optimize resource allocation, and promote cost-effective sustainable practices. Innovative financial tools, green finance methods, and investment incentives can help to accelerate the transition to sustainable construction practices while reducing financial risks and uncertainties.

Finally, Level 7 barriers are peripheral challenges that, while considerable, have a relatively small impact on overall system dynamics. Resistance/fear of change exemplifies such obstacles, emphasizing the psychological and cultural barriers that inhibit the adoption of green products. To overcome resistance to change, change management methods, stakeholder engagement efforts, and communication campaigns must be implemented in order to build an innovative and open culture to sustainable practices.

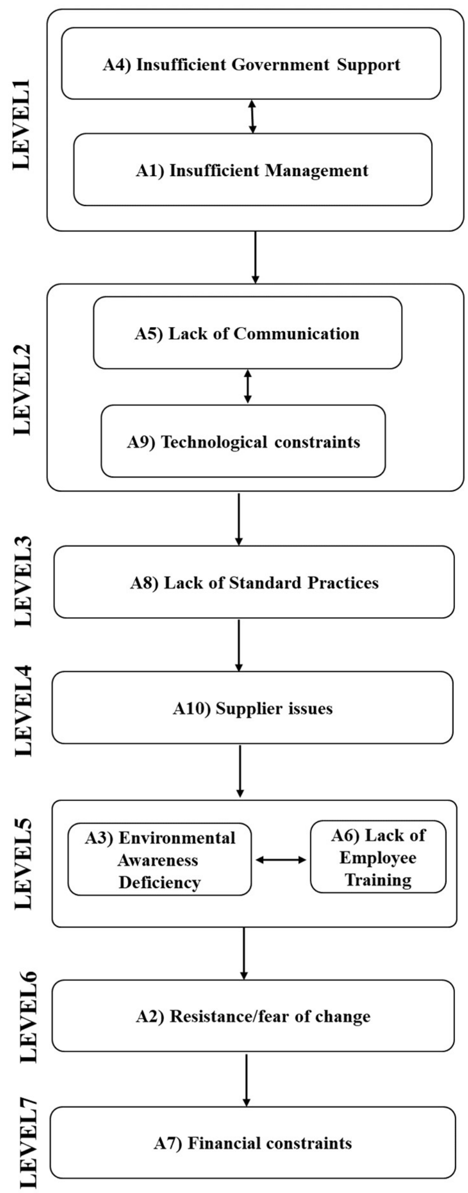

Figure 4- 7 ISM-Hierarchy of barriers impeding GP implementation in Iran's construction industry.

In our MICMAC analysis (Figure 4-8), we found two driving factors: A4) insufficient government support and A8) a lack of standard practices. These parameters have a considerable impact on other variables in the system but are not influenced by them. In addition, we discovered two dependent factors: A2) resistance/fear of change and A6) lack of employee training. These factors have low driving power but high reliance power, relying substantially on other parts in the system for influence. The remaining elements are classified as linking factors, which means they have both strong driving and dependent effects on other variables. We found no components classed as autonomous, implying that all factors in our analysis are interconnected inside the system. This categorization gives useful insights into the system's dynamics, assisting stakeholders in prioritizing actions and developing strategies to overcome important impediments to advancement. Understanding the driving forces and dependencies of elements enables stakeholders to make educated decisions that reduce difficulties and encourage good change within the system.

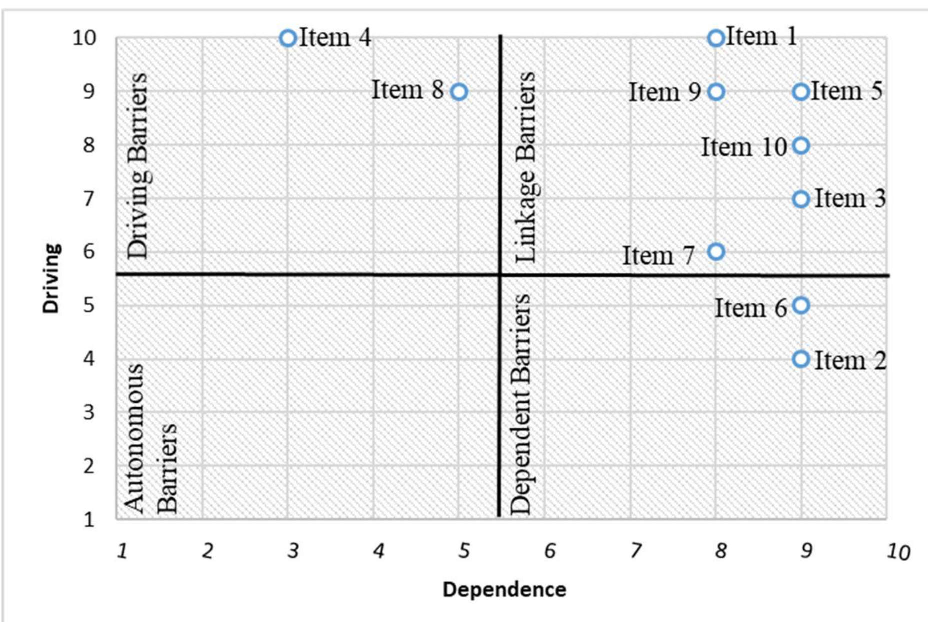

Figure 4- 8 MICMAC classification

Conclusion and Recomandation

Introduction

Iran's transition to sustainable construction methods is both complicated and encouraging. This study uses ISM and MICMAC methods to analyze barriers to green product implementation in the construction industry, revealing both challenges and opportunities for sustainability. Our research findings highlight critical elements that might guide stakeholders in promoting sustainable development.

Evaluation of Sustainable Construction Practices

Understanding the Interconnection of Barriers: Our analysis highlights the linked nature of impediments to green product implementation. Barriers range from insufficient management and government support to sector-specific issues including lack of environmental awareness and employee training, creating a complicated web of interdependence. Recognizing these relationships is crucial for developing holistic strategies that address core causes, promote synergies between intervention levels, and maximize the impact of sustainability programs.

Leveraging Collaborative Partnerships: Collaboration is essential for successfully overcoming barriers to implementing green products. Sustainability concerns are complex and require collaboration from multiple entities and sectors to generate significant change. Collaboration among government agencies, industry companies, academic institutions, civil society organizations, and communities is critical. Partnerships can promote sustainability by sharing information, mobilizing resources, transferring technology, and co-creating policies, leading to systemic transformation in the construction sector.

Empowering Stakeholder Engagement: Successful sustainability efforts require active engagement and empowerment of stakeholders at all stages of the value chain. Engaging stakeholders (developers, contractors, architects, engineers, suppliers, regulators, and end-users) promotes ownership, accountability, and shared responsibility for sustainability outcomes. Stakeholders can collaborate to create sustainable solutions that meet their specific needs and goals through participatory decision-making, capacity-building programs, and inclusive discourse forums.

Acceptance Innovation and Technology: Innovation and technology enable green product deployment and sustainable construction techniques. Using advanced technologies like Building Information Modeling (BIM), prefabrication, renewable energy systems, smart materials, and digital construction tools can improve efficiency, resource utilization, environmental impact, and resilience of built infrastructure. Investing in R&D, fostering technological diffusion, and incentivizing innovation ecosystems can accelerate the adoption of transformative technologies and enhance sustainable construction practices.

Promoting policy and regulatory support: Policy and regulatory frameworks significantly impact sustainable construction methods. Governments, politicians, and regulatory authorities play a significant role in creating and implementing laws that promote sustainability, control environmental performance standards, offer financial incentives, and streamline licensing processes for green building projects. Governments can create an enabling environment for sustainable construction by aligning regulatory frameworks with sustainability goals, fostering regulatory certainty, and promoting market-based mechanisms like green building certification systems.

Developing a Culture of Sustainability: Transitioning to sustainable construction processes involves a culture transformation that prioritizes environmental care, social responsibility, and economic prosperity. To cultivate a sustainable culture, it's important to raise awareness, educate, teach ethical ideals, and promote behavioral change at individual, organizational, and societal levels. Education and awareness campaigns, sustainability literacy programs, green building certifications, and corporate social responsibility efforts can embed sustainability in decision-making processes, business strategies, and daily activities.

The MICMAC research provides insights into the system dynamics and identified hurdles to green product implementation in Iran. By categorizing obstacles based on their driving and dependency powers, we acquire a better understanding of their roles in the system and their potential impact on the success of green product projects.

Insufficient government support and a lack of standard practices. These elements have a considerable impact on the system and drive other variables. Insufficient government support emphasizes the importance of policies, laws, and incentives in promoting green product uptake. The lack of standard practices emphasizes the need for standardized procedures and regulations to guide enterprises towards sustainability. Identifying driving variables enables stakeholders to prioritize legislative initiatives and industry standards, effectively addressing systemic constraints.

We discovered two dependent factors: resistance to change and a lack of employee training. These aspects are crucial for the acceptance of green products, notwithstanding their lower driving force. Fear of change can create psychological and cultural hurdles to organizational sustainability changes. Lack of employee training highlights the importance of developing human capital and establishing ability to promote green practices. To address these dependent factors, focused interventions like change management and training programs can improve organizational readiness and empower stakeholders to adopt sustainable practices.

The identification of connection factors highlights the interrelated nature of barriers within the system. Environmental Awareness Deficiency and Lack of Communication play significant factors in determining the deployment of green products. To effectively create sustainable change, it's important to address many barriers at once, leverage synergies, and mitigate feedback effects.

Challenges and limitations

Although the MICMAC analysis provides vital insights on hurdles to green product implementation in the Iranian construction industry, it is important to acknowledge the study's shortcomings. These limitations suggest topics for further investigation and care when interpreting results. The study's principal weakness is the small sample size of experts participated in data collecting. With only 35 experts involved, the findings' generalizability may be limited. Although attempts were taken to ensure diversity in knowledge, there may still be biases in the perspectives represented, potentially missing important insights from underrepresented groups. MICMAC analysis relies significantly on expert judgments to estimate the driving and dependent powers of variables. Individual biases, experiences, and perceptions can influence opinions, making them subjective. The categorization of obstacles into dependent, driving, and connection elements may not fully convey the system's intricacies and may require interpretation.

The analysis presupposes independent variables, which may not necessarily be true in real-world circumstances. In complex systems, such as the construction industry, obstacles can interact nonlinearly, resulting in emergent features that traditional analytical tools cannot represent. Ignoring interdependencies can simplify system dynamics and lead to incorrect results. Although efforts were made to develop a thorough list of barriers to green product deployment, some significant elements may have been overlooked or underrepresented in the analysis. The investigation did not explicitly consider socio-cultural elements, legal frameworks, and market dynamics, which may have a substantial impact on sustainable practice uptake.

This analysis is a snapshot of the system at a certain point in time, assuming consistent interactions between variables over time. However, in dynamic contexts like the construction industry, barriers, challenges, and relationships can change due to external influences. The static analysis may not fully convey the system's continuing dynamics and complexity. This study's conclusions are exclusive to the Iranian construction industry and may not be applicable to other sectors or regions. Cultural, legislative, and economic variables can effect hurdles to green product implementation, limiting the findings' applicability beyond the study environment.

MICMAC analysis is a formal framework for examining the driving and dependent powers of variables, although it relies on quantitative data from expert judgments. A quantitative approach may oversimplify qualitative barriers, resulting in missed insights that in-depth qualitative research might provide. The MICMAC study may oversimplify the system's intricacies by categorizing barriers as dependent, driving, or linkage elements. Oversimplifying real-world systems might result in too deterministic interpretations due to complex interactions and feedback loops.

Recommendations

Combining quantitative MICMAC analysis with qualitative research approaches such as interviews, focus groups, and case studies can provide a more comprehensive understanding of hurdles to green product deployment. Qualitative techniques allow researchers to investigate stakeholders' underlying motives, perceptions, and experiences, revealing nuanced insights that quantitative analysis alone may not convey. Given the contextual nature of hurdles to green product implementation, cross-cultural research would be useful in determining how cultural differences influence the adoption of sustainable practices in the construction industry. By comparing and contrasting barriers across cultural contexts, researchers can uncover common challenges, culturally specific characteristics, and best practices for fostering global sustainable development.

Engaging a varied range of stakeholders in the study process, such as legislators, industry professionals, community people, and environmental advocates, can improve the relevance and impact of green product implementation studies. Collaborative techniques that involve stakeholders in problem identification, data collection, and decision-making can produce more actionable insights and promote the co-creation of long-term solutions. Exploring the role of emerging technologies such as Building Information Modeling (BIM), the Internet of Things (IoT), and blockchain in overcoming hurdles to green product deployment offers great potential. Using technology breakthroughs, researchers can uncover potential for optimizing procedures, boosting communication, and improving the sustainability performance of construction projects.

Researching the efficacy of policy interventions, regulatory frameworks, and incentive programs in boosting green product deployment is crucial for influencing evidence-based policymaking. By assessing the impact of current policies and finding gaps in policy implementation, researchers can make recommendations for improving policy coherence, alignment, and enforcement in order to speed the transition to sustainable construction methods. Building capacity among construction industry stakeholders through training, education, and knowledge exchange activities can help to foster a sustainable culture and promote wider adoption of green products and practices.

Summary

In conclusion, achieving sustainable construction standards in Iran requires collaborative action, creativity, and transformative leadership. To achieve the full potential of green product implementation in the construction industry, stakeholders should understand the interconnectedness of barriers, leverage collaborative partnerships, empower stakeholder engagement, embrace innovation and technology, promote policy and regulatory support, and cultivate a sustainable culture. As we embark on this journey, let us remain committed to our common goal of a sustainable future, where prosperity is harmonized with environmental integrity and social equality, resulting in long-term benefits for current and future generations. ,Also the MICMAC study offers a thorough framework for analyzing the numerous hurdles to green product implementation. By categorizing barriers based on their driving and dependency powers, stakeholders can build focused solutions to tackle systemic challenges and expedite progress towards sustainability goals. Intervention effectiveness in the Iranian construction industry varies based on context and dynamics. Continuous monitoring and assessment are essential for assuring the effectiveness of policies over time. Although MICMAC analysis provides a structured approach to analyzing hurdles to green product deployment, it's important to acknowledge its limits and use caution when interpreting findings. To better understand sustainable development difficulties, future research should use mixed-methods, broaden the scope of variables, and take into account the dynamic character of complex systems. To summarize, future research on green product in the construction industry should take a multidisciplinary approach, use innovative research methods and technologies, engage diverse stakeholders, and prioritize capacity building and policy analysis in order to overcome barriers and accelerate the transition to a more sustainable built environment. By addressing these research goals, academics may help to improve knowledge, support evidence-based decision-making, and generate beneficial environmental and social impact in the building industry and elsewhere.

Appendix 1

Questionnaire: Identifying Barriers to Green Product Adoption in Iran

Dear Participant,

Thank you for agreeing to participate in this survey. Your expertise is invaluable to our research on identifying barriers to green product adoption in Iran. Please take a few moments to answer the following questions thoughtfully. Your responses will remain confidential and will only be used for research purposes.

Section 1: Demographic Information

1. Name: [Optional]

2. Position/Title:

3. Educational Level:

4. Years of experience in your field:

5. Age/Gender

Section 2: Perceptions of Green Product Adoption

Please rate the following factors according to their perceived impact as barriers to green product adoption in Iran, using a scale of 1 to 5, where:

1 = Not a significant barrier

2 = Minor barrier

3 = Moderate barrier

4 = Significant barrier

5 = Very significant barrier

1. Environmental Awareness Deficiency

2. Insufficient Management

3. Resistance/Fear of Change

4. Financial Constraints

5. Lack of Employee Training

6. Insufficient Government Support

7. Technological Constraints

8. Lack of Communication

9. Supplier Issues

10. Lack of Standard Practices

Section 4: Additional Comments

1. Are there any other barriers to green product adoption in Iran that you believe should be included in this survey? If so, please specify.

If you would like to receive a summary of the survey findings or be contacted for further discussion, please provide your email address or preferred contact information:

Email: ________________________

Thank you for your participation.

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