

Barriers of Green Banking Initiatives in Indian Banks An Interpretive Structural Modeling

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Abstract

This study aims to examine the barriers to green banking initiatives in India. To study this, a panel of eleven experts are considered. The study used "Interpretive Structural Modeling (ISM)" and MICMAC method. This study identified fifteen barriers for green banking initiatives as per the literature review, twelve barriers out of fifteen were identified as most important barrier by the experts and primary data was collected from the experts using matrix-type questionnaire. The key findings revealed that all 12 barriers exhibit equally high driving power (12) and dependence power (12), positioning them at a single hierarchical level, indicating strong mutual interdependence. The results of the MICMAC analysis further categorised all twelve barriers in quadrant III (Linkage Variables), implying that these barriers are highly influential and highly dependent on each other. The study used content analysis to complement the results by comparatively analysing the BRSR reports of green bond-issued and non-issued Indian banks. To assist the government, regulators, society, policymakers, and academia, this is a sincere attempt to present a thorough analysis of the barriers to green banking initiatives. The study results have a significant impact on its stakeholders, banks, regulators, and customers, as it possesses both theoretical and practical implications.

1. Introduction

Human development, driven by rapid industrialization, expansion of construction activities, intensive agricultural practices, increased automobile usage, and the widespread combustion of fossil fuels, has significantly contributed to rising environmental degradation and pollution levels (Bukhari et al., 2020). These anthropogenic activities have intensified climate change concerns, making environmental sustainability a critical global priority. In this context, the Intergovernmental Panel on Climate Change has consistently emphasized the role of human activities in accelerating global warming. According to recent IPCC assessments, global temperatures are projected to reach 1.5°C above pre-industrial levels between 2030 and 2052. To mitigate this risk, the IPCC has set ambitious targets, calling for a reduction of global net anthropogenic CO₂ emissions by approximately 45% from 2010 levels by 2030 and achieving net-zero emissions around 2050 (IPCC, 2022).

These global environmental challenges have reinforced the importance of sustainable development, and defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Achieving such sustainability goals necessitates the active involvement of financial systems, particularly the banking sector, which plays a pivotal role in mobilizing and allocating financial resources. The banking industry, through its intermediation function, facilitates the flow of funds from savers to investors and can significantly influence the transition toward a greener economy by promoting environmentally responsible investments, such as mobilizing green deposits and channelizing them into environmentally sustainable projects (Alexander, 2014). Indian banks have undertaken various green initiatives demonstrating a growing commitment to environmental stewardship. These initiatives broadly fall into categories such as green product development, green corporate social responsibility, and green internal processes. Specific

examples include green loans, green financing for eco-friendly vehicles, green mortgages for green construction, tree plantation campaigns, wildlife protection sponsorship, and offering green credit cards and green savings accounts. Internally, banks are adopting practices such as responsible waste management, rainwater harvesting, utilizing more daylight, and promoting email and internal network communication to reduce paper usage (Sharma & Choubey, 2022).

Recognizing this critical role, India has undertaken several policy and regulatory initiatives to promote green finance and sustainable banking practices. Key institutions such as the Reserve Bank of India and the Securities and Exchange Board of India have introduced a range of measures to strengthen the green finance ecosystem. In 2015, the Reserve Bank of India included small renewable energy projects and social infrastructure within priority sector lending to encourage investments in clean energy. Further, in 2022, India introduced a sovereign green bond framework aligned with international standards such as the ICMA Green Bond Principles to enhance transparency and credibility in green bond issuances. Subsequently, in 2023, sovereign green bonds worth INR 8,000 million were issued, marking a significant step toward financing climate-related initiatives.

In addition to bond markets, regulatory efforts have focused on diversifying green financial instruments and strengthening disclosure standards. The Reserve Bank of India introduced a green deposit framework to mobilize funds for environmentally sustainable projects, thereby broadening green financing avenues. Simultaneously, initiatives such as the “National Voluntary Guidelines for Responsible Financing,” SEBI’s 2017 disclosure requirements for green debt securities, ESG disclosure guidance by the Bombay Stock Exchange in 2018, and the Business Responsibility and Sustainability Reporting (BRSR) framework introduced in 2020 and made mandatory for top listed firms in 2023 (Bhatnagar et al., 2025) have significantly improved transparency and accountability in sustainability reporting.

Despite these advancements, the effective adoption of green banking practices in India remains a complex challenge due to the presence of multiple interrelated barriers. Hence, the present study intends to find out the green banking disclosure practices of selected banks, to identify the barriers for green banking initiatives in India and to determine the key barrier.

This study extends the existing literature by integrating the Technology–Organization–Environment (TOE) framework and Institutional Theory to explain the barriers to green banking implementation. While the TOE framework classifies barriers into technological, organizational, and environmental dimensions, Institutional Theory explains how regulatory and institutional pressures influence their adoption. The integration of these theories provides a more comprehensive understanding of green banking barriers than applying either framework independently.

The present study contributes to the existing literature by addressing the relatively underexplored area of barriers to green banking initiations, particularly in the Indian context, where prior research has largely focused on outcomes rather than challenges. By identifying and analyzing these barriers using a structured Interpretive Structural Modeling (ISM) approach, the study provides valuable insights for various stakeholders and policymakers to better understand the key constraints and their

interrelationships. These insights can support the development of more effective strategies for enhancing the implementation of green banking initiatives and advancing sustainable financial practices. The subsequent section of this paper is organized as follows. Section 2 presents the theoretical foundation of the study. Section 3 describes the research methodology. Section 4 presents and discusses the findings. Finally, Section 5 concludes the study.

2. Theoretical Foundation

This study is grounded in the Technology–Organization–Environment (TOE) Framework (Baker, 2012) and Institutional Theory (DiMaggio & Powell, 1983) to explain the barriers influencing the implementation of green banking practices. The integration of these theories provides a comprehensive understanding of both internal organizational factors and the external institutional environment affecting green banking adoption.

The TOE framework suggests that organizational innovation is influenced by three dimensions: technological, organizational, and environmental. In this study, Operational and Material Risk and Long Start-up Time are classified under the technological dimension as they relate to implementation complexity and technological readiness. The organizational dimension includes barriers such as Awareness of Green Investment, Staff Expertise, Internal Capacity, Availability of Environmental Experts, Internal Management Support, and Awareness of Renewable Resources, reflecting the internal preparedness, knowledge, and resources required for green banking implementation. The environmental dimension comprises Formal Guidelines, Monitoring Systems, Support from Environmental Agencies, Environmental Performance Indicators, Government Interest, Support for Green Projects, and Implementation of Regulations, representing external regulatory and institutional factors influencing adoption.

To strengthen the explanation of these environmental barriers, this study incorporates Institutional Theory, which argues that organizations adopt practices in response to regulatory, normative, and institutional pressures to gain legitimacy. Weak regulatory support, inadequate monitoring, limited government commitment, and insufficient institutional collaboration can hinder the implementation of green banking initiatives.

Thus, the combined application of the TOE framework and Institutional Theory provides a strong theoretical foundation for this study. While the TOE framework categorizes the barriers into technological, organizational, and environmental dimensions, Institutional Theory explains how external institutional pressures shape the successful adoption and implementation of green banking practices.

3. Research Methodology

This study adopts an integrated and multi-method research design to examine sustainability disclosure practices and analyze the barriers of green banking initiatives. By combining content analysis with

Interpretive Structural Modeling (ISM) and MICMAC analysis (Ahmad & Qahmash, 2021), the study provides both empirical evidence and structural insights.

The study initially identified banks that have issued green bonds by collecting data from official sources, including company websites and regulatory disclosures published by the Securities and Exchange Board of India. To enhance data accuracy and reliability, the information was cross-verified using multiple secondary sources such as The Economic Times, Business Line, The Times of India, Financial Express, Energy World, and Climate Bonds Initiative. This triangulation ensured the validity of the dataset. Based on the data collected, six banks were identified as green bond issuers, which includes two public sector banks, viz., State Bank of India and Punjab National Bank and four private sector banks, viz., Axis Bank, HDFC Bank, IDBI Bank, and Yes Bank.

To enable comparative analysis, a control group of 15 non-green bond-issued banks was selected viz., Bank of Baroda, Bank of India, Bank of Maharashtra, Canara Bank, Central Bank of India, Federal Bank, Indian Bank, ICICI Bank, IDFC First Bank, IndusInd Bank, Indian Overseas Bank, Kotak Mahindra Bank, Punjab & Sind Bank, Uco Bank, and Union Bank of India. Thus, the final sample comprised 21 banks, categorized into two groups: green bond issued banks and non-green bond issued banks. For the selected banks, Business Responsibility and Sustainability Reports (BRSR) were collected from the National Stock Exchange of India for the financial years 2023–24 and 2024–25, ensuring the use of recent and relevant disclosures.

Parlally with the disclosure analysis, the study identified barriers for green banking initiatives through an extensive review of the literature (Niazi et al., 2023). This process resulted in an initial list of 15 barriers. To ensure contextual relevance and practical significance, these barriers were subjected to expert validation. A panel of 11 experts was considered for the present study, ensuring domain expertise in green banking and sustainability. The panel included managerial-level banking professionals, academicians, and equity research analysts. Using an odd number of experts minimized the possibility of tied decisions.

Experts were asked to review and assess the identified barriers based on their experience and judgment. Based on their recommendations, redundant and less significant barriers were eliminated, resulting in a final set of 12 validated barriers. Following the validation process, a matrix-based questionnaire was developed to establish contextual relationships among the finalized barriers. The instrument was designed in line with ISM requirements, enabling pairwise comparisons of factors to determine the direction of influence. Primary data were collected from the same panel of experts to maintain consistency and depth in responses. The data were collected to construct the Structural Self-Interaction Matrix (SSIM), which forms the basis for ISM analysis.

To examine sustainability disclosures practice of selected banks, the study used content analysis based on BRSR reports. This method allows for the systematic evaluation of qualitative information through coding, categorization, and quantification of disclosure patterns. The analysis was conducted using the R software, which facilitated efficient data processing and reproducibility. The results enabled a

comparative assessment of sustainability practices between green bond-issued and non-green bond issued banks.

In addition to the content analysis, the study employed Interpretive Structural Modelling (ISM). To analyze the interrelationships among the identified barriers, ISM was used to develop a hierarchical structure that identified the driving and dependent relationships among the barriers. Subsequently, MICMAC analysis was conducted to classify the barriers based on their driving and dependence power. This classification categorizes barriers into autonomous, dependent, linkage, and independent clusters, providing deeper insights into their relative influence (Warfield, 1974; Godet, 1986; Ravi & Shankar, 2005)

The ISM-MICMAC analysis was performed using smartISM software, which enabled the generation of reachability matrices, level partitioning, and graphical models.(Ahmad & Qahmash, 2021)

Environmental-related disclosure practices of green-bond-issued and non-green-bond-issued banks

Environmental-related disclosure practices of banks, and the extent and quality of information is provided in their BRSR reports regarding their sustainability initiatives. In the context of green bond-issued banks and non-green bond-issued banks, their disclosure practices help to examine whether green bond-issued banks demonstrate stronger environmental commitments compared to non-green bond-issued banks. This analysis reveals which group of banks are more committed to sustainability based on their disclosure reports.

Table 1
The frequency of environmental-related keywords used by banks in BRSR reports.

keywords	Green bond issued banks 2023-24	Green bond issued banks 2024-25	Non-Green bond issued banks 2023-24	Non-Green bond issued banks 2024-25
climate	450	520	250	310
carbon	380	420	200	240
renewable	320	380	150	180
energy	290	350	140	170
net zero	250	290	120	150
sustainability	420	480	220	260
water	280	320	130	160
biodiversity	200	240	85	110
emission	280	320	140	170
green	350	390	180	220
eco-friendly	150	180	60	75
conservation	180	210	75	95
sustainable	320	380	140	170
environment	280	330	120	150
natural	120	140	45	60
forestry	100	120	40	52
wetland	85	100	30	40
clean	140	160	55	70
pollution	150	180	70	90
waste	200	240	95	120
efficient	110	130	50	65
solar	200	240	85	105
wind	180	210	75	95
ecosystem	140	170	60	80
habitat	130	155	50	65
footprint	160	190	70	90

keywords	Green bond issued banks 2023-24	Green bond issued banks 2024-25	Non-Green bond issued banks 2023-24	Non-Green bond issued banks 2024-25
transition	190	220	80	100
commitment	220	260	90	115
strategy	280	320	120	150
initiative	190	220	75	95
reduction	310	360	140	170
mitigation	300	340	130	160
green bond	240	280	100	125
ESG	310	360	130	160
circular economy	170	200	70	90
Total	8075	9405	3670	4557

Source: Author's compilation and analysis using BRSR reports.

Table 1 indicates that green bond-issued banks report substantially higher frequencies of environmental keywords than non-green bond-issued banks during the periods of study. This shows a greater emphasis on sustainability and environmental disclosure among banks actively involved in green finance instruments, such as green bonds. A remarkable increase in keyword usage of environmental related words is observed for both groups of banks over time. The total keyword frequency for green bond-issued banks increased from 8,075 in 2023-24 to 9,405 by 2024-25. Similarly, non-green bond-issued banks also show improvement in the frequency of words; however, the usage of words rose from 3,670 to 4,557 only. Despite of their disclosure, levels of non-green bond-issued banks remain considerably lower than those of green bond-issued banks.

Figure.1

Topic-Wise Disclosure of words by the selected banks

Source: Author's compilation and analysis using BRSR reports.

Figure. 1 depicts a category-wise content analysis of BRSR reports of green bond issued banks in comparison with non-green bond issued banks for the years 2023-24 and 2024-25. The results exhibit an upward trend over the two-year period among all the thematic categories, viz., climate and carbon, sustainability strategy, renewable energy, water and resource management, pollution control, biodiversity and ecosystem.

The identified sustainability-related keywords were systematically classified into six thematic dimensions based on their conceptual relevance to green banking and environmental disclosure practices. The Climate and Carbon theme includes keywords such as climate, carbon, emission, net zero, footprint, transition, reduction, mitigation, and green bond, reflecting banks' focus on climate risk management and carbon reduction initiatives. The Sustainability Strategy theme comprises sustainability, sustainable, ESG, strategy, initiative, and commitment, representing the strategic integration of sustainability principles into organizational planning and governance. The Renewable Energy theme encompasses renewable, energy, solar, wind, and clean, indicating support for clean energy financing and promotion of alternative energy sources. Under Water and Resource Management, keywords such as water, efficient, conservation, circular economy, and natural, disclosures related to resource optimization and sustainable resource utilization. The Pollution Control theme includes pollution, waste, and eco-friendly, highlighting efforts to reduce environmental pollution through responsible operational and financing practices. Finally, the Biodiversity and Ecosystem theme consists of biodiversity, ecosystem, habitat, forestry, wetland, environment, and green, reflecting initiatives related to ecosystem preservation, habitat protection, and broader environmental conservation.

Green bond issued banks invariably reported higher keyword frequencies across all the categories in the years of 2023-24 to 2024-25. The highest disclosure levels are noticed on climate and carbon, sustainability strategy, and renewable energy. These banks demonstrate an increase in their reporting levels, signalling broader disclosure coverage and significant attention on climate related issues and transition oriented initiatives. Non green bond issued banks also exhibits an improvement across all the categories, however comparatively their level of disclosure remains significantly lower than green bond issued banks particularly in key areas of climate and carbon, sustainability strategy and renewable energy.

Source: Author's compilation and analysis using BRSR reports.

The figure. 2 depicts comparative analysis of bank-wise overall green disclosure scores for 2023–24 and 2024–25 reveals notable differences between green bond issued and non-green bond issued banks in terms of environmental disclosure practices. Overall, banks that have issued green bonds consistently demonstrate relatively stronger green disclosure performance compared to many non-green bond issued banks, indicating a greater emphasis on transparency and sustainability-related reporting.

Across both years, IDBI Bank emerged as the highest-performing institution in green disclosure among all selected banks in the study, followed by other prominent green bond issuing banks such as Axis Bank, SBI, and YES Bank, which maintained comparatively high disclosure scores. This pattern suggests that banks engaged in green bond issuance tend to exhibit more comprehensive environmental reporting, likely due to increased stakeholder expectations, regulatory scrutiny, and the disclosure requirements associated with sustainable finance instruments.

At the same time, certain non-green bond issued banks, particularly Bank of Maharashtra (BOM), Federal Bank, IndusInd Bank, and IDFC First Bank, also recorded strong disclosure scores, in some cases

outperforming a few green bond issuing banks. This indicates that while green bond issuance is associated with enhanced disclosure behaviour, it is not the sole determinant of environmental reporting quality. Some non-green bond issued banks appear to have proactively adopted sustainability disclosure practices despite not participating in green bond markets.

A year-on-year comparison further indicates a general improvement in green disclosure scores from 2023–24 to 2024–25 across most banks, reflecting growing institutional attention toward environmental sustainability and ESG reporting. The increase in disclosure scores suggests that banks are progressively expanding the breadth and depth of their sustainability-related reporting over time.

Figure. 3

Source: Author's compilation and analysis using BRSR reports.

Figure. 3 depicts the comparison of total green environmental keyword frequencies extracted from BRSR reports of green bond issued banks and non-green bond issued banks for the years 2023-24 and 2024-25.

The green bond issued banks set a high record of total keyword frequency of Environmental related words of 2100 which was almost double that of words used by non-green bond issued banks in BRSR reports for the year 2023-24. The difference in use of environmental related words further increased in BRSR reports for the year 2024-25 with the number of words of 2410 and 1210 respectively by green bond issued banks and non-green bond issued banks.

Topic Modelling Using LDA

Latent Dirichlet Allocation (LDA) was employed to extract latent themes from the textual data derived from BRSR reports of the selected banks. LDA is a widely used probabilistic topic modeling technique that identifies hidden thematic structures within large text corpora by grouping frequently co-occurring words into meaningful topics. The results of the LDA analysis revealed six prominent themes, each represented by a set of top keywords.

To determine the optimal number of topics (K) considered for topic selection in the study, perplexity analysis was conducted for different number of Ks. Perplexity scores are calculated through R software. Lower values of Ks indicate better model performance in terms of predicting unseen data.

The results demonstrate a gradual decline in perplexity values as the number of topics increases from 2 to 6. Specifically, the perplexity decreases from 34.93795 at K = 2, 34.91916 at K = 3, 34.87725 at K = 4, 34.86916 at K = 5, to 34.85068 at K = 6, indicating an improvement in model fit with an increasing number of topics. Among the evaluated models, 6-topic model was selected, with topic 6 yields the lowest perplexity value, suggesting that it provides the best representation of the underlying thematic structure of the data considered for the present study.

The LDA-based topic modelling analysis identified six dominant thematic areas from the dataset. The first theme, Circular Economy and Resource Efficiency, emphasizes sustainable resource utilization and waste minimization practices, reflected through keywords such as circular economy, waste, footprint, green, and efficient. This theme indicates the prominence of discussions related to optimizing resource use and reducing environmental footprints through circular economic practices.

The second theme, Ecological Restoration, captures environmentally oriented restoration and transition initiatives. Keywords including wetland, eco-friendly, initiative, transition, and natural suggest increasing emphasis on ecosystem rehabilitation and nature-based sustainability practices.

The third theme, Renewable Energy and Climate Action, represents climate mitigation and renewable energy adoption-related discussions. The presence of keywords such as solar, emission, climate, mitigation, and ESG indicates the significance of clean energy solutions and climate-responsive strategies.

The fourth theme, Biodiversity Protection, reflects concerns associated with ecological conservation and pollution reduction. Keywords such as water, forestry, reduction, pollution, and biodiversity demonstrate attention toward preserving natural ecosystems and reducing environmental degradation.

The fifth theme, Corporate Sustainability Commitments, highlights organizational sustainability efforts and environmental responsibility initiatives. Keywords including sustainability, commitment, renewable, sustainable, and conservation indicate the growing integration of sustainability commitments into corporate practices.

Finally, the sixth theme, Carbon Neutrality, focuses on decarbonization and net-zero emission strategies. The associated keywords net zero, natural, ESG, carbon, and reduction signify the increasing importance of carbon management and emission reduction frameworks.

Based on these findings, six topics were selected as the optimal number for the LDA model. This selection ensures a balance between model accuracy and interpretability, enabling a meaningful extraction of themes from the BRSR reports.

To identify the barriers of green banking initiatives in India and to determine the key barriers using the ISM MICMAC.

The study considered eleven experts to find out the barriers for adoption of green banking initiative in India. The demographic profile of the experts considered for the study is shown in Table 2.

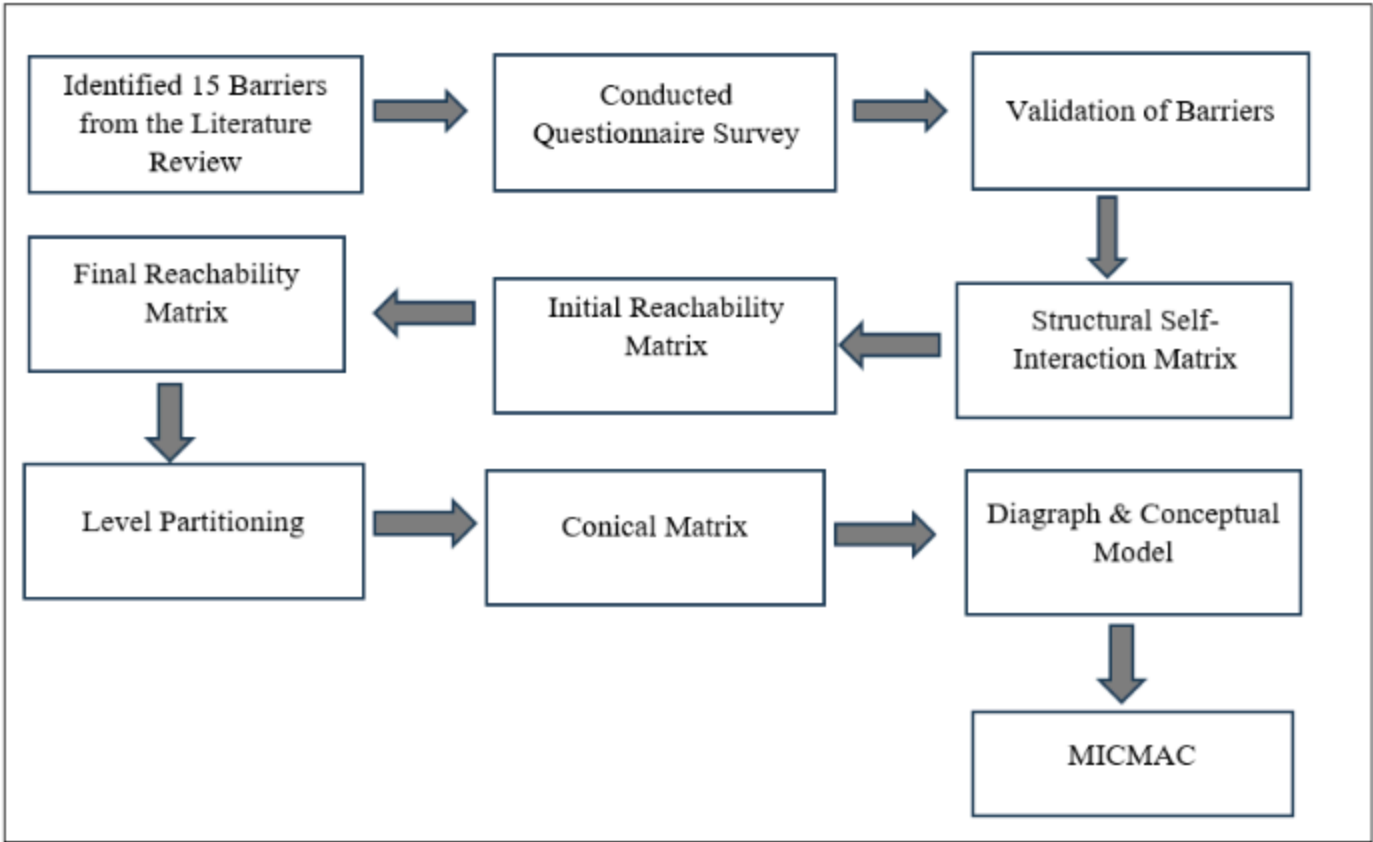
Table 2
Profile of Respondents

Description	Categories	Number	% of Respondents
Age	25–35	3	27.27
	36–45	6	54.55
	46–55	2	18.18
Educational Qualification	Graduate	4	36.36
	Post Graduate	5	45.46
	Doctorate	1	9.09
	Other Courses	1	9.09
Designation	Chief Manager	1	9.09
	Senior Manager	2	18.18
	Branch Manager	2	18.18
	Assistant Manager	2	18.18
	Relationship Manager	1	9.09
	Cashier	1	9.09
	Professor	1	9.09
	Equity Research Analyst	1	9.09
Organisation Type	Bank	9	81.82
	Academic Institution	1	9.09
	Other	1	9.09
Work Experience	0–5 Years	2	18.18
	6–10 Years	1	9.09
	11–15 Years	5	45.46
	16 years and above	3	27.27
Area of Expertise	Banking / Finance	11	100
Total		11	100.0

ISM is a qualitative and interpretive method that helps to generate solutions for complex problems through discourses based on structural mapping of interconnections of elements (Pfohl et al., 2011). ISM is a widely accepted and established method to discover the relationship among elements that

define a problem, and it is a modeling technique for examining the effect of one element on other elements. ISM comprises nodes and links that represent a system’s variables and direction of a relationship. The result of ISM is a model that shows the contextual relationship among its elements. ISM is widely used to study causal and hierarchical relationships among the factors. (Marak et al., 2021)

Table 3: Stages of ISM Method



Source: Author’s own creation

The stages of ISM and MICMAC are as follows

The SSIM is an analytical tool used in Interpretive Structural Modeling to establish contextual relationships among variables, which are identified and verified by experts in the study. It helps in determining how one variable/factor influences or is influenced by another variable. In this matrix, every row variable and column variable are systematically paired and compared to examine the direction and nature of the relationships that exist. This is represented by four different symbols viz., V, A, X, and O.

In order to prepare the matrix, barriers are arranged in rows (i) and columns (j). Experts are asked to compare pair wise and to symbolise V, A, X, O.

If (i) lead to (j) it should be symbolised as ‘V’, if (j) lead to (i) to is symbolised as ‘A’, if (i) lead to (j) and (j) lead to (i) then it is symbolised as ‘X’, if (i) do not lead to (j) and (j) also do not lead to (i) it is symbolised a ‘O’.

The collected data is further verified and considered the V A X O score based on the highest scores offered to the variables by the experts. Based on this information, the Structural Self-Interaction Matrix (SSIM) was prepared. (Annexure I).

After constructing a pairwise relationship in a matrix using VAXO symbols, the SSIM is further converted into a reachability matrix.

The Reachability Matrix converts qualitative relationships from the SSIM into binary form (0 and 1) to identify direct and indirect influences among factors based on the criteria. It helps to determine each factor's driving and dependence power, forming the basis for the ISM hierarchy.

(1) Indicate V as 1 when i leads to j and 0 in the opposite cell. (2) Indicate A as 0 when i leads to j and 1 in the opposite cell (3) Indicate X as 1 irrespective of the variable's direction (4) Indicate O as 0 irrespective of the variable's direction. It help to determine each factors driving and dependence power, which will form the basis for ISM hierarchy.

The matrix is first converted to binary form, then flipped to reverse variable order for a fresh analysis of driving and dependence powers. The Reachability Matrix (RM) illustrates the relationships among twelve green banking barriers, where a value of 1 indicates a direct influence between variables. Driving Power is the sum of each row, showing how many variables a factor influences (e.g., "Awareness About Green Investment" drives 11 others). Dependence Power is the sum of each column, indicating how much a variable is influenced by others (e.g., "Implementation of Regulation" depends on 7 variables).

After incorporating transitivity into the reachability matrix, level partitioning is carried out to determine the hierarchical levels of the identified barriers.

The level partitioning iterations are derived from the final reachability matrix. For each variable, the Reachability Set (Row), Antecedent Set (column), and Intersection Set are identical, indicating that every variable influences and is influenced by all others. Since all sets are the same, all twelve variables fall under Level 1, showing a fully interconnected system with equal driving and dependence power. Hence, there is no hierarchy among the variables, and each factor needs to be addressed collectively.

After completion of the level partitioning process, the final reachability matrix was transformed into a conical matrix by arranging the barriers according to their hierarchical levels. Variables belonging to the same level were grouped together across rows and columns to provide a structured representation of their positioning within the ISM framework. However, in the present study, all identified barriers were positioned at the same hierarchical level, indicating the absence of distinct hierarchical stratification among the barriers. This suggests that the barriers are highly interdependent and operate at a comparable structural level within the adoption framework of green banking initiatives.

A digraph, or directed graph, visually represents interactions among items using nodes to describe elements and arrows to represent directed connections; collectively, these form the ISM model.

The final step of the ISM analysis involves an Impact Matrix Cross-Reference Multiplications Applied to Classification (MICMAC).

MICMAC analysis was first developed by Duperrin and Godet (1973) (Chandramowli et al., 2011) for analysing the influence and dependence of factors used in the model by plotting each elements dependence versus its driving power as determined by the reachability matrix.

MICMAC analysis was used to classify the barriers of green banking initiatives into four quadrants based on driving and dependence power, viz., autonomous/excluded variables, dependent variables, relay/linkage variables, and influential/independent variables. (Ravi & Shankar, 2005b) (Chandramowli et al., 2011)

4. Discussion

This study examined the barriers for the adoption of green banking initiatives in India, using ISM and MICMAC analysis.

From the literature, 15 barriers were identified, of which 12 barriers were found more relevant as per the expert opinion. These are (1) awareness about green investment, (2) formal guidelines for green financing, (3) system for monitoring green banking practices, (4) adequate support from environmental agencies, (5) environmental measurement and performance indicators, (6) government interest in green initiatives, (7) operational and material risk, (8) staff expertise in green banking operations, (9) implementation of regulation, (10) environmental experts, (11) long start-up-time, and (12) internal capacity to adopt green initiatives. The remaining 3 barriers were eliminated based on the expert opinion, as they were not considered material. These included (1) internal management support, (2) support for green projects, and (3) awareness about renewable resources.

The results of ISM reveal that all 12 barriers exhibited equal driving power (12) and dependence power (12), positioning them at the same level in the ISM hierarchy. This indicates that no single barrier has a dependence or driving factor over the other barriers. In other words, each barrier has the same level of dependence and driving power. These results indicate a strong interdependence among the 12 barriers, as shown in Fig. 4. Addressing one barrier will simultaneously impact the others. Therefore, these barriers need to be addressed collectively rather than focusing on them individually.

Based on the ISM analysis results, the barriers are further classified into four clusters according to their driving and dependence power using MICMAC analysis, as shown in Fig. 5. Quadrant I (Autonomous) comprises factors characterized by weak driving power and weak dependence, indicating minimal interaction with the system. Quadrant II (Dependent) includes factors with weak driving power but strong dependence. Quadrant III (Linkage) represents factors possessing both strong driving and strong dependence power, reflecting a high level of interdependence. Finally, Quadrant IV (Independent) consists of factors with strong driving power and weak dependence, indicating their significant influence on other variables within the system.

MICMAC results reveal that all identified barriers are classified within the Linkage cluster, demonstrating that each factor exhibits both strong driving and strong dependence power and therefore affected by its own actions. These barriers include awareness about green investment, formal guidelines for green financing, system for monitoring green banking practices, adequate support from environmental agencies, environmental measurement and performance indicators, government interest in green initiatives, operational and material risk, staff expertise in green banking operations, implementation of regulation, environmental experts, long start-up-time, and internal capacity to adopt green initiatives. The concentration of all variables within this quadrant highlights a high degree of interdependence, indicating that changes in any one barrier are likely to have significant ripple effects across the system.

No factor is figured out in the autonomous cluster, suggesting that none of the identified barriers are isolated or insignificant within the system. Similarly, no factors fall under the Dependent cluster, indicating the absence of barriers that are primarily influenced by others without exerting significant influence themselves. Furthermore, no factors are identified within the independent cluster, implying that none of the barriers function as dominant driving forces with minimal dependence on other variables, as shown in Fig. 4. Overall, the results emphasize the complex and interconnected nature of barriers to green banking adoption, where all factors simultaneously influence and are influenced by one another.

The results of content analysis reveal systematic differences in environmental disclosure practices between green bond-issued and non-green bond-issued banks. Green bond issuers exhibit a higher frequency of usage of environmental keywords and broader thematic coverage across the years 2023-24 and 2024-25, indicating stronger institutional commitment to sustainability reporting and transparency. The reports strongly emphasized climate and carbon, sustainability strategy, and renewable energy, indicating that green bond-issued banks are more aligned with SDG 13 (Climate Action) and SDG 7 (Affordable and Clean Energy). On the other hand, non-green bond-issued banks show a gradual increase in disclosure intensity over time, although their reporting levels remain significantly lower than green bond-issued banks.

However, the findings also show that disclosure performance varies substantially across banks, regardless of bond issuance status. While some green bond-issued banks demonstrate leadership in disclosure, others record only moderate scores, and certain non-green bond-issued banks outperform them. This implies that green bond issuance alone does not guarantee superior disclosure quality; rather, broader organizational sustainability orientation, governance commitment, and strategic ESG integration likely influence disclosure performance. It is evident that there is an increase in the disclosure of information relating to the environmental in both the bank groups, indicating the impact of SEBI's mandatory BRSR framework on improving sustainability reporting. Overall, the results reveal a disclosure gap between green bond-issued and non-green bond-issued banks, but green bond-issued banks show stronger sustainability reports than non-green bond-issued banks.

5. Conclusion

The study suggests that green bond-issued banks in India are increasingly focusing on sustainability. This trend indicates a growing commitment toward environmental responsibility within the banking sector. However, these positive developments must be viewed alongside the barriers to the adoption of green banking initiatives, such as awareness about green investment, formal guidelines for green financing, system for monitoring green banking practices, adequate support from environmental agencies, environmental measurement and performance indicators, government interest in green initiatives, operational and material risk, staff expertise in green banking operations, implementation of regulation, environmental experts, long start-up-time, and internal capacity to adopt green initiatives. These ongoing barriers highlight that, although some banks have made progress, green banking is still not widely adopted in India.

The study presents a comprehensive analysis of the barriers hindering green banking initiatives in India, using Interpretive Structural Modeling (ISM) and MICMAC analysis. The Structural Self-Interaction Matrix (SSIM) and subsequent Reachability Matrix reveal that all twelve identified barriers exhibit equal driving and dependence power, indicating a high degree of interdependence and no clear hierarchical structure among them.

The MICMAC analysis further categorises these barriers into the linkage quadrant, reinforcing their mutual influence and the complexity of overcoming them. Notably, no barriers fall into the autonomous, dependent, or independent quadrants, highlighting that none of the factors can be considered isolated or easily dismissible. These barriers are intricately linked and must be addressed collectively rather than in isolation to effectively promote green banking practices. This interconnectedness emphasises the need for a holistic approach involving multiple stakeholders, including policymakers, financial institutions, and environmental experts, to simultaneously tackle these challenges. Addressing one barrier will likely have a cascading effect on others, underscoring the importance of integrated strategies and coordinated efforts. The results underscore the urgency of developing comprehensive policies, enhancing institutional capacities, and fostering greater environmental consciousness within the banking sector.

Overall, the study advances the understanding of barriers to green banking initiatives in India, providing a valuable framework for researchers and practitioners to design effective interventions. The findings advocate for collective action and systemic change to overcome the multifaceted barriers and accelerate the adoption of sustainable banking practices. Content analysis highlights the sustainability reporting disclosure of green bond-issued banks. The adoption of green banking initiatives has become essential to achieve the UN SDGs.

Declarations

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The authors acknowledge the use of OpenAI's ChatGPT for assistance with language refinement, content organisation, and structural editing during the preparation of this manuscript. Its use was strictly supervised by human and it did not independently generate original academic ideas, analysis or

interpretations. Additionally, Grammarly was utilized to improve grammar, punctuation, and overall clarity. All intellectual contributions, critical interpretations and theoretical insights presented in this study remain the sole responsibility of the authors.

Data Availability Statement

The data supporting the findings of this study consist of both primary and secondary data. The primary data comprise expert responses collected for the Interpretive Structural Modelling (ISM) analysis and are available from the corresponding author upon reasonable request, subject to confidentiality considerations. The secondary data comprises publicly available Business Responsibility and Sustainability Reports (BRSR) of the selected Indian banks, which are available through the respective banks' official websites and NSE website. <https://www.nseindia.com/companies-listing/corporate-filings-bussiness-sustainabilitiy-reports>

Conflict of Interest

On behalf of all authors, the corresponding author declares that there is no conflict of interest and do not have financial or non-financial interests that are directly or indirectly related to this research work.

Consent to Participate

Informed consent was obtained from all individual participants before data collection. Participants were informed about the purpose of the study, the confidentiality and anonymity of their responses, and their right to withdraw from the study at any time without any penalty. The study included only adults; therefore, parental or legal guardian consent was not required.

Funding Declaration

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Clinical Trial Number

Not applicable

Ethical approval

The study protocol was reviewed and approved by the Institutional Human Ethics Committee (IHEC), Central University of Karnataka, India (Ref. No. IHEC-CUK/EC-01/004, Project No. 2026-04, dated 03 September 2026).

Accordance

The study was conducted in accordance with the ethical guidelines of the Indian Council of Medical Research (ICMR) and the requirements of the Institutional Human Ethics Committee (IHEC), Central University of Karnataka.

Consent to Publish

Not applicable

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Figures

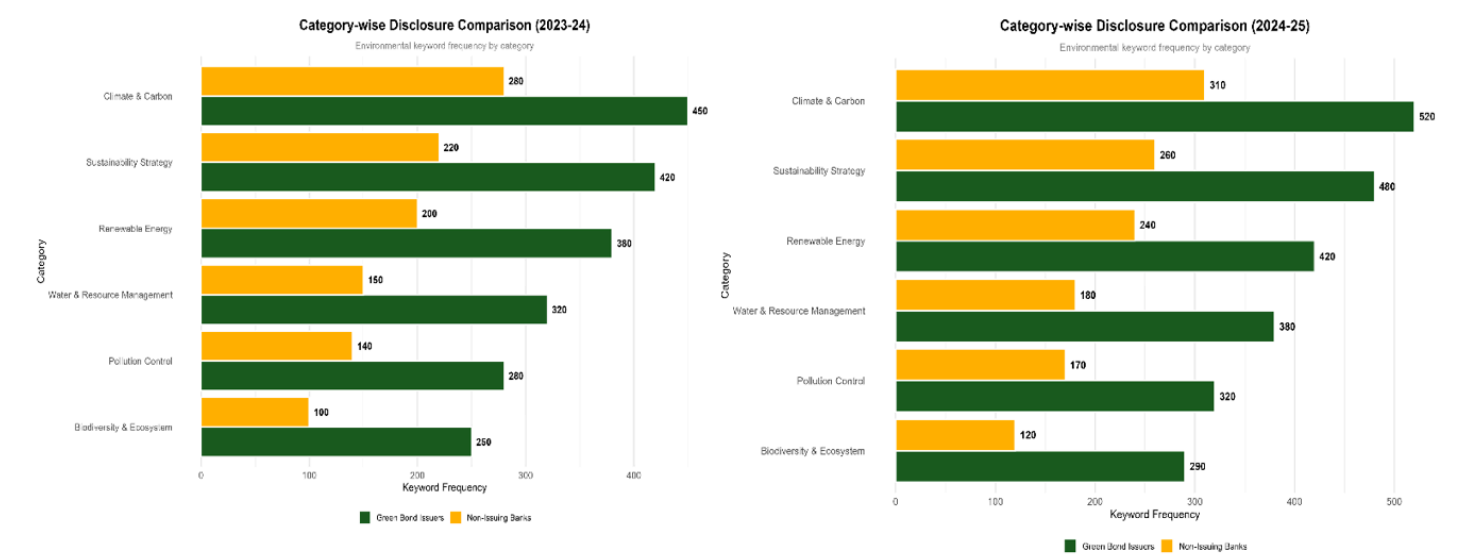


Figure 1

Topic-Wise Disclosure of words by the selected banks

Source: Author's compilation and analysis using BRSR reports.

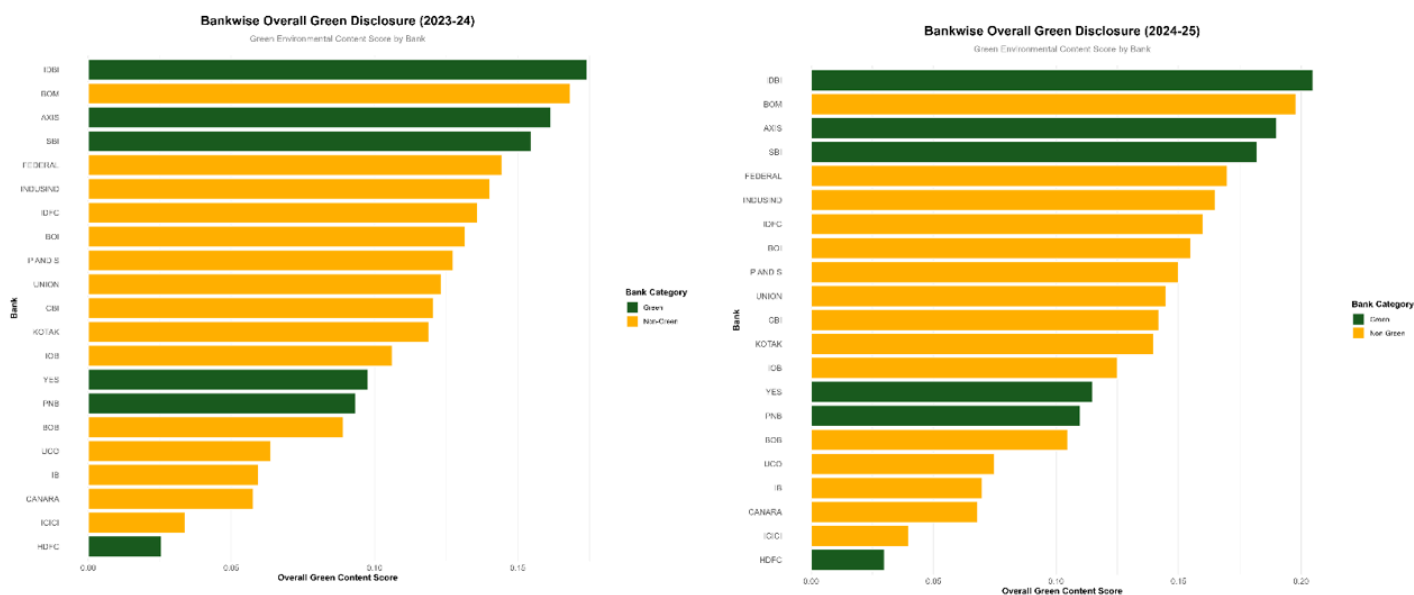


Figure 2

Bank-wise Overall Green Disclosure for the years of 2023-24 and 2024-25

Source: Author's compilation and analysis using BRSR reports.

Green Environmental Disclosure: Year-on-Year Comparison

Total keyword frequency by bank group (2023-24 vs 2024-25)

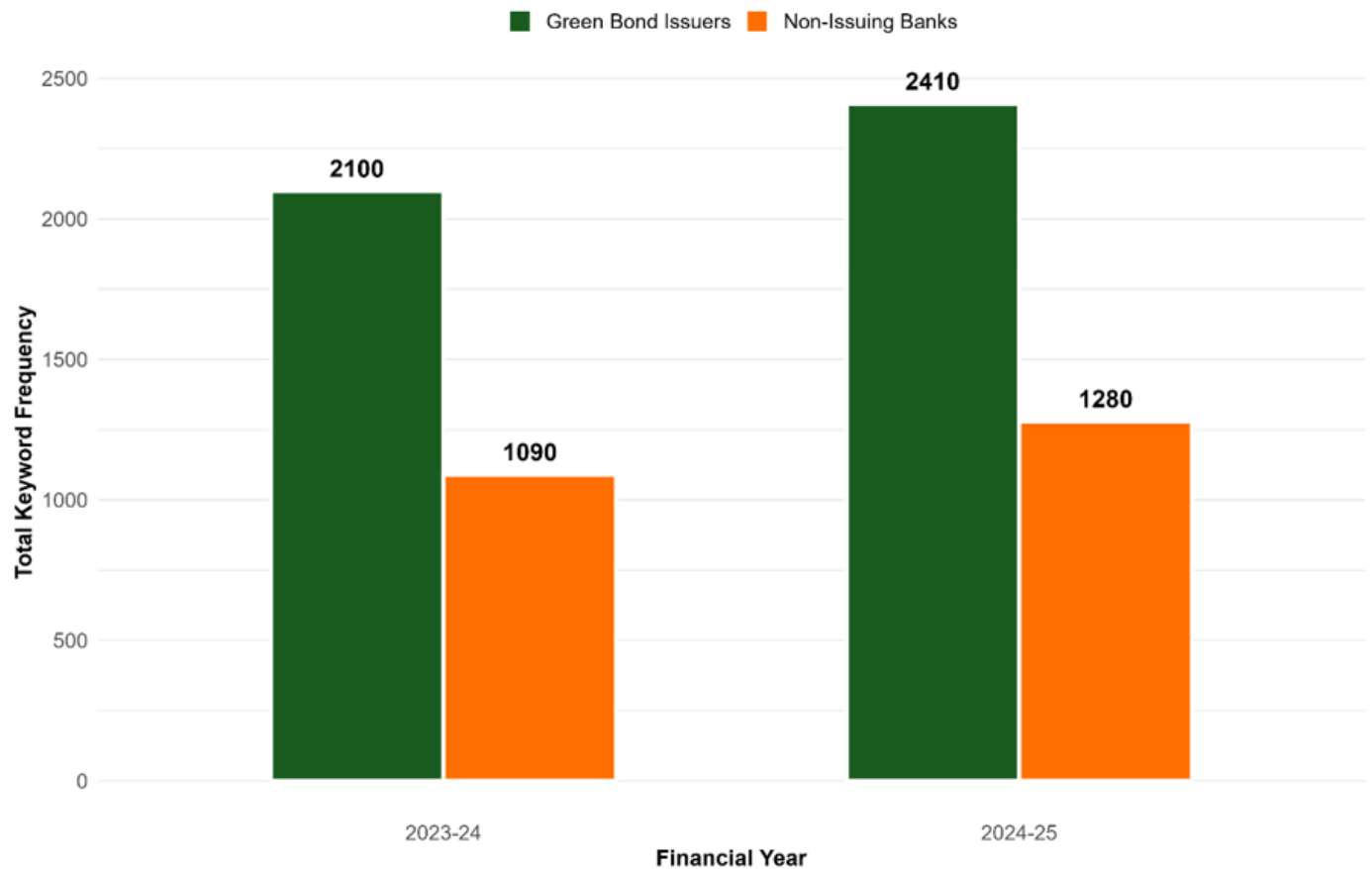


Figure 3

See image above for figure legend.

Source: Author's compilation and analysis using BRSR reports.

Digraph

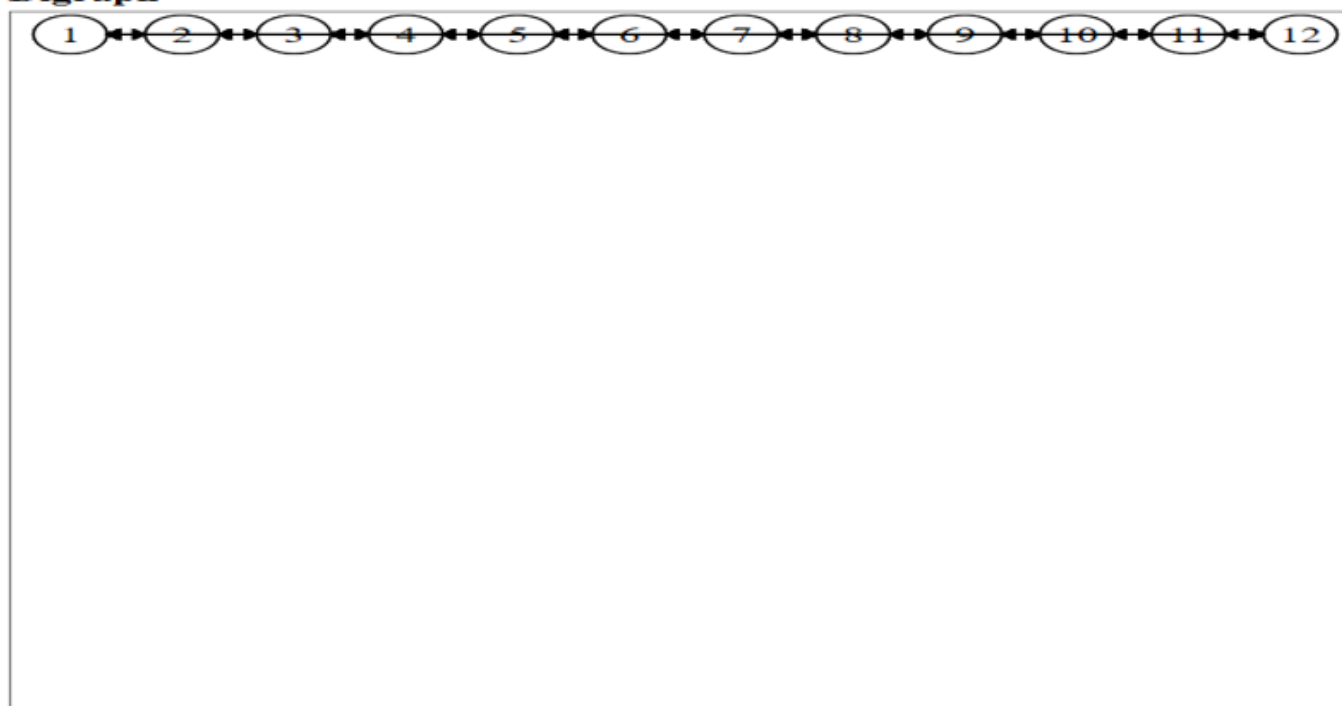


Figure 4

Diagraph

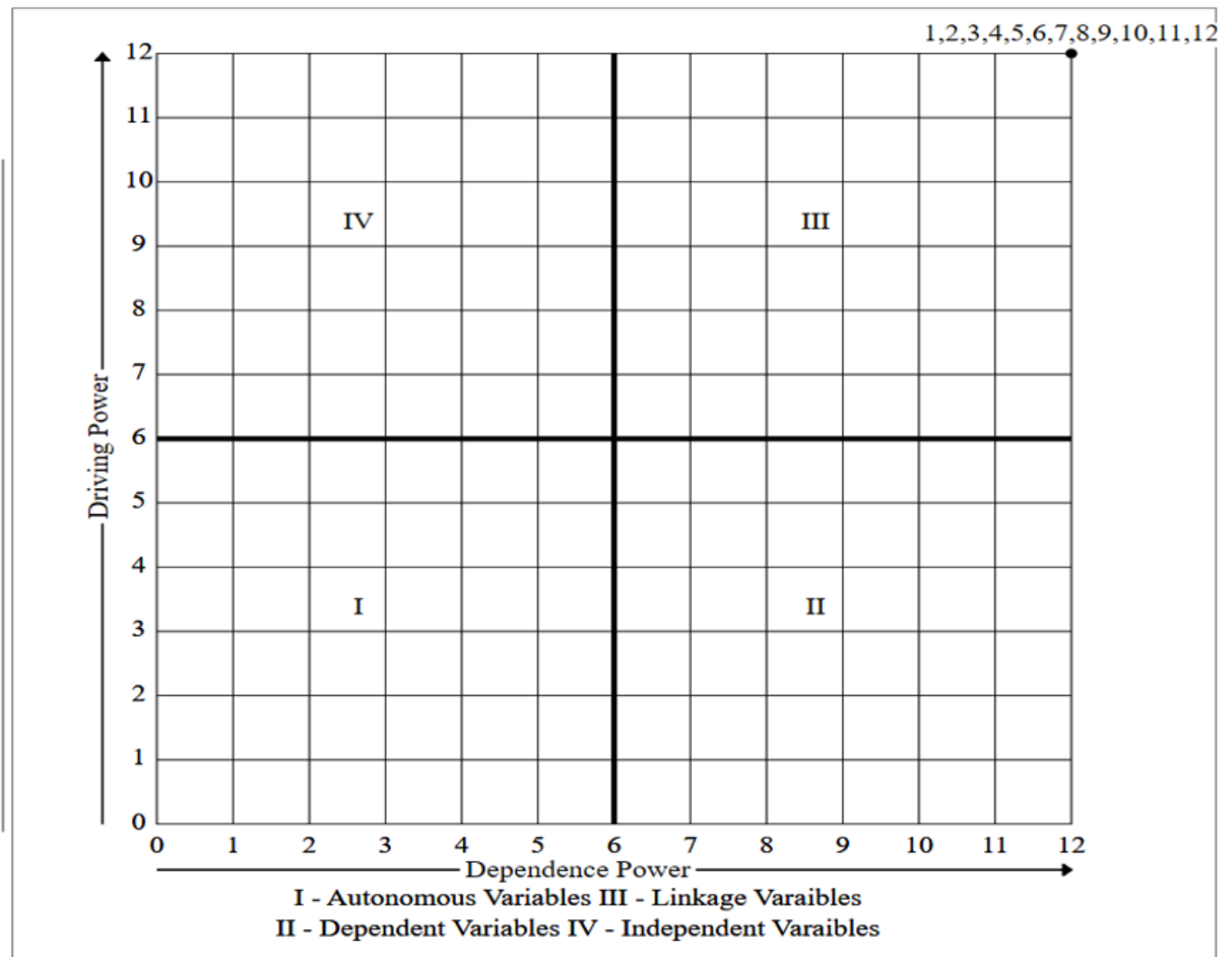


Figure 5

MICMAC Analysis

Supplementary Files

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- [AnnexureI.docx](#)